The Influence of Behavioral Inhibition and Approach on Affective Modification of the Startle Response

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Abstract

Startle modification is a robust phenomenon that has been used as a tool in the research of emotion and motivation. In a picture viewing paradigm, valence of affective pictures modulates startle magnitude. There is a debate on whether emotional or attentional processes are the mechanism of startle modification. The present study sought to address this question by investigating the individual differences related to startle modification and explore the relationship of the trait-like physiological variables and startle modification. The study creatively calculated standardized startle scores and treated personality variables as continuous variable. The results showed that specific contents of the affective pictures had different effects of startle modification. Personality variables influence the startle modification in emotion conditions differently. Cardiac activities were related to raw startle magnitude but not to startle modification. The results have suggested that there are the influences of individual differences in attention and effortful control on startle modification and attention and that emotion and attention interact with each other in startle modification. The study filled gaps in the research on startle modification and personality and guided future studies of this topic.

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Introduction

The startle response, which is found across mammalian species, is a reflexive protective response to an intense and sudden stimulus. The startle response is modulated by antecedent affective events. The mechanism of affective startle modification is motivational priming: affective significance modulates the startle response (Lang, Bradley, & Cuthbert, 1990). In a picture viewing paradigm, negative pictures enlarge the startle response, while positive pictures attenuate the startle response (Vrana, Spence, & Lang, 1988; Lang et al., 1990).

However, it has been debated that whether attentional processes also play an important role in startle modification (Graham, Putnam, & Leavitt, 1975). Research on individual differences may be helpful to address this debate. Previous studies (Hawk & Kowmas, 2003; Gros, 2011) have shown that the behavioral inhibition and activation system (BIS/BAS) influence startle modification. However, studies on this topic have some problems in methodology, including picture selection and statistical analysis of personality variables; and the evidence of individual differences in attention is little. In the present study, the author sought to investigate the influence of individual differences in both emotional and attentional processes on startle modification and examine the modulation effects of specific contents in a picture viewing paradigm.

Startle Response

Landis and Hunt (1939) first used high-speed cinematic recording to capture the startle response of humans to a sudden pistol shot. The startle response functions to protect the back of the neck and the eye via the blink, and to facilitate escape by shoving the head forward, curling the shoulders forward and up, shortening the whole body, stiffening the limbs, and descending flexor wave reaction (Lang et al., 1990). Elicited by abrupt stimuli, the startle response interrupts and disengages the organism from ongoing activities and prepares for directed evasive movements (Graham, 1992). The startle response is primarily organized in the brain stem, but the neural circuits of the startle response are also modulated by higher neural systems (Davis, 1988).

The research on the startle response has employed the startle stimulus of different sensory modality. Compared to visual and tactile, the acoustic startle stimulus is convenient to conduct and induces less harmful effects on the subjects. The parameters of acoustic startle stimulus, including intensity, rise time, duration, and bandwidth, influence the startle response (Berg & Balaban, 1999). The threshold of intensity of the auditory stimulus has been thought to be 80 dB; the threshold of rise time is 30 ms; and the threshold of the duration is 50 ms (Berg, 1973; Graham, 1973, 1979). In general, a stimulus of higher intensity, shorter rise time, longer duration, and wider bandwidth induces a larger startle response (Berg, 1973; Blumenthal, 1988; Blumenthal & Berg, 1986).

Measurement of Startle Response

The techniques to measure the startle response have been developed in the last century. There are two major methods to quantify startle responses: to measure the general body reaction and measure the startle blink. In addition, the startle stimulus activates the sympathetic nervous system. Therefore, a pattern of physiological changes marks the startle response: cardiac acceleration and skin conductance increase immediately after a startle response.

The general body reaction is mostly applied in animal study (e.g. rats). Rats show a whole-body jerk when they are exposed to startle stimuli, which can be detected by the “rat stabilimeter”. The magnitude of startle response is assessed as the change of force recorded by the device (Davis & Astrachan, 1978). In humans, on the other hand, the startle blink can occur without the whole-body reaction (Brown, Kalish, & Farber, 1951). And, sudden closure of the eyelids is the first, fastest, and most stable component in the startle response (Lang et al., 1990). Rapid contraction of the orbicularis oculi muscle generates blink, which provides scientists with an easy way to measure the startle response in humans. Facial electromyography (EMG) is applied to record electrical activities of the orbicularis oculi that contains the orbital and palpeberal portion. Electrical signals from either portion can be used as magnitude of a blink. Yet, the palpebral portion is more sensitive, while the signals from the orbital portion are easier to obtain.

Modification of Startle Response

Sechenov (1863) found that events that preceding stimuli can modify the startle response. The phenomenon was rediscovered by Hoffman and Ison (Hoffman & Searle, 1965; Ison & Hammond, 1971; Ison & Hoffman, 1983). Two types of startle modification are categorized by the length of interval between non-startle-eliciting stimulus and startling stimulus defines: short lead and long lead startle modification. The non-startle-eliciting stimulus is called lead stimulus or lead. The interval the short lead startle modification ranges from 15 to 400 milliseconds. And, the sensory modalities of the lead and the startle stimulus are usually the same (e.g. both are auditory stimuli) (Ison & Hammond, 1971). A well-known phenomenon of the short lead startle modification is the "prepulse inhibition" (PPI) (Hoffman & Searle, 1965, 1968): the prepulse inhibits the startle response; and the maximal inhibition effect appears when the time interval between lead and startle stimulus is of 100-150 milliseconds (Graham et al., 1975).

The interval between lead and startle stimulus in the long lead startle modification paradigms can be as long as several seconds. Lead and startle stimulus are usually of different sensory modalities; and lead can either facilitate or inhibit startle responses. The startle stimulus in long lead startle modification is called the "startle probe". Affective attributes of lead alter the magnitude of startle probe. Brown et al. (1951) reported that the magnitude of startle in rats was enlarged when the lead had been paired with electric shocks. Startle potentiation by conditioned fear has also been observed in humans (Ross, 1961; Davis, 1986). Moreover, some researchers extended types of lead from conditioned fear to anticipated aversive stimuli (Grillon, Ameli, Woods, Merikangas, & Davis, 1991).

Picture Viewing Paradigm

Lang et al. (1990) explained startle potantiation in fear conditioning as the effect of affective significance: aversive emotions, such as fear, enlarge the startle response. In other words, the emotional or motivational state elicited by lead modifies the startle response. Viewing pictures has been shown as an effective method to elicit emotions (Lang, Greenwald, Bradley, & Hamm, 1993). A standard picture system (the International Affective Picture System; IAPS, Center for the Study of Emotion and Attention, 1999) has been developed to allow for prediction and control of valence and arousal levels of induced emotions. Therefore, it has been postulated that viewing pictures of different emotions selected from the standard system should modulate the startle response.

In the picture viewing paradigm, startle stimuli are presented to subjects while viewing affective pictures. The startle response has been shown to be systematically modulated by the valence of affective pictures: compared to neutral pictures, unpleasant pictures augment the startle response whereas pleasant pictures inhibit the startle response (Vrana et al, 1988).

Attributes of emotional pictures and the startle stimulus influences startle modulation. When the interval between the onset of picture and the startle stimulus is too short, the startle response is inhibited by pictures of all valences, which is similar to the PPI. Maximal effect of startle inhibition occurs at 300 milliseconds after picture onset; and the typical pattern of valence modulation occurs at 500 milliseconds after the picture onset (Bradley, Lang, & Cuthbert, 1993, 1996). It has also been found that although magnitude of the startle response decrease during habituation process, the valence modulation resists habituation (Bradley et al., 1993, 1996).

Furthermore, affective startle modification varies with specific content of pictures. Startle responses during pictures of different categories within each valence have been examined (Lang, Bradley, Drobes, & Cuthbert, 1995; Schupp, Cuthbert, Hillman, Raymann, Bradley, & Lang, 1996). For unpleasant pictures, the images of danger and threat had the greatest effect of startle potentiation; disgusting scenes had the smallest effect of startle potentiation. For pleasant pictures, startle responses during erotic pictures were significantly smaller than other types of pleasant stimuli.

The differences in startle modification among specific categories might be due to the arousal level. A study comparing different arousal levels within each valence addressed the issue of the interaction of valence and arousal (Cuthbert, Bradley, & Lang, 1996). The results of this study suggested that there was a threshold of arousal below which an orienting disposition overrides emotional activation. The threshold of arousal rating for affective modulation was about six points on a nine-point Likert scale. Cuthbert et al. (1996) further suggested that the startle response could index mobilization of the appetitive and aversive system.

In sum, the startle response appears to be sensitive to both valence and arousal level of emotional stimuli. Above a certain arousal level, unpleasant affective stimuli facilitate the startle response, while pleasant stimuli inhibit the startle response. These modulation effects are reliable and consistent across studies using the picture viewing paradigm.

Biphasic Emotion Theory and Motivational Priming

According to Lang, the mechanism of affective startle modification is motivational priming (Lang et al., 1990; Lang, 1995). There are two opponent motivational systems driving human behaviors: attractive/appetitive and aversive/defensive (Konorski, 1967; Masterson & Crawford, 1982). The two systems control approach and avoid behaviors, respectively. Human emotions can be organized into the dimension model; the dimensions are valence and arousal (Russell, 1979; Lang et al., 1990).

Motivational priming is based on this motivational perspective of emotion. Subjects are primed by certain emotional stimuli, and the subjects's reactions to following emotional stimuli are changed. The effect of priming depends on the valence of the preceding emotion. In regard to startle modification, it has been widely found that negative emotions amplify the startle response, whereas positive emotions inhibit the startle response, by using pictures (Vrana et al., 1988; Lang et al., 1990, 1997; Bradley, Cuthbert, & Lang, 1999; Ferrari, Bradley, Codispoti, & Lang, 2011) and using body postures (Thibodeau, 2010; Price, Dieckman, & Harmon-Jones, 2012) as the lead.

Challenge to Affective Startle Modification: Attentional Theory

Some researchers have maintained a different view on the mechanism of startle modification. They argue that attentional processes are the mechanism of the long lead startle modification (Graham, et al., 1975; Anthony & Graham, 1985). According to the attentional theory, the more attentional resources allocated for startle stimulus, the larger startle response. The lead occupies attentional resources, so less attentional resources are available for the startle stimulus, which results in an attenuated startle response. The cardiac deceleration in startle modification seemed to support the attentional theory in that decreased heart rate is associated with the anticipatory attention and orienting response (Graham et al., 1975). Thus, Graham et al. (1975) suggested that an orienting response always precedes startle facilitation and the systems of orienting and startle are mutually inhibitory.

Lang and associates (1990, 1992) found that attention theory fails to explain the startle modulation in fear conditioning. First, the attentional theory did not predict the modification effect in a fear conditioning study in which the conditioned stimulus was visual while the startle probe was auditory (Berg & Davis, 1984). Moreover, Lang et al. (1990) suggested that heart rate deceleration did not necessarily occur when perceiving a lead, which was in contrast to results of the previous study (Graham et al., 1975). Rather, unpleasant stimuli induce cardiac deceleration, whereas pleasant stimuli generate cardiac acceleration (Bradley et al., 1990).

However, there has been no conclusion of the debate. Startle modification may involve a mechanism that has to do with both motivation and attention. Calvo and Lang (2003) found that more attentional resources are allocated to emotionally evocative stimuli than neutral stimuli at the early stage of perception of pictures; but there is no difference in attention allocation between emotional pictures and neutral pictures 500 ms after the onset of stimuli. Using the event-related potential (ERP), a net effect of multiple processes has been found in affective startle modification which includes sequential or concurrent processes of prepulse inhibition, prepulse facilitation, attention inhibition, and affective modulation (Bradley, Codispoti, & Lang, 2006).

Taken together, the mechanism of startle modification is not attentional or motivational alone, but is complex and involves the interaction of attention and motivation. Further study is expected to expand the understanding on startle modification using physiological indices and neuroimaging techniques. Besides, there is an enormous variation across individuals in attentional and motivational processing, which provides an approach other than psychophysiology and neuropsychology to the explanation of startle modification.

Behavioral Inhibition and Activation System

Accumulating research has shown that high dispositional sensitivity to negative emotional cues is associated with exaggerated startle responding (Hamm, Cuthbert, Globisch, & Vaital, 1997). However, findings of startle modification and individual differences are inconsistent (Grillon & Baas, 2003). Therefore, it is important to find the dimensions that represent individual differences in startle modification.

Eysenck (1967) proposed that the reticulo-cortical and the reticulo-limbic circuits act as the neural basis of the extraversion-introversion and neuroticism-stability dimensions of personality. Gray (1981) modified Eysenck's theory and assumed anxiety proneness and impulsivity as the basic dimensions of personality. The two orthogonal dimensions of anxiety and impulsivity were oriented at 30° relative to Eysenck's extraversion and neuroticism dimension, respectively. Anxiety and impulsivity reflect individual differences in the sensitivity of two independent neural systems, the *behavioral inhibition system* (BIS) and *behavioral activation system* (BAS). Some researchers use the BAS to refer to the *behavioral approach system* which is the same thing as the behavioral activation system (Carver & White, 1994; Hawk & Kowmas, 2003).

The BIS consists of the septo-hippocampal system (SHS), the monoaminergic afferents from the brainstem, and the projections from the SHS to the frontal lobe (Gray, 1981). The BIS regulates aversive motivation and is sensitive to signals of punishment, non-reward, novelty, and innate fear stimuli, and inhibits behaviors that can lead to negative outcomes and movement toward goals (Gray & McNaughton, 1982).

The BAS is responsible for appetitive motivation. This system facilitates the response to the signals of reward and nonpunishment. The BAS is comprised of catecholaminergic, especially dopaminergic, pathways. Its activation promotes approach behaviors and the experience of positive feelings when the organism is presented with cues of impending reward.

It is worth noting that the original BIS/BAS model did not contain the amygdala which plays a vital role in startle modification (Gray, 1982). However, the amygadala has been involved in the revised BIS/BAS model as a part of the fight-flight-freezing system (FFFS) (McNaughton & Gray, 2000). The FFFS controls the primary responses to explicit dangers. Concurrent activation of the FFFS and the BAS activates the BIS, which increases arousal and attention of the organism (McNaughton & Gray, 2000). The FFFS is envisaged as the mechanism of fear, while the BIS is viewed as the mechanism of anxiety that involves inhibition of the prepotent behaviors (McNaughton & Gray, 2000).

Measurement of BIS/BAS Sensitivity

BIS sensitivity is the sensitivity to anxiety-relevant cues and experience of non-reward, punishment, and novelty, while BAS sensitivity is the sensitivity to non-punishment and reward, as well as experience of positive emotions (Gray, 1981). BIS and BAS sensitivity are assumed to be orthogonal (Carver & White, 1994).

Carver and White (1994) designed the BIS/BAS scales to measure BIS and BAS sensitivity by assessing responses to real life situations. The BIS/BAS scales include twenty-four items with four fillers. The items for BIS sensitivity describe negative circumstances and assess the behavioral reactions to the potentially punishing events. Responses to the items reflect the proneness to anxiety. The BAS scale contains three subscales: (a) the Drive scale, which measures persistent pursuit of goals; (b) the Fun Seeking scale, which reflects a desire for new rewards; and (c) the Reward Responsiveness scale, which reflects positive responses to anticipated reward.

The BIS scale is independent of the BAS subscales. BIS scores significantly predict responses to punishment, but BAS scores cannot predict such responses (Carver & White, 1994).

The BIS scale is less sensitive than the BAS scales to reward-cue manipulations. Among three BAS subscales, the Drive and Reward Responsiveness scale successfully predict the sequent happiness reports, but the Fun Seeking scale is only a marginally significant predictor of the reports (Carver & White, 1994).

BIS/BAS and Startle Modification

The framework of BIS/BAS represents individual differences in sensitivity to affective stimuli, thus it is reasonable to posit that BIS and BAS sensitivities are associated with affective startle modification. Hawk and Kowmas (2003) hypothesized that high BIS sensitivity leads to stronger startle potentiation during unpleasant stimuli, while high BAS sensitivity produces larger effect of startle inhibition during pleasant stimuli in the picture viewing paradigm. To test the hypothesis, subjects were grouped according to their scores on the BIS/BAS scales (Carver & White 1994). The results showed that startle inhibition during pleasant pictures was significant in the high-BAS group whereas valence modulation was not significant in the low-BAS group. However, the interaction between the BIS and valence was not significant: modification effects occurred in the high-BIS group but not in the low-BIS group, and neither BIS group exhibited robust startle potentiation during unpleasant pictures.

The failure to find the expected results in this study may be due to the particular unpleasant pictures selected in the study (Hawk & Kowmas, 2003). The greatest startle potentiation has been observed when viewing fearful pictures depicting attacking animal and human (Lang et al., 1995; Schupp et al., 1996), and startle responses are not significantly augmented during pictures of accidents or pollution (Lang et al., 1995; Schupp et al., 1996). However, Hawk and Kowmas (2003) chose only three pictures of attacking animal and none of attacking human; and there were eight unpleasant pictures depicting accidents or pollution in the study. Another limitation in this study is that only overall BAS scores were collected and the interaction of valence and specific BAS subscales was not examined.

Subsequent studies have been conducted to address these problems. It has been found that the startle response during pictures of anger does not significantly differ from neutral pictures; anger-modulated startle potantiation occurs only in subjects with dispositional approach (Amodio & Harmon-Jones, 2011; Peterson & Harmon-Jones, 2012). These findings are consistent with the notion that the BAS relates to experience of not only positive emotions but also some negative emotions (Carver, 2004). Gros (2011) examined the relationship between valence modulation and BAS subscales: startle inhibition in all subjects during pleasant pictures is driven by the inhibition effects in the high-BAS group, and the Drive scale contributes most to this inhibition.

As for the BIS, both high- and low-BIS groups has have shown startle potentiation during blood-disgust images; but startle potentiation during fearful images has only been found in the high-BIS group, not in the low-BIS group (Caseras, Fullana, Riba, Barbannoj, Aluja, & Torrubia, 2006). The stronger effects of blood-disgust pictures in this study may be because that instead of eliciting disgust alone, blood-disgust pictures elicit both disgust and fear.

In summary, the extant literature of affective modification of startle modification and BIS/BAS has some gaps and inconsistency, which suggests a need for future research. First, it is necessary to investigate the effects of different picture contents in startle modification. Second, the influences of BIS/BAS on different pictures should be examined separately. Third, it is expected to treat BIS/BAS scores as continuous variables, rather than dichotomization, when assessing the relationship between BIS/BAS and startle modification.

Temperament and Startle Modification

The BIS/BAS is based on neurophysiology and only represents the individual differences in motivation or emotion. However, the individual differences in startle modification include emotion, attention, and sensitivity to neutral stimuli, which calls for a comprehensive model of personality. Temperament is an integrative framework entailing behavioral genetics, personality theory, neuropsychology, and developmental psychology (Derryberry & Rothbart, 1988). Temperamental processes also root in biological systems and reflect individual differences in emotion as well as attentional capacities (Thomas & Chess, 1977; Rothbart & Derryberry, 1981). According to Derryberry and Rothbart (1988), the constructs of temperament include arousal, emotion, and self-regulation. Temperament reflects individual differences in reactivity and self-regulation (Rothbart, Ahadi, & Evans, 2000). Reactivity refers to excitability, responsivity, or arousability of the behavioral and physiological systems of the organisms, which embraces the construct of arousal and emotion; whereas self-regulation refers to behavioral and neural processes to modulate the reactivity (Rothbart et al., 2000). The framework of temperament matches biphasic emotion theory and reflects the individual differences related to startle modification.

Measurement of Temperament

In adulthood, self-report is a feasible and effective approach to studying temperament, although it has its limitations (Rothbart et al., 2000). Derryberry and Rothbart (1988) developed the Physiological Reactions Questionnaire (PRQ) to measure individual differences in reactivity and self-regulation. Based on results of subsequent studies (Rothbart et al, 2000), the Adult Temperament Questionnaire (ATQ) has been adapted from the PRQ. The ATQ contains four factor scales reflecting specific components of temperament, including effortful control, negative affect, extraversion/surgency, and orienting sensitivity. The reliability of the four scales are .72, .75, .70, and .84, respectively.

Temperament and BIS/BAS

Among those components of temperament, effortful control, orienting sensitivity, and negative affect are theoretically related to the individual differences in startle modification. Effortful control is based on the executive attention system and reflects self-regulation; orienting sensitivity is an index of reactive and reflexive attention focus; negative affect reflects tendency of negative emotions induced by various events (Evens & Rothbart, 2007).

Effortful control includes attention control, inhibitory control, and activation control. Attention control reflects the capacity to focus and shift attention to desired targets. Attention control and orienting sensitivity together measure the individual difference in attentional processes.

Inhibitory and activation control reflect the capacity to suppress inappropriate behaviors and to perform actions when the organisms have a tendency to avoid them. Although inhibitory and activation control are not strictly consistent with the BIS/BAS, there is evidence that they are correlated with each other. Elliot and Thrash (2010) found that approach temperament measured by the ATQ is positively correlated with BAS sensitivity, $r = .67$; and avoidance temperament is also positively correlated with BIS sensitivity, $r = .76$. The authors further suggested that approach and avoidance temperament may be construed as the underlying cores of BAS and BIS sensitivity variables (Elliot & Thrash, 2010).

Moreover, negative affect is associated with emotionality and sensitivity to negative emotional cues which have been documented as individual differences related to startle modification (Hamm et al., 1997). For example, the Primary Fear and Auditory Discomfort subscales of the ATQ are directly associated with dispositional fear and auditory reactivity which play important roles in the startle response.

To sum up, temperament provides a more comprehensive framework than BIS/BAS to explore individual differences in startle modification. The ATQ measures individual differences in both motivation and attention. For one thing, there is a convergence of the BIS/BAS and approach and avoidance temperament. For another, the measurement of temperament is also a supplement to BIS and BAS sensitivity as the ATQ reflects individual differences in attenional processes.

Individual Differences in Cardiac Activity and Startle Modification

The startle response involves a series of characteristic physiological changes among which cardiac measures are important indices of autonomic activity. Heart rate (HR) increases after the onset of startle stimulus (Lang et al., 1990). Moreover, heart rate variability (HRV) has been associated with affective startle modification, as a trait-like variable (Ruiz-Padial, Sollers, & Thayer, 2003). The results of this study showed that the resting HRV is negatively related to the magnitude of startle blink during both inter-trail interval and affective foreground, and the high-HRV group has the greater magnitude of startle response during pleasant and neutral pictures relative to the low-HRV group. This study supported the notion that high levels of resting respiratory sinus arrhythmia (RSA) indicate physiological flexibility that is associated with emotional reactivity and engagement (Beauchaine, 2001).

However, the finding of HRV reactivity and startle modification is scant. HRV has been shown being associated with attention allocation and emotion regulation and gives us a window to the moment-to-moment output of the central autonomic network and the capacity to modulate physiological response in the emotional context (Thayer & Lane, 2000). Porges (2001) posited that RSA is associated with the regulation of the emotional process underlying social behavior.

Gross (1988) found that HRV is associated with attentional deployment. Therefore, it is reasonable to extend the study on HRV and startle modification to individual difference to dynamic measures.

Towards A Comprehensive Understanding of Startle Modification

To summarize the research of individual differences in startle modification, first, the magnitude of startle response is related to reactivity to cues of negative emotion and autonomic activity, because a startle stimulus itself is an unpleasant stimulus. Heart rate reactivity (HRR) refers to the change of mean heart rate between baseline and tasks. Startle magnitude, HRR and HRV in a picture viewing paradigm may correlate with each other in the picture viewing paradigm.

Second, a high level resting HRV has been associated with a well-regulated reaction to affective stimuli. Thus, resting HRV can be regarded as trait-like variable that is related to picture modulation of the startle response in the picture viewing paradigm.

Third, personality variables related to capacity of controlling emotional and attentional processes should link, similar to resting HRV, to the modulation effects in the picture viewing paradigm and have different influences on startle responses in different emotion conditions.

Aims and Hypotheses

General Aims

1. To investigate the influences of behavioral inhibition and activation and individual differences in attention and on startle modification using the picture viewing paradigm. In contrast to previous studies of startle modification (Hawk & Kowmas, 2003; Gros, 2006) that dichotomized personality variables into high and low groups, the present study would treat personality variables as continuous variables.

2. To compare the BIS/BAS scales with avoidance and approach temperament measures of the ATQ in regard to startle modification.
3. To investigate individual differences in cardiac activity and reactivity, including HR and HRV, in startle modification. This aim was twofold: to examine the moderation of resting HRV in startle modification and to explore the relationship between HR and HRV reactivity and startle modification.
4. To compare modulatory effects of pictures of different contents. It was expected to not only replicate the typical pattern of valence modulation (Vrana, et al., 1988; Lang et al., 1990) but also have different effects of specific contents on startle modification.

Specific Hypotheses

1. The magnitude of startle blink during pleasant pictures was expected to be smaller than those during neutral pictures, whereas the magnitude of startle blink during unpleasant pictures was expected to be larger than those during neutral pictures, replicating general findings on affective startle modification.
2. Among categories of unpleasant pictures, direct threat would induce the greatest effect of startle potentiation; and among pleasant pictures, erotic scenes were expected to elicit the greatest effect of startle inhibition.
3. The mean raw startle magnitude of all trials would be positively correlated with Primary Fear and Auditory Discomfort score.
4. Inhibitory Control and/or BIS score would be (a) positively correlated with startle magnitude during pleasant pictures and (b) negatively correlated with startle magnitude during unpleasant pictures.
5. Activation Control and/or BAS score would be (a) negatively correlated with startle magnitude

during pleasant pictures and (b) positively correlated with startle magnitude during unpleasant pictures.

6. Attention Control score would be (a) negatively correlated with startle magnitude during pleasant pictures and (b) positively correlated with startle magnitude during unpleasant pictures.
7. HRR would be positively correlated with raw startle blink across trials.
8. Resting HRV and HRV reactivity were expected to be (a) negatively correlated with raw startle blink across trials; (b) positively correlated with startle magnitude during unpleasant pictures; and (c) negatively correlated with startle magnitude during pleasant pictures.

Method

Subjects

Eight-three college-aged subjects (mean age: 19.4 years; standard deviation: 1.4 years; 37 female) were recruited from undergraduate psychology courses via the Virginia Polytechnic Institute and State University SONA system and received course credit for their participation. Subjects were screened for history of neurologic and psychiatric illness, drug abuse, and psychotropic medication using the “Health History Questionnaire” (see Appendix A) and the “Recent Health Questionnaire” (see Appendix B). All subjects were non-smokers. They were required to abstain from alcohol for at least 12 hours and from caffeinated drink for at least six hours. Virginia Tech Institutional Review Board (IRB) approval was obtained.

Materials

The BIS/BAS Scales

The BIS/BAS scales are based on Carver and White’s work (1994) (see Appendix C). The scales consist of 24 items, on which respondents indicate the extent to which they agree using a four-point scale, from “very false for me” to “very true for me”. The BAS scale is comprised of three subscales: drive, fun seeking, and reward responsiveness. Three BAS scales contain a total of 13 items. The overall BAS scores were calculated by summing three BAS subscales scores together. The BIS scale includes seven items.

The BIS/BAS scales have adequate psychometric properties (Hawk & Kowmas, 2003). Sutton and Davison (1997) reported that in their study test-retest reliabilities for both BIS and BAS scale are .81 and .82, respectively, which are acceptable. Internal consistency reliabilities are .82 for the BIS scale and .85 for the BAS scale. Factor analyses have shown the convergent and divergent validity of the BIS/BAS scale are adequate for psychology study (Heubeck, Wilkinson, & Cologon, 1998; Jorm, Christensen, Henderson, Jacomb, Korten, & Rodgers, 1999).

The Adult Temperament Questionnaire

Forty-four items were selected from the ATQ long version (see Appendix D; Evens & Rothbart, 2007), including all items of the Effort Control subscale, six items of the Primary Fear subscale and three items of the Auditory Discomfort subscale. Among the selected subscales, the Effortful Control assesses the capacity to voluntarily control reactivity in attention and behavioral inhibition and activation; Primary Fear and Auditory Discomfort assess emotional reactivity. The items of the ATQ are presented on a seven-point scale, for which respondents indicate the extent to which they agree from “extremely untrue” to “extremely true”. When respondents feel an item is not applicable for them, they can select “X”. The reliability of the subscales of effortful control and negative affect are .72 and .75, respectively (Evens & Rothbart, 2007).

The Self-Assessment Manikin

The Self-Assessment Manikin (SAM, see Appendix E; Bradley & Lang, 1994) was used to rate affective pictures in according to the dimension of valence (pleasant to unpleasant) and arousal (excited to calm). Both are nine-point scales.

Affective Stimuli

Visual affective stimuli consisted of 36 color digitalized pictures, depicting 12 unpleasant events, 12 pleasant events, and 12 neutral events, selected from the IAPS. Specifically, 12 unpleasant pictures included six pictures of attacking animals and people (number of the pictures in the IAPS: 1120, 1300, 1930, 6350, 6510, 6550), three pictures of targeted weapons (direct threats) (6230, 6260, and 2811), and three pictures describing bloody scenes (9253, 9420, and 9433); 12 pleasant stimuli included six pictures of a naked model or erotic couples (4220, 4232, 4460, 4533, 4669, and 4680), three pictures of money (8501, 8502, and 8503), and three pictures of food (7330, 7350, and 7475). The 12 neutral pictures depicted household objects, neutral face, vehicles, and mushrooms (2190, 5510, 5731, 7009, 7039, 7080, 7090, 7100, 7140, 7235, 7705, and 7950). The orders of presentation were counterbalanced across all subjects.

Startle Stimulus

The startle-eliciting stimulus was a burst of 96-dB white noise with approximately instantaneous (< 1 ms) rise and fall times generated by the software Audacity 2.0.2 for Windows.

Physiological Recording and Apparatus

The instructions and affective pictures were presented on a computer screen using DMDX presentation software (Forster & Forster, 2003; Amodio & Harmon-Jones, 2011). The monitor (61-cm diagonal wide screen) was located 0.5 m in front of the subject. The startle stimulus was presented through a pair of matched JVC HA-X580 headphones.

Physiological data were collected using a BIOPAC MP150 system (BIOPAC Systems Inc, Goleta, CA). Raw signals recorded from the device were digitized at 1,000 Hz (16 bit) and analyzed by the BIOPAC AcqKnowledge software 4.1 (BIOPAC Systems Inc, Goleta, CA). Electrocardiography (ECG) was measured from CONMED disposable, pre-gelled stress-testing spot electrodes using modified lead II. HRV was derived from ECG data and analyzed by Kubios HRV analysis software v2.0 (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland). Facial EMG was collected from 4-mm Ag/AgCl electrodes filled with electrolyte gel. The EMG electrodes were placed at the margin of the bony orbit, centered under of the eye, and the location was about one centimeter lateral to the other (Blumenthal, Cuthbert, Filion, Hackley, Lipp, & Van Boxtel, 2005). The EMG signal was digitally bandpass filtered at 28 to 500 Hz. Electrode impedances were kept below 10 kΩ.

Procedure

After arriving in the lab, subjects were informed that they were participating in a study of "physiological reactivity to auditory and visual stimuli". Written informed consent was obtained for each subject. Subjects were asked to complete the "Health History Questionnaire" and "Recent Health Questionnaire" and screened for health problems. Eligible subjects were instructed to complete the BIS/BAS scales and the ATQ. Upon completion of the questionnaires, the electrodes for ECG and the respiratory gauge were attached on the subject by a sex-matched experimenter. Subjects were then instructed to sit still and quietly for two minutes to measure resting ECG. After the two minutes, the experimenter came back to the lab and attached facial EMG electrodes. Subjects were told that there would be several trials of sound presented over the headphones which aimed to get the subjects familiar with the sound; to watch each picture on screen for the entire duration of its presentation, and to ignore the occasional sound from the headphones (Blumenthal et al., 2005). Subjects were allowed to ask any question before the experiment began. Light was then turned off and picture presentation began.

Before picture presentation, there were 12 habituation trials in which the startle stimulus was delivered to subjects without presenting pictures. The interval between each habituation trial was 10 seconds. Picture presentation began immediately after the habituation trials. Pictures were randomly presented to subjects. Each of the 36 pictures was presented to subjects for 6 s and followed by a 20-second inter-slide interval. For each valence, eight trials of the acoustic startle stimulus were presented at any time between 3 to 5.5 seconds after onset of each picture. Twelve trials of the startle stimulus were presented during inter-slide interval, at 5, 10, and 15 seconds before picture onset, respectively. There were a total of 36 trials of startle stimuli presented to each subject in picture presentation session. Following the picture presentation, there was a two-minute recovery period. Afterwards, subjects were asked to rate each picture in the same order of picture presentation using the SAM. Upon completing the picture rating, subjects were thanked and informed of the purpose of the study.

Data Reduction

The EMG data were rectified and smoothed using a variable-weight finite impulse responses (FIR) filter (101 coefficients, low-pass cutoff frequency = 40 Hz). For each trail, the baseline EMG value was defined as the mean value of EMG in the 30 ms preceding the onset of the startle stimulus. The peak EMG value was defined as the maximum value of EMG in a time window from 20 to 150 ms after startle probe offset. The magnitude of a startle response was calculated as the difference between the peak value and baseline value of EMG of the trial. If there was no discernable EMG activity for a certain trial, the magnitude of the trial was recorded as zero. Trials were rejected from analysis (1.2% of all trials) due to excessive baseline activity and movement artifacts. The startle data were standardized within subjects by calculating T scores that yield a mean of 50 and standard deviation (SD) of 10 for distribution of EMG data of each subject. The trials of T score greater than 3 SD were considered as outliers and deleted (Blumenthal et al., 2005).

HR was defined as the mean beats per minute (BPM) during a given time interval. Heart rate change or HRR was assessed as the difference in HR between tasks and baseline (i.e. resting HR). HRV was derived from the ECG data. Heart rate was calculated as the average heart rate occurring in the given time window. Inter-beat intervals (IBIs) were calculated as intervals between consecutive R-waves detected by a BIOPAC analysis routine. The time domain metric of vagally mediated HRV was the root mean square of successive differences (RMSSD) (Berntson, et al., 1997). RMSSD was assessed as:

$$RMSSD = (\Sigma\ (IBIj+1 - IBIj)2)^\wedge 1/2$$

The frequency domain measure of HRV controlled by the vagus is high frequency HRV (HF HRV) (Berntson et al., 1997). To calculate frequency domain measures of HRV, a power spectrum density (PSD) estimate was assessed for RR series. The discrete Fourier transform (FFT) was performed. The frequency band of HF HRV was set to .15 -.4 Hz. Spectral estimate of power (in milliseconds squared per hertz) was normalized by taking the natural log of HF HRV. HRV reactivity was calculated as the difference in RMSSD and HF HRV between tasks and baseline (i.e. resting HRV).

Data Analysis

The experiment used a within-subject design. To test the first and second hypothesis, comparisons among pictures of different valence and specific categories were required. Each startle blink score was considered as a signal observation. That is, there were 36 startle blink scores within each subject. Therefore, one-way ANOVAs were performed to compare startle blink scores of different valence and categories. Post Hoc tests were used to analyze the difference between each two conditions.

To test the third hypothesis, Pearson correlations among raw startle magnitude, Primary Fear and Auditory Discomfort score, and cardiac reactivity measures were calculated. To test the fourth to the eighth hypothesis, Pearson correlations between personality variables and standardized startle scores were calculated. The T score was used in the analysis to test the hypotheses about startle modification. To calculate correlations among personality variables and physiological measures, each subject was considered as a unit and had one score for each variable. All analyses were performed with Statistical Software Package for the Social Sciences (SPSS) v 21.0.

Results

Comparisons of Startle Blink of Different Pictures

The subjective picture ratings of valence and different contents are shown in Table 1 and 2. For pleasant pictures, the mean valence was 6.42, the mean arousal was 4.02; for neutral pictures, the mean valence was 5.17, the mean arousal was 1.94; and for unpleasant pictures, the mean valence score was 2.71, the mean arousal was 5.33. Specifically, for erotic scenes, the mean valence was 5.9, the mean arousal was 4.56; for money, the mean valence was 6.54, the mean arousal was 3.31; for food, the mean valence was 7.33, the mean arousal was 3.6; for attacking scenes, the mean valence was 2.94, the mean arousal was 5.35; for targeted weapons, the mean valence was 2.9, the mean arousal was 5.24; for bloody scenes, the mean valence was 2.06, the mean arousal was 5.38 (see Table 2).

The mean raw magnitude and mean T score of startle blink during pleasant, neutral, unpleasant, and inter-slide intervals are shown in Table 3 and 4. For both raw and standardized score of startle blink, the pleasant pictures elicited the smallest startle response, 4.75 micro-volts in raw EMG and 47.84 for T score; whereas the unpleasant pictures generated the largest startle blink, 5.65 micro-volts in raw EMG and 51.84 for T score (see Table 3 and 4 and Figure 1 and 2). The results of ANOVA for the raw EMG showed no significant effect of valence modulation, $F(3, 2960) = 2.305$, $p = .075$. However, the results of ANOVA for T score indicated significant differences among startle blink scores during pleasant, unpleasant, neutral, and inter-slide interval, $F(3, 2960) = 25.094$, $p < .001$. Bonferroni Post Hoc multiple comparisons showed that there were significant differences between the pair of pleasant and neutral pictures, $p < .001$, of unpleasant and neutral pictures, $p < .001$, and of pleasant and unpleasant pictures, $p < .001$. The unpleasant pictures were significantly different from inter-slide trials, $p < .001$.

As to the mean raw magnitude and mean T score of startle blink during different picture contents, the erotic pictures produced the smallest startle response, 4.04 micro-volts in raw EMG and 46.13 for T score; while the pictures of targeted weapons induced the greatest startle response, 6.1 micro-volts in raw EMG and 54.01 for T score (see Table 5 and 6 and Figure 3 and 4). The results of ANOVA showed a significant effect of content modulation, $F(7, 2956) = 2.356$, $p < .05$. Post Hoc tests showed that the neutral pictures were only significantly different from the erotic picture, $p < .05$. However, the ANOVA for T score and following Bonferroni Post Hoc tests have shown that the neutral pictures were significantly different from the erotic scenes, $p < .001$, and the targeted weapons, $p < .001$. There were no differences between the neutral pictures and pictures of money, $p = 1$, food, $p = 1$, bloody scenes, $p = 1$, and attacking scenes, $p = .17$. Moreover, erotic scenes were significantly different from the pictures of money, $p < .005$, food, $p < .005$, attacking scenes, $p < .001$, targeted weapons, $p < .001$, and bloody scenes, $p < .005$. And the targeted weapons were significantly different from the pictures of money, $p < .001$, food, $p < .001$, attacking scenes, $p < .05$, and bloody scenes, $p < .001$.

Correlations among Personality Variables

In the BIS/BAS scales, the three BAS subscales were significantly correlated with each other, whereas the BIS scale was only significantly correlated with Reward Responsiveness subscale and overall BAS scale. In the ATQ, Primary Fear was positively correlated with Auditory Discomfort. Moreover, Attention Control, Inhibitory Control, and Activation Control were positively correlated with each other; and Attention Control was negatively correlated with Primary Fear. As for relationships among different measurements, BAS Fun Seeking scale was negatively correlated with both Attention Control and Inhibitory Control; overall BAS was negatively correlated with Inhibitory Control; and BIS was positively correlated with Primary Fear (see Table 7).

Correlations of Reactivity and Startle Blink

There was no significant correlation between the self-report measurements of reactivity (Primary Fear and Auditory Discomfort) and the mean raw startle blink (see table 8).

Correlations of Personality Variables and Startle Modification

To analyze the relationship of personality and startle modification, the correlations of personality variables and T scores of startle blink in different emotion conditions were computed (see Table 9). The results showed that Attention Control was negatively correlated with the startle blink during the pictures of money, $r = -.237$, $p < .05$, and the picture of food, $r = .239$, $p < .05$; and that Inhibitory Control was negatively correlated with the pictures of money, $r = -.255$, $p < .05$, and the pictures of targeted weapons, $r = -.237$, $p < .05$. In addition, the startle score during the neutral pictures was negatively correlated with the startle score during the erotic picture, $r = -.308$, $p < .01$, and the targeted weapons, $r = -.227$, $p < .05$; whereas there was no significant relationship among different contents within pleasant or unpleasant valence.

Correlations of HRR and Startle Blink

The HR change in the habituation trials and the picture presentation were positively correlated with the raw startle blink, $r = .358$, $p < .01$ and $r = .241$, $p < .05$, respectively. Moreover, HR change in the habituation trials was correlated with raw startle blink during all picture categories and the inter-slide intervals; HR change in the picture presentation was significantly correlated with all unpleasant picture contents and the inter-slide intervals and marginally significantly correlated with the erotic pictures, $r = .211$, $p = .056$, and the neutral pictures, $r = .212$, $p = .054$ (see Table 10).

Correlations of HRV and T Scores of Startle Blink

Resting HRV measures (baseline RMSSD and HF HRV) were showed not to significantly correlate with startle score in any emotion condition. Also, HF HRV reactivity in the habituation trials and picture presentation and RMSSD change in the habituation trials were not correlated with startle scores in any emotion condition. However, RMSSD change in the picture presentation was correlated with the startle scores during the bloody scenes, $r = -.268$, $p < .05$ (see Table 11).

Correlations of HRV and Raw Startle Blink

There was no significant relationship of resting HRV measures, RMSSD changes, HF HRV reactivity in the picture presentation, and raw startle blinks. However, HF HRV reactivity in the habituation trials was correlated with startles blinks during the pictures of money, $r = -.233$, $p < .05$, and during the pictures of targeted weapons, $r = -.264$, $p < .05$ (see Table 12). RAS reactivity was also shown to correlate with the standard deviation of raw startle blink in different emotion conditions, $r = -.277$, $p < .05$.

Discussion

Valence Modulation and Specific Contents of Affective Stimuli

The comparisons of T scores support the first hypothesis. The effects of valence modulation were significant for T scores: pleasant pictures elicited smaller startle responses and unpleasant pictures induce larger startle responses in relative to neutral pictures, which is consistent with previous studies (Vrana et al., 1988; Lang et al., 1990) and the subjective ratings of valence. The raw EMG data failed to show the same results. This might be because of the variance of raw EMG across subjects, which was enormous. Although the author aimed to examine the variance across individuals, it might mask the effects of valence modulation when testing the first two hypotheses. The T score of a startle probe represents the position of a startle probe in the distribution of all startle trials within each subject. Therefore, T score partialed out the variance across subjects, and was more suitable for the analysis of modulatory effects than raw EMG for testing the hypotheses about valence and contents modulation.

The startle scores of inter-slide intervals were not different from startle scores during the neutral pictures. This was not expected. According to the attentional theory (Graham et al., 1975), perception of pictures would occupy attentional resources and the resources for auditory sense were decreased. Moreover, the neutral pictures were not emotional charged and low in arousal level. Thus, startle responses during the neutral pictures were expected to be smaller than startle responses in inter-slide intervals. The instructions and design of the experiment might account for the result. The subjects were told to ignore the noise during the whole picture presentation session and visually fixate at the center of the screen during the inter-slide intervals. In addition, the habituation trials already habituated the subjects with the startle stimulus, which resulted that fewer resources were needed for the startle stimulus. Therefore, the difference between the two conditions was not significant.

The results of comparisons of different contents were expected. The startle scores during the neutral pictures were only different from the startle scores during the erotic scenes and the pictures of targeted weapons. Different contents produced different effects on startle modification. Among pleasant pictures, the erotic scenes were the most effective in inhibiting a startle response and elicited smaller startle responses than any other kinds of pleasant pictures. For unpleasant contents, only the direct threats, or the targeted weapons, could elicit significantly larger startle responses than the neutral pictures. In other words, the erotic scenes and the pictures of targeted weapons have driven the effects of startle inhibition and potentiation. These results are partly consistent with the previous data. The previous studies have shown that erotic pictures induced the strongest startle inhibition, that pictures of food have small effect of startle inhibition, and that bloody scenes had relatively smaller effects of startle potentiation (Lang et al, 1995; Cuthbert et al., 1996; Casares et al., 2006).

In contrast to those findings, however, the pictures of an attacking animal or human failed to enlarge startle responses in the present study. This might be explained by picture selection and experimental design of the study. In some studies (e.g. Casares et al., 2006), the pictures of target weapons were included in the picture set of attacking humans. However, the targeted weapons present direct threats whereas scenes of attacking are indirect, which is the reason to use these two categories separately. The present study suggested the difference between direct threats and indirect cues. The alternative explanation is that the targeted weapons could be associated with gun firings, which is similar to the auditory startle stimulus (Balaban & Taussig, 1994).

The results that the startle scores of different contents within each valence have shown no correlation with each other (see Table 9) further supported the notion. Moreover, although the instructions and habituation trials would not alter the pattern of startle modification (Bradley, Drobes, & Lang, 1996; Cuthbert, Schupp, Bradley, McMannis, & Lang, 1997), these manipulations might decrease the difference in startle scores among picture categories.

Interestingly, the subjective picture rating did not reflect the physiological responses. Food was rated as highest score among pleasant pictures, while the erotic scenes were highest in arousal. Bloody scenes were lowest in valence score, which means the subjects regarded blood scenes were most unpleasant pictures. The results of picture rating were primarily due to the reflection on the pictures, not the physiological reactions to the pictures. The judgment came from the reflection on the pictures was different from the emotional or motivational reactions to the affective stimuli.

Taken together, the first and the second hypothesis were supported by the results. There were effects of valence modulation of the startle responses. The different contents showed different effect of startle modification. Whereas other pleasant and unpleasant pictures failed to inhibit or enlarge the startle response, erotic scenes and targeted weapons had significant effects of, and contributed most to, startle inhibition and potentiation, respectively.

Relationships among Personality Measures

The results of variables within each personality measurement are consistent with the extant research (Carver & White, 1994; Evens & Rothbart, 2007). There were also a few correlations among variables from different measurements. The results seemed to be contradictory to the findings by Elliot and Thrash (2010). This study showed the correlations between items of the ATQ and the BIS/BAS scales and suggested that avoidance and approach temperament might be underlying cores of BIS/BAS. However, it is worth noting that Elliot and Thrash did not directly use the subscales of the ATQ; rather, they selected 12 items from the ATQ to represent avoidance and approach temperament. Most of these 12 items were from the subscales of reactivity. In the present study, the ATQ subscales of Effortful Control were used without selecting items, and there was little convergence of effort control and reactivity (Derryberry & Rothbart, 1988). Only Primary Fear and Auditory Discomfort had to with reactivity. In addition, the current results showed that Primary Fear score was positively correlated with BIS score. So the current results are consistent with and support the previous study (Elliot & Thrash, 2010).

Reactivity and Startle Response

Primary Fear and Auditory Discomfort scores failed to predict raw magnitude of startle blink. It was assumed that a strong reaction to the startle stimulus was associated with fearful behaviors and subjective discomfort. The current result suggested that the connections of self-report measurements and psychological reaction are loose and that regulatory effects at the cortical level might mediate the relationship between physiological responses and overt behaviors. Alternatively, the insignificant relationships might be explained by that Primary Fear and Auditory Discomfort were not directly associated with the primary startle circuit (Davis, Walker, & Lee, 1999). Perception and processing of unpleasant stimuli might not be involved in the primary startle circuit. Thus, it is possible that Primary Fear and Discomfort do not relate to the mean startle magnitude of all trials, but to startle modification.

Influences of Personality on Startle Modification

The expected relationships of BIS/BAS and startle scores did not appear. BIS/BAS scores failed to predict startle scores during any pictures. This result was inconsistent with previous studies on BIS/BAS and startle modification (Hawk & Kowmas, 2003; Gros, 2011). Most of these studies found BAS moderated startle modification, but not BIS. Gros (2011) have shown it was BAS Drive subscale contributed to the moderation of BAS. But none of these results have been obtained in the present study. In fact, in those studies (Hawk & Kowmas, 2003; Gros, 2011), startle responses were recorded and scored using raw magnitude; and BIS/BAS scores were analyzed as categorical variables by recruiting the subjects with extreme BIS/BAS scores from a large sample. The present study, on the other hand, randomly sampled from the subject pool and treat BIS/BAS scores as continuous variables, which make calculation of Pearson correlations possible. Also, the startle scores were standardized in the present study for comparisons across subjects and to decrease error. These differences in methodology would explain the inconsistency between the current results of BIS/BAS and the previous data.

Attention Control was correlated with startle scores during the pictures of money and food. This result was not expected. For one thing, these two picture categories did not differ from the neutral pictures in startle modification and had no effect of startle inhibition. For another, the correlations of these two categories and startle scores were inversed. In other words, a strong capacity to control attention predicted a small startle probe during the picture of money but a large startle probe during the pictures of food. The correlations suggested that these two categories were different from the neutral and unpleasant pictures in terms of relationships with attentional processes; and that the pictures of money and food were also different from each other. The images of money might be novel to the subjects, so although these pictures did not inhibit startle response compare to neutral pictures in all subjects, they did modulate startle response in subjects who control their attention well. The pictures of food were ambiguous for some subjects, and there was a large variation in preference to food.

Inhibitory Control was negatively correlated with the pictures of money and targeted weapons, which partly supported the fourth hypothesis. The correlation of the targeted weapons and Inhibitory Control was expected. The subjects who have strong capacity to inhibit fear elicited by direct threat would have smaller startle probes. However, the correlation of the pictures of money and Inhibitory Control was not expected. The reason might be the attribute of the images. As for Activation Control, in contrast to hypothesis five, there was no significant relationship between Activation Control and startle scores. It might be because that in the present study, the subjects were not required to perform no active task but only viewing pictures; and thus no physiological process related to Activation Control was involved in the experiment.

In sum, the relationships between personality variables and startle scores in different emotion conditions did exist but were not completely consistent with hypothesis. These relationships were more complicated than expected. The pictures of money were similar to unpleasant pictures in terms of correlations with personality variables. Along with the results that the bloody scenes were similar to the pleasant pictures in startle modification, the correlations of personality variables and startle scores suggested that valence is too crude and global in the study of startle modification and individual differences in emotional processing.

Comparison of BIS/BAS and ATQ

The ATQ might fit the framework of startle modification better than the BIS/BAS. The BIS/BAS scales measures BIS sensitivity that is related to nervousness while performing tasks involving an anticipated punishment in daily life and BAS sensitivity that is related to positive affect in response to impending reward (Carver & White, 1994). Neither of BIS and BAS sensitivity is directly associated with the immediate response to the threat. In Gray's (1981) theory, the reaction to direct threats is controlled by the FFFS, rather than BIS or BAS. The FFFS is the neural mechanism of the startle response and perception of direct threats. Therefore, BIS/BAS might be not an ideal construct of personality to represent individual differences in startle modification. On the contrary, the subscales selected from the ATQ measure the effortful control of attention and inhibition that are involved in processing emotional stimuli and the startle response

Cardiac Activities and Startle Modification

Cardiac activity was associated with the startle response. The positive correlations of HRR and startle blink indicated that larger HR changes during the habituations trials and picture presentation predict larger startle responses. All startle blinks were measured during the picture presentation. The correlation of HRR in the habituation trials and startle responses was greater than that of HRR in the picture presentation and startle responses. This result demonstrated an effect of habituation. Because the autonomic nervous system was habituated with the startle stimulus, the correlation of HRR and startle magnitude was attenuated. More importantly, the result of HRR and startle showed the effects of anticipation on HRR in the picture presentation. Although the startle probes in the habituation trials were not analyzed, the startle probes in the habituation trials were larger than the startle probes in the picture presentation, which would result in a greater correlation between HRR and the startle probes in the habituation trials than that between HRR in the habituation trials and the startle probes in the picture presentation. Thus, the correlation of HRR and the startle probes in the picture presentation would be even smaller than the correlation of HRR and the startle probes in the habituation trials. That is, startle scores account for more variance of HRR in the habituation trials then in the picture presentation. The difference between the two experiment sessions mainly lies in anticipation to possible stimuli. Picture perception also influenced autonomic activity, but its influence was relatively small in relative to anticipation. Therefore, the difference of the correlations of HRR and startle scores between two experiment sessions is mainly due to the anticipation.

The hypotheses about HRV were not supports by the results. Resting HRV, including

RMSSD and HF HRV, failed to predict a moderated startle modification. However, RMSSD and HF HRV reactivity were associated with startle score during bloody scenes (HF HRV reactivity was marginally correlated with startle score during bloody scenes, $r = -.211$, $p = .055$). This result implies that parasympathetic activity might play a role in perception of the bloody scenes.

For raw startle blinks, HF HRV reactivity in the habituation trials predicted startle magnitude in some emotion conditions. The fact that most HRV measures were correlated with raw startle blink but not with standardized startle scores might suggest that HRV is related to the startle response but not to startle modification. HF HRV reactivity in the habituation trials might reflect the individual differences in the primary startle circuit, because there was no perception of visual stimuli in the habituation trials. This could account for the relationships of HF HRV reactivity and raw magnitude of startle probes.

It is interesting to find that HRV reactivity and HRR to the habituation trial had stronger relationships with the raw startle blink than HRV reactivity in the picture presentation. As mentioned above, the cardiac reactivity in the habituation trials might exclusively relate to the response to auditory stimuli, because no picture presentation was in those trials. This could account for the stronger relationships for the habituation trials. The alternative explanation would be that the duration of the picture presentation (approximate 17 minutes) was much longer than the resting period (2 minutes). This difference in time brings an error in assessing cardiac reactivity, especially for HRV reactivity, because the total numbers of IBIs were unequal in the two sessions. On the contrary, the habituation trials were about two minutes in length and comparable with the resting period. The HRV reactivity and HRR in the habituation trials, thus, was less biased than in the picture presentation. To clarify the relationships of autonomic activity and startle modification, sympathetic measures, including impedance cardiography and electrodermal activity, are needed in the future studies.

The current results failed to replicate the previous finding (Ruiz-Padial et al., 2003). Similar to many studies of BIS/BAS and startle modification, this study dichotomized HRV variables, which could inflate the effects of HRV as a moderator in the study. Further study is expected to clarify the relationship of HRV and startle modification using continuous variables and sensitive HRV measures.

Limitation and Future Direction

Although the present study yielded new findings on startle modification and personality, it was not without its limitations. First, behavioral inhibition and approach did not fit the framework of startle modification very well, which resulted in the lack of correlation between the BIS/BAS and the startle scores in emotion conditions. The ATQ, in fact, did not measure sensitivity to appetitive and aversive cues either, rather the capacity to control reaction to affective cues. Therefore, it is still a primary task to find the constructs that can represent the individual differences related to startle modification. Second, some of affective pictures in the present study failed to elicit corresponding emotions. Although to compare different contents was one of aims of the study, choosing effective pictures in emotion elicitation would increase the effect sizes of future studies. In the study of affective startle modification, homogeneous effects of emotion elicitation across pictures of the same category are important. Finally, the analysis of HRV during the picture presentation had some problems. In the picture presentation, the subjects were viewing pictures of different categories in a random order, which made the whole process heterogeneous. A better experimental design is expected to make it possible to analyze HRV in different emotion conditions. Also, the unequal durations of the baseline, habituation trials, and picture presentation biased the results of cardiac reactivity.

Future studies on this topic might follow these directions. First and foremost, more research on the neural mechanism of startle modification is expected. The startle response has been thought to be controlled at the brainstem. However, recent research revealed that the startle response is also regulated by the amygdala and the prefrontal cortex that have been associated with emotional processing and effortful control. A comprehensive understanding of the mechanism of startle modification will be helpful for any studies of this topic. Second, the research on individual differences and startle modification will benefit from the better measurements reflecting reactivity to affective stimuli in the paradigms of startle modification. Third, the measures of sympathetic activity are expected in the future study on the autonomic activity and startle modification. Last but not least, the techniques of emotion elicitation should be refined. For the picture viewing paradigm, some picture contents have multiple effects on the startle response. For example, the pictures of money could not inhibit a startle response, but the startle probes during money pictures were associated with Attention Control and Inhibitory Control. A good emotion technique should be able to allow researchers control the emotional and motivational state and minimize the variation in effects across individuals.

Conclusion

The present study sought to address the question how individual differences influences affective startle modification. The hypotheses were partly supported by the results. First, valence modulates the startle response in the picture viewing paradigm; the erotic pictures generated smallest startle responses and drove the inhibition effect by pleasant pictures, while the direct threat produced the largest startle response and drove the potentiation by unpleasant pictures. Some picture contents, such as the images of money and attacking, had complicated effects in startle modification. Second, self-report personality measures did not predict the raw magnitude of the startle response; and, BIS/BAS was not associated with startle modification; yet, individual differences in attention and effortful control influenced startle modification. Moreover, the ATQ fits the framework of startle modification better than BIS/BAS. Third, cardiac activities have shown to associate with the raw magnitude of startle response. Parasympathetic activities indexed by HRV were not associated with startle modification; but, they only influence the startle response. Compared to resting HRV, HRV reactivity to the startle stimulus was more sensitive in predicting the magnitude of the startle response. Future studies on startle modification and personality are expected. The techniques in neuroscience will be helpful in exploring the neural mechanism of startle modification. In the meantime, in personality psychology, it is need to find the better measures representing individual difference in startle modification.

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Table 1

Subjective ratings of pictures of different valence

Category	Valence	Arousal
Pleasant	6.42	4.02
Neutral	5.17	1.94
Unpleasant	2.71	5.33

Table 2

Subjective ratings of pictures of different contents

Content	Valence	Arousal
Erotic Scenes	5.90	4.56
Money	6.54	3.31
Food	7.33	3.60
Neutral	5.17	1.94
Attacking Scenes	2.94	5.35
Target Weapons	2.90	5.24
Bloody Scene	2.06	5.38

Table 3

Means and standard deviations of raw EMG of different valences

(Unit: μV)

Valence	N	Mean raw EMG	SD
Pleasant	654	4.75	6.38
Neutral	660	5.36	7.03
Unpleasant	677	5.65	6.88
Inter-Slide	973	5.04	6.60
Total	2964	5.18	6.72

Table 4

Means and standard deviations of T scores of different valences

Valence	N	Mean T score	SD
Pleasant	654	47.84	8.86
Neutral	660	49.88	9.05
Unpleasant	677	51.84	8.81
Inter-Slide	973	48.91	8.83
Total	2964	49.56	8.99

Table 5

Means and standard deviations of raw EMG of different contents

(Unit: μV)

Content	N	Mean raw EMG	SD
Erotic Scenes	334	4.04	5.50
Money	162	5.41	7.01
Food	158	5.56	7.23
Neutral	660	5.36	7.03
Attacking Scenes	311	5.60	6.91
Targeted Weapons	212	6.10	6.75
Bloody Scenes	154	5.13	7.01
Inter-Slide	973	5.04	6.60
Total	2964	5.18	6.72

Table 6

Means and standard deviations of T scores of different contents

Content	N	Mean T score	SD
Erotic Scenes	334	46.13	8.63
Money	162	49.53	9.18
Food	158	49.72	8.32
Neutral	660	49.88	9.05
Attacking Scenes	311	51.54	8.32
Targeted Weapons	212	54.01	9.37
Bloody Scenes	154	49.45	8.34
Inter-Slide	973	48.91	8.83
Total	2964	49.56	8.99

Table 7

Correlations of personality variables

	BASD	BASF	BASR	BIS	BASO	PF	AD	ATC	IC	AC
BASD	1									
BASF	.345**	1								
	.001									
BASR	.310**	.392**	1							
	.004	.000								
BIS	.054	.097	.598**	1						
	.627	.384	.000							
BASO	.682**	.783**	.785**	.357**	1					
	.000	.000	.000	.001						
PF	.118	.039	.027	.276*	.075	1				
	.286	.730	.806	.012	.500					
AD	.132	.077	.098	.095	.133	.286**	1			
	.233	.489	.380	.391	.232	.009				
ATC	.003	-.366**	-.022	-.206	-.179	-.285**	-.140	1		
	.977	.001	.846	.061	.105	.009	.206			
IC	-.074	-.427**	-.104	-.112	-.277*	-.173	-.076	.619**	1	
	.505	.000	.348	.313	.011	.119	.492	.000		
AC	.108	-.170	.118	.055	.019	-.148	-.031	.498**	.369**	1
	.330	.125	.288	.621	.864	.181	.784	.000	.001	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

P values are under correlations.

BASD: BAS Drive subscale score; BASF: BAS Fun Seeking subscale score; BASR: BAS Reward Responsiveness subscale score; BIS: BIS score; BASO: overall BAS score; PF: Primary Fear score; AD: Auditory Discomfort score; ATC: Attention Control score; IC: Inhibition Control score; AC: Activation Control score.

Table 8

Correlations of reactivity and raw EMG

	ERPMR	MOPMR	FOPMR	NEPMR	GUPMR	ATPMR	BLOPMR	INPMR	raw EMG
PF	.123	.182	.086	.189	.196	.178	.171	.174	.172
	.270	.101	.443	.087	.076	.108	.123	.115	.119
AD	-.050	-.012	-.082	-.039	-.019	-.046	.007	-.008	-.029
	.653	.915	.464	.729	.862	.682	.951	.942	.794

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

PF: Primary Fear score; AD: Auditory Discomfort score; ERPMR: mean of raw startle blink during erotic scenes; MOPMR: mean of raw startle blink during money pictures; FOPMR: mean of raw startle blink during food pictures; NEPMR: mean of raw startle blink during neutral pictures; ATPMR: mean of raw startle blink during attacking pictures; GUPMR: mean of raw startle blink during targeted weapons; BLOPMR: mean of raw startle blink during bloody scenes; INPMR: mean of raw startle blink during inter-slide intervals; raw EMG: mean of raw startle blink across trials.

Table 9

Correlates of personality variables and T scores of startle blink

	BIS	BASO	ATC	IC	AC	ERPMT	MOPMT	FOPMT	NEPMT	GUPMT	ATPMT	BLOPMT	INPMT
BIS	1												
BASO	.357**	1											
	.001												
ATC	-.206	-.179	1										
	.061	.105											
IC	-.112	-.277*	.619**	1									
	.313	.011	.000										
AC	.055	.019	.498**	.369**	1								
	.621	.864	.000	.001									
ERPMT	.002	.083	.056	-.038	.026	1							
	.984	.457	.616	.736	.817								
MOPMT	.108	.160	-.237*	-.255*	-.076	-.001	1						
	.333	.151	.032	.021	.497	.993							
FOPMT	.100	-.049	.239*	.074	.038	-.135	-.038	1					
	.371	.664	.031	.508	.731	.225	.740						
NEPMT	.013	-.185	.062	.155	.003	-.308**	.038	.007	1				
	.910	.095	.579	.162	.975	.005	.733	.951					
GUPMT	.049	.145	-.183	-.237*	-.046	.068	.171	-.089	-.227*	1			
	.661	.192	.099	.031	.681	.540	.125	.429	.039				
ATPMT	-.046	-.120	-.073	-.032	.121	-.195	-.164	-.133	-.195	-.097	1		
	.679	.280	.512	.777	.275	.078	.140	.235	.078	.385			
BLOPMT	-.056	.071	.053	.082	.041	-.152	-.032	-.150	-.061	.066	.109	1	
	.613	.521	.636	.461	.715	.171	.776	.179	.585	.554	.328		
INPMT	-.148	-.031	.116	.120	-.060	-.243*	-.251*	-.096	-.207	-.305**	-.068	-.165	1
	.183	.781	.295	.282	.591	.027	.023	.393	.060	.005	.539	.136	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

BIS: BIS score; BASO: overall BAS score; PF: Primary Fear score; AD: Auditory Discomfort score; ATC: Attention Control score; IC: Inhibition Control score; AC: Activation Control score; ERPMT: mean standardized startle blink during erotic scenes; MOPMT: mean standardized startle blink during money pictures; FOPMT: mean standardized startle blink during food pictures; NEPMT: mean standardized startle blink during neutral pictures; ATPMT: mean standardized startle blink during attacking pictures; GUPMT: mean standardized startle blink during targeted weapons; BLOPMT: mean standardized startle blink during bloody scenes; INPMT: mean standardized startle blink during inter-slide intervals.

Table 10

Correlations of HRR and raw EMG

	ERPMR	MOPMR	FOPMR	NEPMR	GUPMR	ATPMR	BLOPMR	INPMR	raw EMG
HRRH	.334**	.308**	.299**	.356**	.380**	.391**	.326**	.334**	.358**
	.002	.005	.006	.001	.000	.000	.003	.002	.001
HRRP	.211	.188	.193	.212	.234*	.267*	.285**	.246*	.241*
	.056	.090	.082	.054	.034	.015	.009	.025	.028

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

HRRH: change of HR between resting period and habituation trials; HHRP: change of HR between resting period and picture presentation; ERPMR: mean of raw startle blink during erotic scenes; MOPMR: mean of raw startle blink during money pictures; FOPMR: mean of raw startle blink during food pictures; NEPMR: mean of raw startle blink during neutral pictures; ATPMR: mean of raw startle blink during attacking pictures; GUPMR: mean of raw startle blink during targeted weapons; BLOPMR: mean of raw startle blink during bloody scenes; INPMR: mean of raw startle blink during inter-slide intervals; raw EMG: mean of raw startle blink across trials.

Table 11

Correlations of HRV and T scores of startle blink

	ERPMT	MOPMT	FOPMT	NEPMT	GUPMT	ATPMT	BLOPMT	INPMT	Betw T SD
BRMSSD	-.213	.024	.015	-.100	.146	-.207	.126	.076	.088
	.053	.830	.894	.370	.187	.061	.258	.493	.428
BHFnu	-.062	-.007	-.014	-.191	.165	-.124	.066	-.015	-.013
	.580	.951	.904	.084	.136	.266	.555	.895	.910
HBrmssd	.194	-.015	-.001	-.093	.080	.004	-.091	-.131	-.006
	.078	.892	.994	.402	.471	.969	.414	.238	.960
HBnu	.059	.059	.027	.006	-.013	-.015	-.036	.031	-.004
	.597	.599	.808	.960	.910	.895	.745	.782	.970
PBrmssd	.163	-.075	.146	.021	-.002	.038	-.268*	-.147	.019
	.141	.501	.189	.851	.985	.730	.014	.184	.863
PBnu	.003	.055	.142	.111	-.002	-.059	-.211	-.019	.105
	.975	.626	.203	.319	.983	.598	.055	.863	.347

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

BRMSSD: resting RMSSD; BHFnu: normalized HF HRV of resting period; HBrmssd: difference in RMSSD between resting period and habituation trials; HBnu: difference in HF HRV between resting period and habituation trials; PBrmssd: difference in RMSSD between resting period and picture presentation; PBnu: difference in HF HRV between resting period and picture presentation; ERPMT: mean standardized startle blink during erotic scenes; MOPMT: mean standardized startle blink during money pictures; FOPMT: mean standardized startle blink during food pictures; NEPMT: mean standardized startle blink during neutral pictures; ATPMT: mean standardized startle blink during attacking pictures; GUPMT: mean standardized startle blink during targeted weapons; BLOPMT: mean standardized startle blink during bloody scenes; INPMT: mean standardized startle blink during inter-slide intervals; Betw T SD: standard deviation of mean T scores of startle blink in different emotion conditions.

Table 12

Correlations of HRV and raw EMG

	ERPMR	MOPMR	FOPMR	NEPMR	GUPMR	ATPMR	BLOPMR	INPMR	raw EMG	Betw raw SD
BRMSSD	-.139	-.032	-.118	-.084	-.023	-.092	-.021	-.049	-.068	-.001
	.211	.772	.289	.451	.840	.406	.850	.659	.539	.992
BHFnu	-.022	.026	.001	.009	.061	.001	.040	.015	.019	.047
	.841	.820	.994	.934	.586	.991	.719	.894	.862	.671
HBrmssd	-.011	-.083	-.010	-.055	-.040	-.043	-.045	-.049	-.042	-.037
	.924	.460	.932	.622	.720	.700	.687	.662	.706	.738
HBnu	-.185	-.233*	-.200	-.214	-.264*	-.196	-.167	-.173	-.208	-.277*
	.094	.035	.072	.052	.016	.075	.131	.117	.060	.011
PBrmssd	.052	-.022	.072	.010	-.019	.003	-.069	-.030	-.001	-.024
	.642	.845	.521	.925	.861	.977	.533	.791	.993	.828
PBnu	-.069	-.079	-.072	-.092	-.106	-.078	-.123	-.084	-.091	-.110
	.534	.478	.520	.409	.342	.483	.267	.450	.414	.322

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

BRMSSD: resting RMSSD; BHFnu: nomalized HF HRV of resting period; HBrmssd: difference in RMSSD between resting period and habituation trials; HBnu: difference in HF HRV between resting period and habituation trials; PBrmssd: difference in RMSSD between resting period and picture presentation; PBnu: difference in HF HRV between resting period and picture presentation; ERPMR: mean of raw startle blink during erotic scenes; MOPMR: mean of raw startle blink during money pictures; FOPMR: mean of raw startle blink during food pictures; NEPMR: mean of raw startle blink during neutral pictures; ATPMR: mean of raw startle blink during attacking pictures; GUPMR: mean of raw startle blink during targeted weapons; BLOPMR: mean of raw startle blink during bloody scenes; INPMR: mean of raw startle blink during inter-slide intervals; raw EMG: mean of raw startle blink across trials; Betw raw SD: standard deviation of raw startle blink in different emotion conditions.

Figure 1

Mean raw EMG of different valences

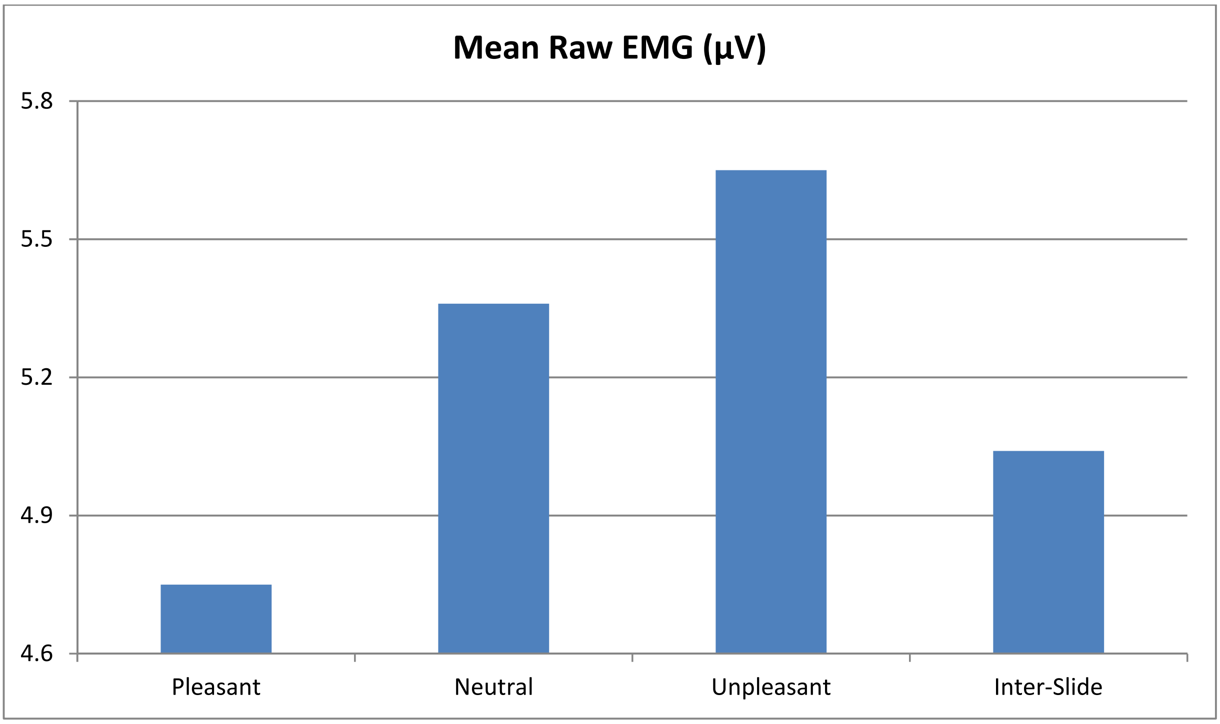


Figure 2

Mean T scores of startle blink of different valences

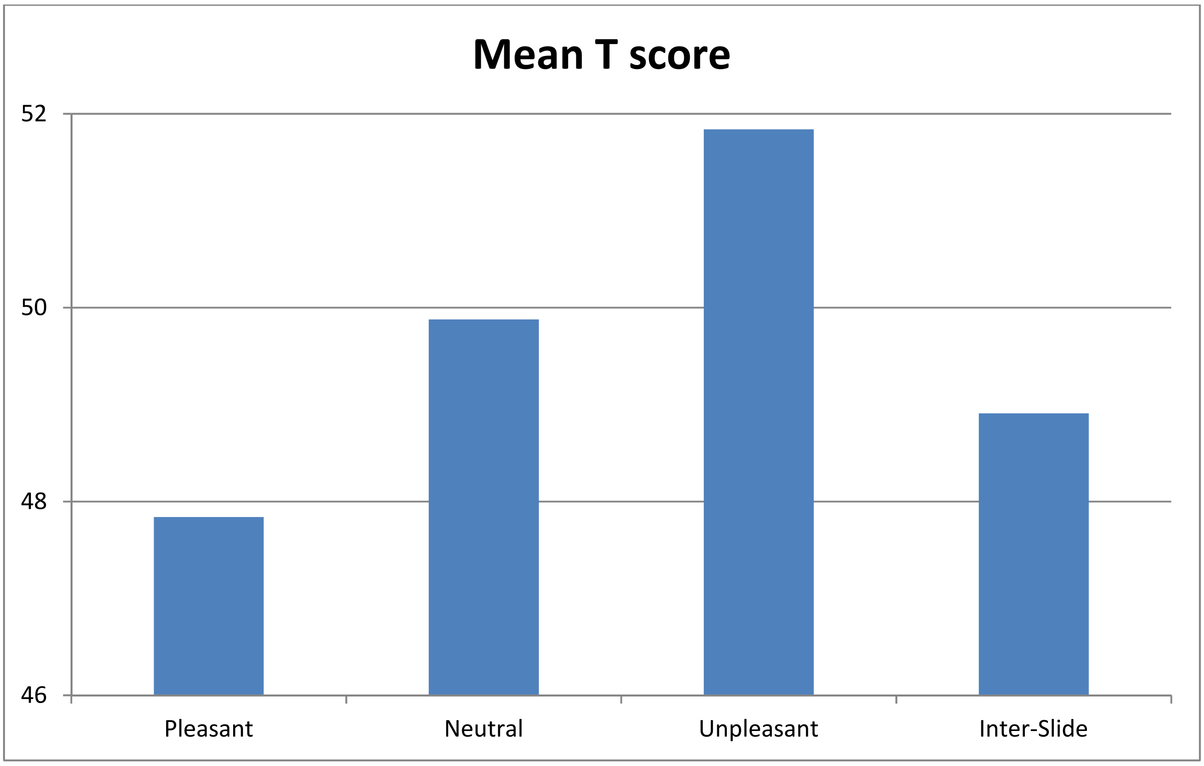


Figure 3

Mean raw EMG of different contents

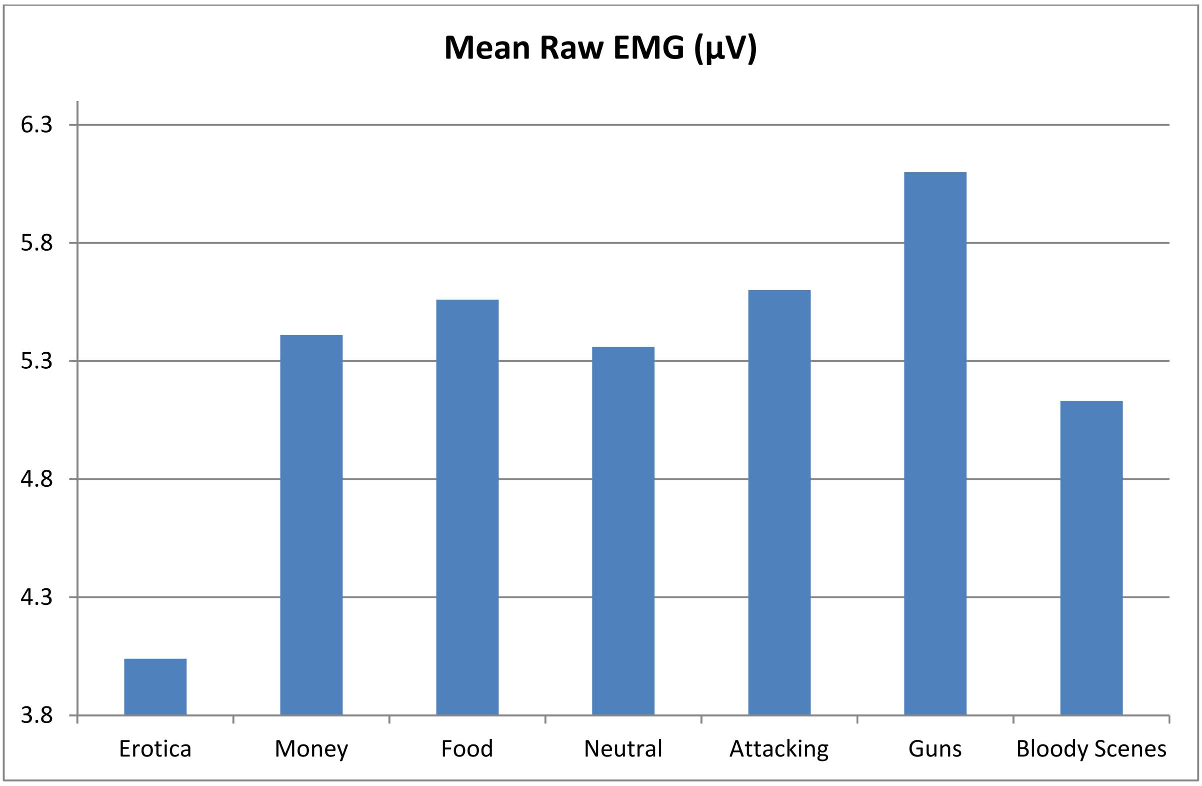
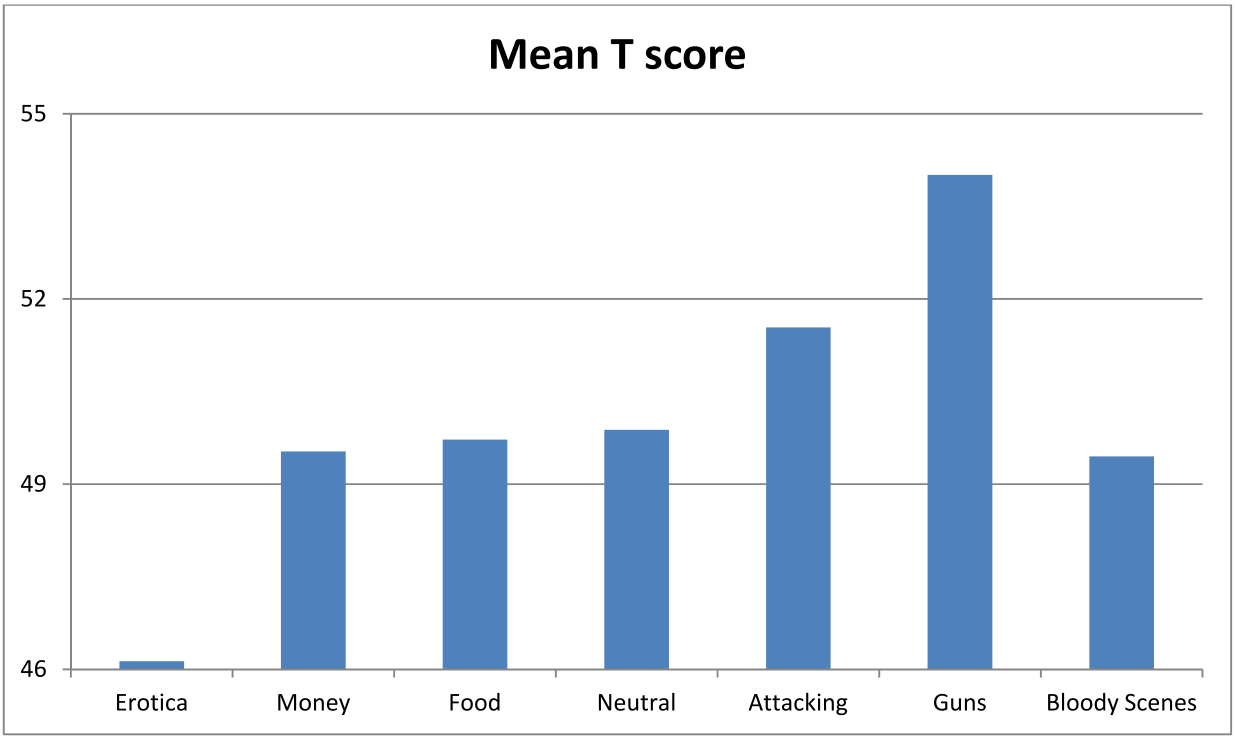


Figure 4

Mean T scores of startle blink of different contents



Appendix A

Mind-Body Laboratory Health History Questionnaire

A very brief medical history must be obtained as part of the experimental protocol. It is very important that you be completely honest. This information will be kept strictly confidential.

1. What is your age, height, weight, and gender?

   Age: _____ years

   Sex: ___M ___F

   Height: _____ feet, _____ inches; weight: _____ pounds

   Handedness: ___R ___L

2. Since birth, have you ever been hospitalized or had any major medical problems?

   ___ Yes ___ No

   If Yes, briefly explain:

3. Have you ever experienced a concussion or lost consciousness due to a blow to the head?

   ___ Yes ___ No

   If Yes, briefly explain:

4. Have you ever had problems that required you to see a counselor, psychologist, or psychiatrist?

___ Yes ___ No

If Yes, briefly explain:

5. Do you use tobacco products of any kind?

___ Yes ___ No

If Yes, describe what kind how often/much:

6. Have you ever been diagnosed with a psychological disorder?

___ Yes ___ No

If Yes, briefly explain:

7. Do you currently have or have you ever had any of the following?

___ Yes ___ No Strong reaction to cold weather

___ Yes ___ No Circulatory problems

___ Yes ___ No Tissue disease

___ Yes ___ No Skin disorders (other than facial acne)

___ Yes ___ No Arthritis

___ Yes ___ No Asthma

___ Yes ___ No Lung problems

___ Yes ___ No Cardiovascular disorder/disease

___ Yes ___ No Diabetes

___ Yes ___ No Hypoglycemia

___ Yes ___ No Hypertension (high blood pressure)

___ Yes ___ No Hypotension (low blood pressure)

___ Yes ___ No Hepatitis

___ Yes ___ No Neurological problems

___ Yes ___ No Epilepsy or seizures

___ Yes ___ No Brain disorder

___ Yes ___ No Stroke

If you responded Yes to any of the above conditions, briefly explain:

8. Have you ever been diagnosed as having:

___ Yes ___ No Learning deficiency or disorder

___ Yes ___ No Reading deficiency or disorder

___ Yes ___ No Attention deficit disorder

___ Yes ___ No Attention deficit hyperactivity disorder;

9. Do you have:

___ Yes ___ No Claustrophobia (extreme fear of small closed spaces)

___ Yes ___ No Blood phobia (extreme fear of needles or blood)

___ Yes ___ No Phobia of any type (if Yes, briefly explain:)

___ Yes ___ No Generalized anxiety disorder

___ Yes ___ No Anxiety disorder of any type (if Yes, briefly explain:)

If you responded Yes, briefly explain here:

10. List any over-the-counter or prescription medications you are currently taking:

11. List the symptoms that these drugs are treating

12. List any other medical conditions that you have or have had in the past:

13. What is your average daily caffeine consumption (approximate number of cups/glasses of coffee, tea, or caffeinated soda)?

14. What is your average weekly alcohol consumption (approximate number of alcoholic beverages)?

15. How many hours of sleep do you average per night?

Appendix B

Mind-Body Laboratory Recent Health History Questionnaire

A very brief medical history must be obtained as part of the experimental protocol. It is very important that you be completely honest. This information will be kept strictly confidential.

1. When was the last time that you have had any alcohol before the study began?

2. When was the last time you have had a caffeinated beverage before the study began?

3. When was the last time that you ate before the study began?

4. How many hours of sleep did you get last night?

5. Did you engage in vigorous exercise within the last 2 hours?

6. (FEMALE ONLY) At what age did you have your first menstrual cycle?

7. (FEMALE ONLY) On the average, how long is your monthly cycle (from menses to menses)? (Number of days)

8. (FEMALE ONLY) How would you describe the regularity of your period in general? (Check one)

Exact the same length each cycle.

Very regular, within one or two days each cycle.

Somewhat regular, within 3 or 4 days.

Somewhat irregular, varying by as much as week in length.

Quite irregular, varying by more than a week in length.

9. (FEMALE ONLY) Over the past 6 months, how many menstrual periods have you missed? (Check one)

Zero

Once

Twice

Three times

Four or more

10. (FEMALE ONLY) Are you currently menstruating?

___ Yes ___ No

If Yes, when did you start this period? And when do you expect to finish this period? (Dates)

11. (FEMALE ONLY) Are you taking a hormone based birth control such the pill, the patch, norplant, or depo-prevera?

___ Yes ___ No

If Yes, what type are you using:

12. (FEMALE ONLY) Refer to the calendar on the wall and estimate where you are in your menstrual cycle. When did you start your last period (bleeding)? (Date)

13. (FEMALE ONLY) When did you finish your last period? (Date)

14. (FEMALE ONLY) When do you expect to start your next period? (Date)

Appendix C

BEHAVIORAL INHIBITION AND APPROACH SCALES

Direction

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

circle #:	if the statement is:
1	very true for me
2	somewhat true for me
3	somewhat false for me
4	very false for me

1. A person's family is the most important thing in life.

1 2 3 4

2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.

1 2 3 4

3. I go out of my way to get things I want.

1 2 3 4

4. When I'm doing well at something I love to keep at it.

1 2 3 4

5. I'm always willing to try something new if I think it will be fun.

1 2 3 4

6. How I dress is important to me.

1 2 3 4

7. When I get something I want, I feel excited and energized.

1 2 3 4

8. Criticism or scolding hurts me quite a bit.

1 2 3 4

9. When I want something I usually go all-out to get it.

1 2 3 4

10. I will often do things for no other reason than that they might be fun.

1 2 3 4

11. It's hard for me to find the time to do things such as get a haircut.

1 2 3 4

12. If I see a chance to get something I want I move on it right away.

1 2 3 4

13. I feel pretty worried or upset when I think or know somebody is angry at me.

1 2 3 4

14. When I see an opportunity for something I like I get excited right away.

1 2 3 4

15. I often act on the spur of the moment.

1 2 3 4

16. If I think something unpleasant is going to happen I usually get pretty "worked up."

1 2 3 4

17. I often wonder why people act the way they do.

1 2 3 4

18. When good things happen to me, it affects me strongly.

1 2 3 4

19. I feel worried when I think I have done poorly at something important.

1 2 3 4

20. I crave excitement and new sensations.

1 2 3 4

21. When I go after something I use a "no holds barred" approach.

1 2 3 4

22. I have very few fears compared to my friends.

1 2 3 4

23. It would excite me to win a contest.

1 2 3 4

24. I worry about making mistakes.

1 2 3 4

Appendix D

ADULT TEMPERAMENT QUESTIONNAIRE

Directions

On the following pages you will find a series of statements that individuals can use to describe themselves. There are no correct or incorrect responses. All people are unique and different, and it is these differences which we are trying to learn about. Please read each statement carefully and give your best estimate of how well it describes you. Circle the appropriate number below to indicate how well a given statement describes you.

circle #:	if the statement is:
1	extremely untrue of you
2	quite untrue of you
3	slightly untrue of you
4	neither true nor false of you
5	slightly true of you
6	quite true of you
7	extremely true of you

If one of the statements does not apply to you (for example, if it involves driving a car and you don't drive), then circle "X" (not applicable). Check to make sure that you have answered every item.

1. I become easily frightened.

   1 2 3 4 5 6 7 X

2. When I am trying to focus my attention, I am easily distracted.

   1 2 3 4 5 6 7 X

3. When I am happy and excited about an upcoming event, I have a hard time focusing my attention on tasks that require concentration.

   1 2 3 4 5 6 7 X

4. If I want to, it is usually easy for me to keep a secret.

   1 2 3 4 5 6 7 X

5. Looking down at the ground from an extremely high place would make me feel uneasy.

   1 2 3 4 5 6 7 X

6. It is easy for me to hold back my laughter in a situation where it is not appropriate.

   1 2 3 4 5 6 7 X

7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts.

   1 2 3 4 5 6 7 X

8. Loud music is unpleasant to me.

   1 2 3 4 5 6 7 X

9. When I see an attractive item in a store, it's usually very hard for me to resist buying it.

   1 2 3 4 5 6 7 X

10. I can easily resist talking out of turn, even when I'm excited and want to express an idea.

    1 2 3 4 5 6 7 X

11. When I decide to quit a habitual behavioral pattern that I believe to be undesirable, I am usually successful.

    1 2 3 4 5 6 7 X

12. When interrupted or distracted, I usually can easily shift my attention back to whatever I was doing before.

1 2 3 4 5 6 7 X

13. When I am sad about something, it is hard for me to keep my attention focused on a task.

1 2 3 4 5 6 7 X

14. When I'm excited about something, it's hard for me to resist jumping right into it.

1 2 3 4 5 6 7 X

15. Even when I feel energized, I can usually sit still without much trouble if it's necessary.

1 2 3 4 5 6 7 X

16. I often avoid taking care of my responsibilities by indulging in pleasurable activities.

1 2 3 4 5 6 7 X

17. At times, it seems the more I try to restrain a pleasurable impulse (e.g., eating candy), the more likely I am to act on it.

1 2 3 4 5 6 7 X

18. When trying to study something, I have difficulty tuning out background noise and concentrating.

1 2 3 4 5 6 7 X

19. I find certain scratchy sounds very irritating.

1 2 3 4 5 6 7 X

20. I am usually pretty good at keeping track of several things that are happening around me.

1 2 3 4 5 6 7 X

21. I usually finish doing things before they are actually due (e.g., paying bills, finishing homework, etc.).

1 2 3 4 5 6 7 X

22. I am often late for appointments.

1 2 3 4 5 6 7 X

23. When I am anxious about the outcome of something, I have a hard time keeping my

attention focused on a task.
1 2 3 4 5 6 7 X

24. When I am enclosed in small places such as an elevator, I feel uneasy.
1 2 3 4 5 6 7 X

25. When I am very happy, it is hard for me to concentrate on tasks that require me to keep track of several things at once.
1 2 3 4 5 6 7 X

26. I usually have trouble resisting my cravings for food drink, etc.
1 2 3 4 5 6 7 X

27. It is easy for me to inhibit fun behavior that would be inappropriate.
1 2 3 4 5 6 7 X

28. It is very hard for me to focus my attention when I am distressed.
1 2 3 4 5 6 7 X

29. Loud noises sometimes scare me.
1 2 3 4 5 6 7 X

30. When I hear good news, my ability to concentrate on taking care of my responsibilities goes out the window.
1 2 3 4 5 6 7 X

31. I often make plans that I do not follow through with.
1 2 3 4 5 6 7 X

32. As soon as I have decided upon a difficult plan of action, I begin to carry it out.
1 2 3 4 5 6 7 X

33. If I think of something that needs to be done, I usually get right to work on it.
1 2 3 4 5 6 7 X

34. I can make myself work on a difficult task even when I don't feel like trying.
1 2 3 4 5 6 7 X

35. I find loud noises to be very irritating.

1 2 3 4 5 6 7 X

36. Even when I have enough time to complete an activity today, I often tell myself that I will do it tomorrow.

1 2 3 4 5 6 7 X

37. If I notice I need to clean or wash something (e.g., car, apartment, laundry, etc.), I often put it off until tomorrow.

1 2 3 4 5 6 7 X

38. It does not frighten me if I think that I am alone and suddenly discover someone close by.

1 2 3 4 5 6 7 X

39. I hardly ever finish things on time.

1 2 3 4 5 6 7 X

40. I usually get my responsibilities taken care of as soon as possible.

1 2 3 4 5 6 7 X

41. Sometimes, I feel a sense of panic or terror for no apparent reason.

1 2 3 4 5 6 7 X

42. It's usually hard for me to alternate between two different tasks.

1 2 3 4 5 6 7 X

43. When I am afraid of how a situation might turn out, I usually avoid dealing with it.

1 2 3 4 5 6 7 X

44. I can keep performing a task even when I would rather not do it.

1 2 3 4 5 6 7 X

Appendix E

SELF-ASSESSMENT MANIKIN

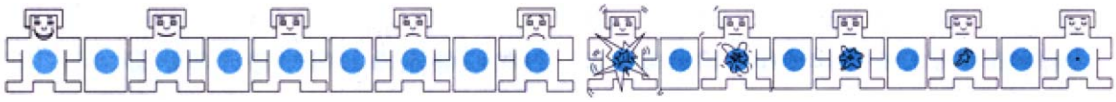
Direction

Thank you for completing the questionnaire and computer session! We appreciate your participation in this study. In this session, you will view the pictures that were presented in the computer session again and rate them. You will be using the figures (self-assessment manikin, SAM) to rate how you feel while viewing each picture. SAM shows two different kinds of feelings: Pleasant vs. Unpleasant (on **the left side**) and Excited vs. Calm (on **the right side**). You will bubble the figures or the space between figures of the two scales to indicate your feelings. Please notice that each of the two feelings is arrayed along a **nine-point** scale. The left panel shows the pleasant-unpleasant scale, which ranges from a smile to a frown. The right panel allows you to describe the intensity of your feeling by bubbling the figure from a intense reaction to a tiny reaction.

For each picture, there is also a list of basic emotions (i.e. amusement, anger, contentment, disgust, fear, neutral, and sadness) below the manikin. Please categorize emotions you have when viewing the pictures according to the basic emotions. You may circle more than one category if you have multiple emotions during the picture presentation.

Valence (pleasant-unpleasant) **Arousal** (excited-calm)

Picture #1



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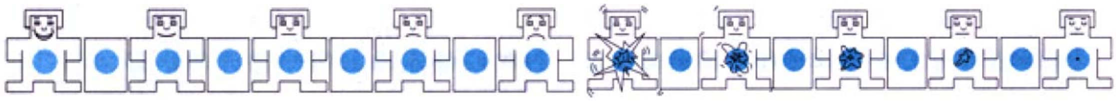

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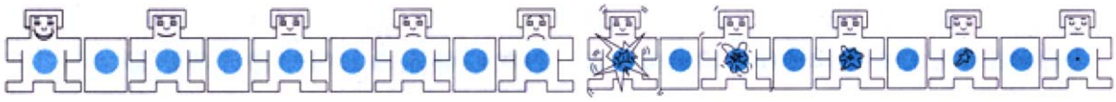

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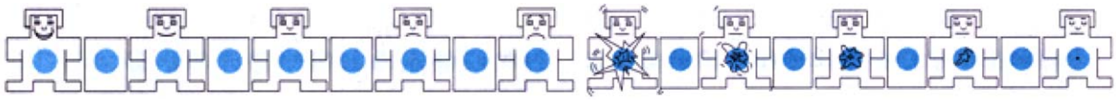

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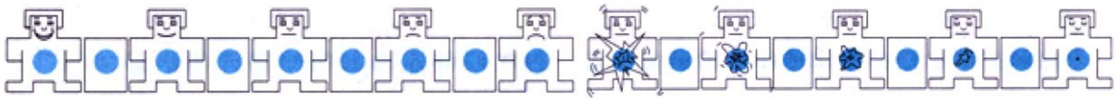

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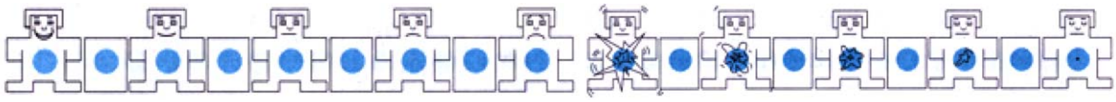

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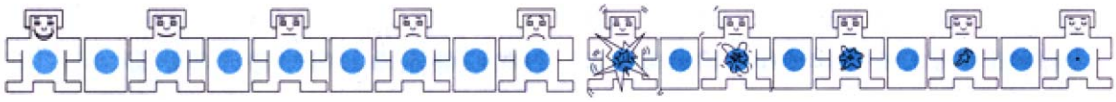

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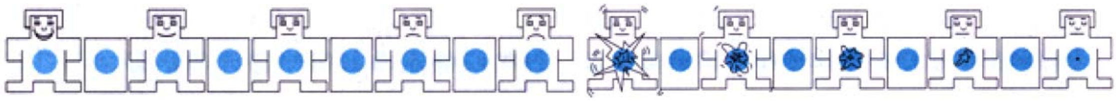

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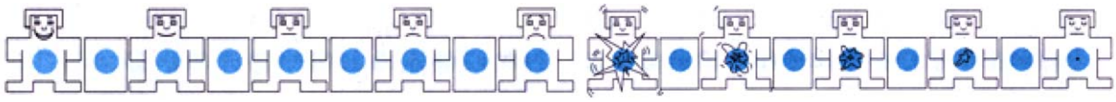

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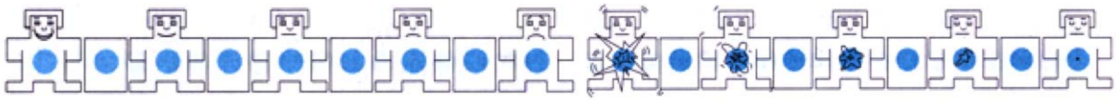

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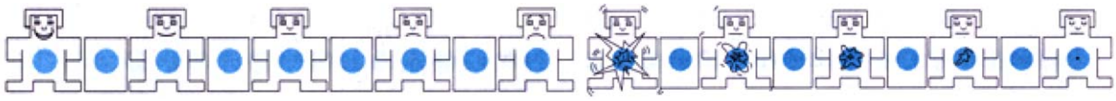

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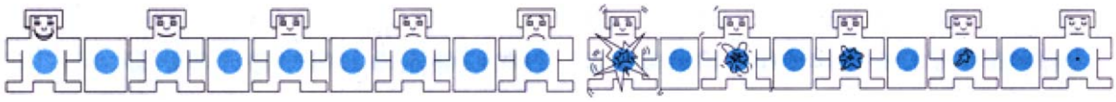

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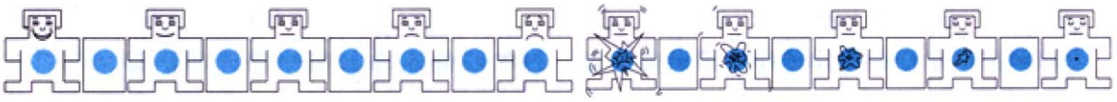

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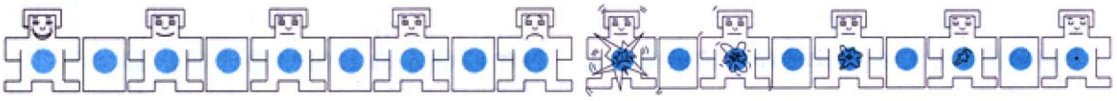

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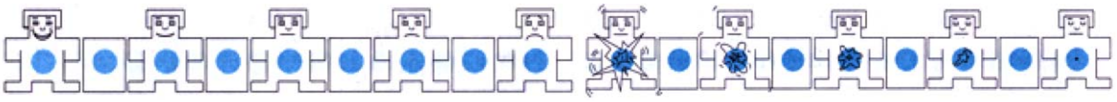

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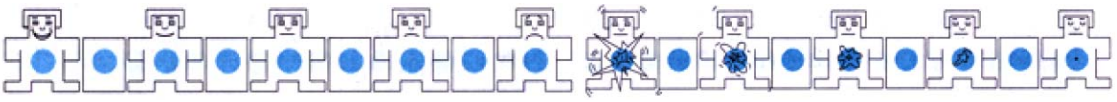

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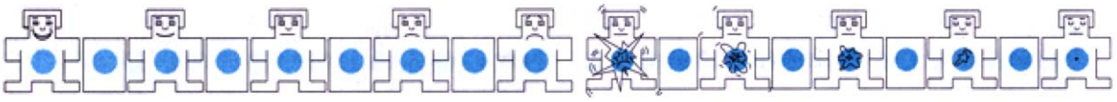

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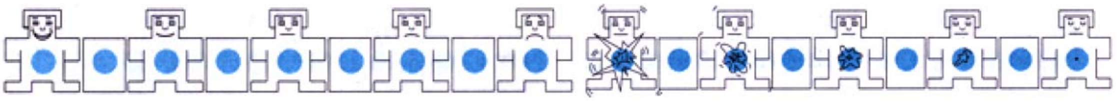

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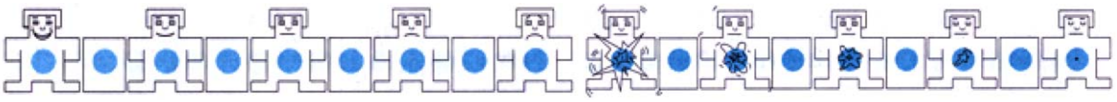

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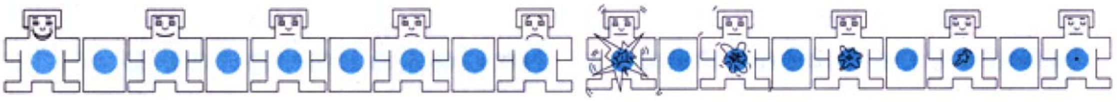

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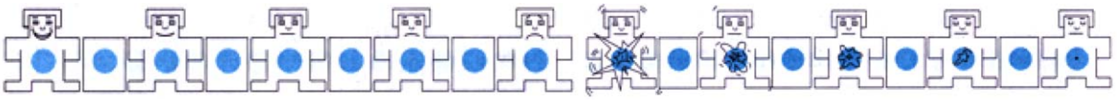

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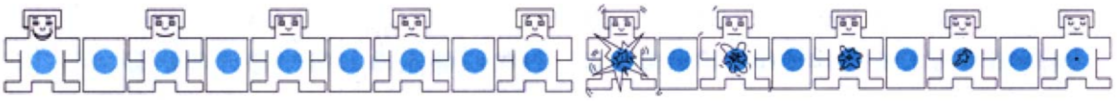

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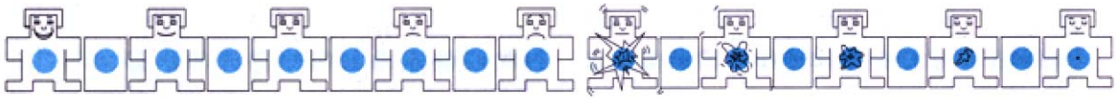

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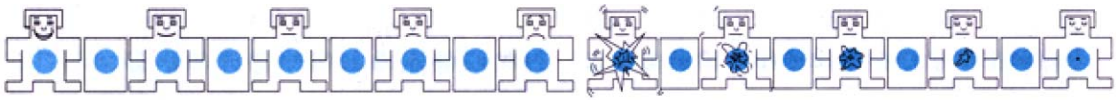

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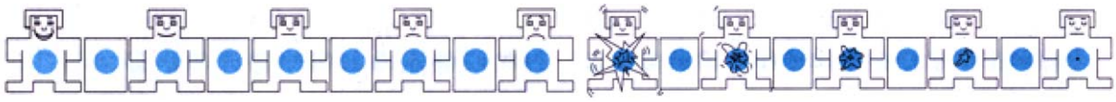

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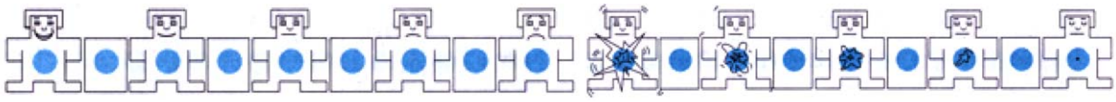

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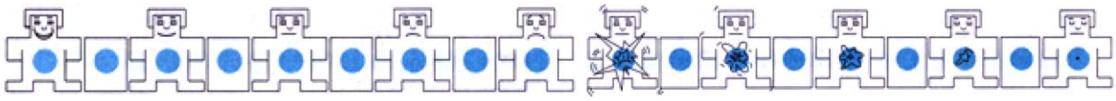

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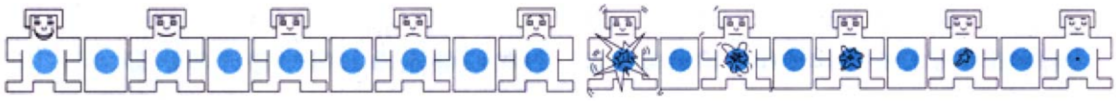
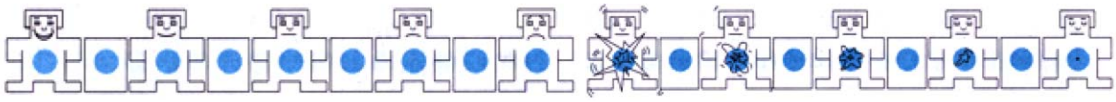
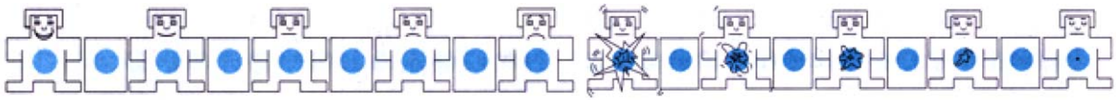


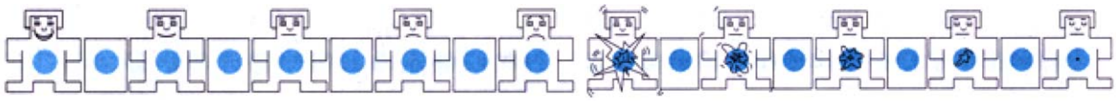
Picture #29



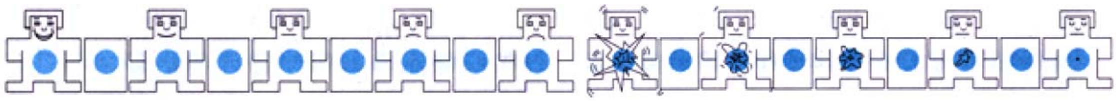
Picture #30



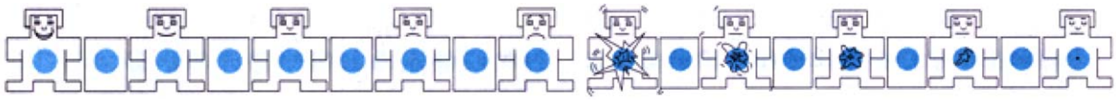
Picture #31



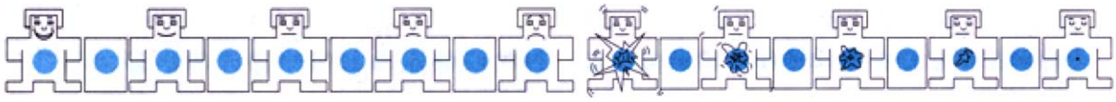
Picture #32



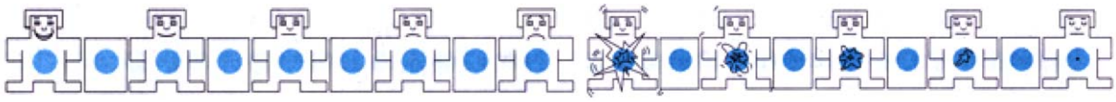
Picture #33



Picture #34



Picture #35



Picture #36