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PERSONALITY AND MODULATION OF THE STARTLE REFLEX BY EMOTIONALLY-TONED FILMCLIPS

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Summary—Several researchers have found that pleasant foreground stimuli attenuate the eyeblink component of the startle reflex while unpleasant foreground stimuli potentiate it. The effects of personality factors on such modulation of the eyeblink response, as measured by electromyographic (EMG) activity in reaction to loud acoustic startle probes, were examined in subjects viewing emotionally-toned (pleasant, unpleasant and neutral) filmclips. During the main part of the experiment, introverts had higher baseline EMG activity and lower response probability than extraverts; no differences were observed at the beginning of the experiment, during an acclimatization session. Reflex modulation, as measured by response latency, was influenced by the Psychoticism (P) factor of the Eysenck Personality Questionnaire: subjects high on P showed longer latencies to eyeblink onset when probed during viewing of pleasant filmclips than subjects low on this dimension; no significant differences were observed between subjects low and high on P for neutral and unpleasant filmclips. No influence of personality factors was found on affective modulation as measured by response amplitude/magnitude. The results are discussed in relation to Gray's and Eysenck's theories of personality. Copyright © 1996 Elsevier Science Ltd.

INTRODUCTION

The startle reflex involves a set of involuntary responses to a sudden, intense stimulus, which in human beings is most easily measured in terms of the amplitude and latency of the eyeblink reflex (Anthony, 1985). Since the observation by Vrana, Spence and Lang (1988) that pleasant foreground stimuli attenuate the basic startle reflex whilst unpleasant foreground stimuli potentiate it, several studies have investigated the role of anxiety and psychopathy in modulated startle responses (for a review, see Lang, Bradley, Cuthbert & Patrick, 1993). The matching or mismatching between the (aversive) properties of the startle probe and environmental cues (such as pleasant or unpleasant images) is hypothesised to lead to a linear relationship, with the largest reflexes occurring in an aversive context, the smallest in an appetitive context, and an intermediate response in a neutral context (Bradley, Cuthbert & Lang, 1990, 1991). However, more recently, it has been suggested (Lang, Bradley & Cuthbert, 1992; Lang *et al.*, 1993) that motivational states underlying startle modulation are not restricted to the (directional) valence (i.e. pleasantness–unpleasantness) dimension only, but also involve an (activational) arousal dimension of affect. Appetitive and aversive stimuli rated high on arousal produce a stronger effect on startle reflex than stimuli rated low or medium on this dimension (Cuthbert, Patrick & Lang, 1990; Cuthbert, Bradley & Lang, 1996; Lang *et al.*, 1992).

Work with fear/anxiety groups has confirmed the basic effect of unpleasant stimuli on startle potentiation (Cook, Hawk, Davis & Stevenson, 1991; Cuthbert, Patrick & Lang, 1991; Greenwald, Bradley, Cuthbert & Lang, 1991). *S*s high on trait fearfulness show an enhanced potentiation of the reflex during unpleasant slide viewing as compared to *S*s low on this trait (Cook, Davis, Hawk, Spence & Gautier, 1992). Phobic *S*s also show potentiated startle reflexes to feared stimuli (Hamm,

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Globisch, Cuthbert & Vaitl, 1991), and in such *S*s the startle reflex can be used to monitor treatment outcome (Vrana & Constantine, 1990). Startle potentiation in humans has also been observed during anticipation of a noxious event (Grillon, Ameli, Woods, Merikangas & Davis, 1991; Grillon, Ameli, Foot & Davis, 1993a; Grillon, Ameli, Merikangas, Woods & Davis, 1993b; Grillon & Davis, 1995; Patrick & Berthot, 1995) and by imagery of fearful situations (Cook *et al.*, 1991; Vrana & Lang, 1990). More recently, pleasant and unpleasant odours (Ehrlichman, Brown, Zhu & Warrenburg, 1995; Miltner, Matjak, Braun, Diekmann & Brody, 1994), and pleasant and unpleasant filmclips (Jansen & Frijda, 1994), have also been used to modulate the startle reflex. However, the two studies using odours did not find startle attenuation during positive experiences.

Affective modulation of the startle reflex, if primarily controlled by the valence of foreground stimuli, offers a powerful paradigm with which to study variation in reactions to appetitive and aversive stimuli. There has been relatively little attempt to use the paradigm to study the relationship between reactions to appetitive/aversive stimuli and factors of normal personality. In personality research, only a few studies (Berenbaum & Williams, 1995; Bunce, Larsen & Cruz, 1993; Larsen & Ketelaar, 1989, 1991) have attempted to examine the effects of personality factors on mood responses in an experimental paradigm manipulating pleasant and unpleasant events, but these have relied exclusively on ratings (either self or by others) for measuring emotional reactivity/mood factors. Typically, an association has been found between extraversion and positive affect, and between neuroticism and negative affect (for a review, see Rusting & Larsen, 1995), though studies have not consistently supported these associations. For example, Bunce *et al.* (1993) found that extraversion was associated with reactivity to unpleasant slides whereas neuroticism was associated with reactivity to pleasant slides; they suggested that these associations were influenced by arousal manipulations. Berenbaum and Williams (1995) reported that, under placebo, extraversion was associated with less reactivity (as measured by ratings of facial expressiveness) to unpleasant (affect-eliciting) filmclips, and neuroticism was associated with less reactivity to pleasant filmclips. These findings warrant further research utilizing objective experimental procedures to measure emotional reactivity and to explore its relationship with personality factors.

Modulated startle seems particularly well suited to test Gray's (1982, 1983, 1987) and the Eysencks' (Eysenck & Eysenck, 1985) biological theories of personality, relating differences in extraversion and neuroticism to sensitivity to appetitive and aversive stimuli. Gray's theory postulates two independent reinforcement systems, the Behavioural Inhibition System (BIS), which mediates responses to conditioned stimuli associated with punishment (and removal of expected reward), and the Behavioural Approach System (BAS), which mediates responses to conditioned stimuli associated with reward (and removal of expected punishment). The BIS is hypothesised to underlie Anxiety (i.e. neurotic–introversion) while the BAS is hypothesised to underlie Impulsivity (i.e. neurotic–extraversion). If BAS-dominant impulsive individuals are highly sensitive to reward, then they would be expected to show greater inhibition of the startle reflex in the context of appetitive stimuli. Conversely, BIS-dominant anxious individuals would be expected to show greater potentiation of the startle reflex in the context of aversive stimuli, since such *S*s are presumably highly sensitive to punishment.

The Eysencks' (1985) theory might predict a greater sensitivity of extraverts (who usually report more pleasant affect) to pleasant/appetitive stimuli and a greater sensitivity of neurotics (who usually report more unpleasant affect) to unpleasant/aversive stimuli. Other predictions can be derived also from Eysenck's (1967) arousal-based theory of personality. A stronger modulation in introverts (who presumably have higher basal reticulo–cortical arousal than extraverts) with both positive and negative filmclips might be expected, since recent evidence (Cuthbert *et al.*, 1996) confirms stronger modulation effects during slides rated high on arousal (as indexed by subjective ratings and skin conductance measures). It might also be predicted that neurotics (who have higher limbic system activation than stables) would show greater modulation with both positive and negative filmclips, if arousing properties of the affective stimuli involve limbic system arousal.

Research in our laboratory using slides to modulate the startle reflex has confirmed the previously reported pattern of affective modulation and, in addition, has shown that personality factors influence the modulation effects (Corr, Wilson, Fotiadou, Kumari, Gray, Checkley & Gray, 1995b). Specifically, extraversion and neuroticism both influenced the modulation as measured by response latency. The potentiation of the startle reflex as measured by response amplitude in reaction to probes while viewing unpleasant slides was restricted to *S*s high on a measure of anxiety (i.e. Harm Avoidance; Cloninger, 1988), whilst attenuation of the startle reflex in response to pleasant slides was restricted to *S*s who were low on this dimension. In general, research suggests that startle latency is more closely associated with affective arousal than affective valence (see Cook *et al.*, 1991), but this has not been established (Cook *et al.*, 1992). While most of the previous studies have found a linear modulation effect for the amplitude measure (startle increasing across pleasant through neutral to unpleasant modulating stimuli), the findings for the latency measure have not been consistent. We therefore decided to study all relevant dependent measures as in Corr *et al.* (1995b). Our emphasis, however, was on startle amplitude as a measure of emotional state and as the main parameter for hypothesis testing with respect to personality influences in affective modulation of startle.

The present study aimed to extend and generalize previous findings in our laboratory to another paradigm. In this paradigm, emotionally-toned filmclips were used to generate affective states instead of slides. Filmclips have been found to produce stronger emotions and arousal than slides for both males (Julien & Over, 1988) and females (Heiman, 1980), and the intensity of stimulation may be an important factor in determining how personality affects emotional responsiveness.

The other objective of this study was to test Gale's (1981) extension of the traditional Eysenckian model. Eysenck's (1967) biologically based theory of human personality postulates that extraverts are cortically less aroused/arousable than introverts. Gale hypothesises that predicted arousal differences between extraverts and introverts will be found only under conditions of 'moderate' stimulation. Under highly stimulating conditions, the (overaroused) introverts will use strategies to reduce arousal whereas, under conditions of very low stimulation, the (underaroused) extraverts will use strategies for compensatory increases in arousal, thus leading to rather comparable levels of arousal in both groups. The first visit to the laboratory (especially, the psychophysiological laboratory) tends to produce higher-than-average levels of arousal (Christie & Todd, 1975; Davis & Cowles, 1988). Gale and co-workers (Gale, 1979, 1981; Gale & Baker, 1981; Gale & Edwards, 1983) argued that a disregard for the arousal potential associated with *S*'s first exposure to the experimental laboratory and for *S*-experimenter interactions are methodological inadequacies of psychophysiological research, which (subject to individual differences) affect the independent variables of interest. Davis and Cowles (1988) have demonstrated that there are arousal properties associated with the psychophysiological laboratory that diminish as familiarity with the laboratory increases. They tested *S*s on four separate days in identical sessions and found that extraverts showed a decrease in physiologically measured arousal (heart rate, basal skin conductance, spontaneous skin conductance responses) across days, while no noticeable change was found for introverts on these measures. Their results strongly support Gale's hypothesis and limit the use of single-session psychophysiological laboratory experiments to study personality–arousal–emotionality associations. The standard procedure of providing *S*s with an 'acclimatization period' at the start of such experiments has been challenged by Gale and Baker (1981). They argue that, the longer one waits for the unexpected to happen, the less relaxed one is likely to be, especially in a psychophysiology laboratory.

In the present study, two sessions were designed to study personality–arousal–emotionality associations. The first (acclimatization) session involved only the basic startle reflex, and the second session was to study personality effects on modulated startle. It was predicted that differences in baseline EMG activity (like other electrodermal measures, this presumably reflects arousal; Bradley *et al.*, 1990) between introverts and extraverts would not be found at the beginning of the experiment (i.e. during the first session), and would emerge only later in the experiment, after habituation to the laboratory environment had taken place to some extent, with the possibility, however, that some individuals (i.e. introverts) might not habituate, and therefore, remain aroused till the end of the experiment.

The Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975) was chosen to measure Extraversion (E), Neuroticism (N), Psychoticism (P) and the Lie (L) dimensions. To be consistent with Corr *et al.* (1995b), the Tridimensional Personality Questionnaire (TPQ; Cloninger, 1988) was also administered to all *S*s. The three major dimensions assessed by this questionnaire are Reward Dependence (RD), Harm Avoidance (HA) and Novelty Seeking (NS).

METHOD

Subjects

Forty-two normal volunteers, 21 males (mean age = 26.81 yr, SD = 7.33) and 21 females (mean age = 31.71 yr, SD = 7.33), served as *S*s. *S* were picked from a *S*s pool kept at the Psychology Department and each was paid £5 for participation. None had any hearing or visual impairment, or any psychiatric illness.

Design and stimulus material

A split-plot design was used, with film type (pleasant, neutral and unpleasant) as a within-*S* factor and dichotomous personality groups as a between-*S* factor.

The study consisted of two 'sessions'. The first session was to acclimatize *S*s with the laboratory environment and experimental procedure. In this session, *S*s received 10 acoustic startle stimuli at a 30 ($\pm$5) sec interval without any background noise or filmclips. In the second session (a few min later), *S*s were shown a series of 12 filmclips of 2.5–4 min durations via a Sharp video recorder (VC-A30 HM) connected to a Sharp colour 20 inch television monitor (DV-5101 A).

The first six filmclips were used only to familiarize *S*s with the experimental procedure and to reduce the habituation of the startle reflex prior to viewing the filmclips used for the experimental manipulation of emotion. Out of the last six filmclips, two filmclips depicted unpleasant (negative, NEG) events [fragment from a horror movie (*Fly*), and a surgical operation (shoulder surgery)], two filmclips depicted neutral (NEU) events (neutral conversation and a documentary) and two filmclips depicted pleasant (positive, POS) events [fragments from romantic movies (*Pretty Woman* and *Dirty Dancing*)].

Filmclips were presented in NEU-POS-NEG-NEU-NEG-POS order, and were separated by 4–10 sec of a blank blue screen. *S*s received three acoustic startle stimuli in the last min of each filmclip with an inter-startle interval of 25 or 30 sec. For each *S*, the sequence of filmclips, intervals and probes remained the same.

Table 1 presents mean affective ratings for the six clips that were chosen to induce positive and negative affect, obtained from 43 (18 males and 25 females) unpaid volunteers (18–55 yr old), on an 11-point scale (+5 through 0 to −5) in a pilot study; these *S*s did not serve as *S*s in the present experiment.

Equipment and scoring

A commercial computerized startle response monitoring system (SR-LAB, San Diego Instruments) was used to elicit acoustic probes [50-msec bursts of 100 dB (A) white noise with nearly instantaneous rise time], and to record and score the EMG activity. The acoustic probes were presented binaurally through headphones (Telephonics). EMG activity of the orbicularis oculi muscle of the right eye was recorded with two disk electrodes (Ag/AgCl, 6 mm electrode cups), filled with Dracard electrode gel. The ground electrode was placed behind the right ear over the mastoid. Recording procedures were identical to those used by Corr *et al.* (1995b), with the exceptions that (a) the amplifier gain control was in all experimental sessions kept at point 3, and (b) there was no

Table 1. Mean subjective affective ratings on an 11-point scale (+5 through 0 to −5) for pleasant, neutral and unpleasant filmclips

Filmclip	Mean	SEM
Pleasant		
Pretty Woman	2.70	0.28
Dirty Dancing	2.42	0.28
Overall	2.56	0.26
Neutral		
Neutral conversation	−0.05	0.12
Documentary	0.77	0.19
Overall	0.36	0.11
Unpleasant		
Fly	−2.67	0.26
Shoulder surgery	−3.09	0.28
Overall	−2.88	0.24

masking white noise; this was replaced by the sound track of the video sequence, consisting of talk, narration and occasional music (39–70 dB A) in the second session.

Baseline EMG activity (during the first 20 msec after the presentation of acoustic probes) [arbitrary Analog to Digital (A/D) units], response latency (msec), amplitude (A/D units), response probability (number of observed responses/number of possible responses) and response magnitude (amplitude × response probability) were used as dependent measures. The amplitude measure represented the mean of recorded responses and not the mean of all possible responses (i.e. startles that did not elicit a measurable blink were ignored by the averaging procedure for the amplitude measure; such trials were also not included in the analysis of the latency measure). The scoring criteria were identical to those used by Corr *et al.* (1995b) and Kumari, Cotter, Corr, Gray and Checkley (1996).

Procedure

All recordings were taken with *S*s sitting in a sound-attenuated dimly lit room approximately 6 feet from the video screen. After the experimenter explained the aims and experimental procedure of the study, monitors for the recording of the EMG activity were attached.

*S*s were told (in advance of both sessions) that, in the first session, they were going to hear a number of auditory clicks through headphones over 5 min (but see no filmclips), and that in the second session, they were going to be shown a series of filmclips varying in content and duration, some of them depicting pleasant and some unpleasant events, and that each clip should be viewed the entire time it was on the screen. They were also told that they would intermittently hear a noise (as in the first session) through the headphones, but that this should be ignored. *S*s were not given any information about the exact duration or number of filmclips, but were told that the second session would last approximately 40 min. The time-interval between the two sessions was 2–3 min. The experimenter remained in the testing room, but out of sight of the *S*s. All *S*s were run between 8.30 and 13.30 hr. *S*s were asked to complete the EPQ and TPQ before the experiment.

Statistical treatment

For each personality variable from the EPQ and TPQ, the sample was divided by median split into two (low and high) groups. *S*s with the median scores were not included in either (low or high) group. The descriptive statistics for the personality variables are given in Table 2, and their intercorrelations are shown in Table 3. The results for the first (Acclimatization) session are based on all *S*s ($N = 42$) tested. For the second session (Modulated Startle), the results (except baseline

Table 2. Summary statistics for personality measures

Measure	Mean	Median	SD	Range
EPQ: Extraversion [E]	13.95	15.00	5.08	2–21
EPQ: Neuroticism [N]	10.14	11.00	4.36	1–22
EPQ: Psychoticism [P]	3.95	3.50	3.23	0–20
EPQ: Lie [L]	6.69	6.00	4.27	1–19
TPQ: Harm Avoidance [HA]	11.21	11.50	5.68	1–28
TPQ: Reward Dependence [RD]	17.57	18.00	3.70	9–26
TPQ: Novelty Seeking [NS]	17.90	18.00	5.35	9–27

EPQ, Eysenck Personality Questionnaire (Eysenck & Eysenck, 1975); TPQ, Tridimensional Personality Questionnaire (Cloninger, 1988).

Table 3. Pearson product-moment intercorrelations of personality variables

Measure	2	3	4	5	6	7
1. EPQ: E	0.146	−0.160	−0.326*	−0.513**	0.263	0.093
2. EPQ: N	—	−0.034	0.012	0.562**	0.147	0.048
3. EPQ: P	—	—	0.047	−0.174	−0.099	0.294
4. EPQ: L	—	—	—	0.100	−0.072	−0.270
5. TPQ: HA	—	—	—	—	0.051	−0.383**
6. TPQ: RD	—	—	—	—	—	0.138
7. TPQ: NS	—	—	—	—	—	—

*$P < 0.05$, **$P < 0.01$.
See Table 2 for abbreviations.

EMG measure) are based on a sample of only 38 Ss, because of either a failure to obtain measurable startle ($N = 2$) or rejected data due to unstable baseline ($N = 2$) in two males and two females (all four Ss belonged to the high N group). The median N score for the remaining 38 Ss was 10.5, and for this reason score 11 was included in the high N group in order to keep the number of Ss in the high and low groups comparable.

All analyses were performed by SPSS (version 5) Windows. The Acclimatization Session data were analysed by one-way analysis of variance (ANOVA) to determine any effects of Sex, and the Modulated Startle data by two-way (Sex × Valence, i.e. differences between startle during pleasant, neutral and unpleasant filmclips) multivariate analysis of variance (MANOVA; Jennings, 1987) for each dependent measure. Wilks' F-ratio was used for significance testing throughout, followed by polynomial contrast tests (assessed by t) on Valence effects (ordered POS-NEU-NEG).

For personality effects, the Acclimatization Session data were analysed by one-way ANOVAs based on the median splits for each personality variable. The Modulated Startle data were analysed by two-way (Personality × Valence) MANOVAs for each dependent measure. To examine for E × N interaction in modulation of the reflex, the Modulated Startle data were also analysed by three-way (E × N × Valence) MANOVAs for each dependent measure.

RESULTS

Acclimatization session

There was no effect of sex or any of the EPQ or TPQ variables on any of the dependent measures (for mean values, see Table 4).

Modulated startle

Sex effects. The main effect of Sex was significant only for response latency [$F(1,36) = 5.60$, $P < 0.05$], with longer latencies in males (POS: 53.18 msec, $\pm$SEM 2.22; NEU: 53.82$\pm$1.51; NEG: 46.09$\pm$1.32) than females (POS: 44.55$\pm$2.84; NEU: 48.25$\pm$3.10; NEG: 44.83$\pm$1.39). Sex × Valence effects were not significant for any of the dependent measures.

Baseline EMG. There was no effect of Valence on this measure. There was, however, a significant main effect of E [$F(1,33) = 4.01$, $P < 0.05$], indicating higher baseline EMG activity in introverts ($N = 19$) than extraverts ($N = 18$) (see Table 5).

Response latency. There was a main effect of Valence [$F(2,35) = 4.88$, $P < 0.05$], latencies being longer when probed during viewing of NEU filmclips than during either POS or NEG filmclips (quadratic component: $t = 2.47$, $P < 0.05$; POS: 48.90$\pm$1.91; NEU: 51.03$\pm$1.76; NEG: 45.46$\pm$0.95). There was also a significant main effect of P [$F(1,36) = 5.62$, $P < 0.05$], with a trend

Table 4. Means for the baseline EMG activity (arbitrary analog-to-digital units), response latency (msec), response amplitude, response probability and response magnitude during the Acclimatization Session

	Mean	SEM
Baseline EMG	20.16	2.45
Response latency	48.40	1.38
Response amplitude	83.62	12.84
Response probability	0.70	0.03
Response magnitude	55.92	8.93

Table 5. Mean (SEM) baseline EMG activity and response probabilities during pleasant (POS), neutral (NEU) and unpleasant (NEG) filmclips for the low and high Extraversion groups

	POS	NEU	NEG
Baseline EMG			
Low Extraversion group	19.94 (2.85)	16.88 (3.79)	17.68 (2.54)
High Extraversion group	11.60 (2.03)	12.13 (2.16)	13.30 (2.14)
Probability			
Low Extraversion group	0.54 (0.05)	0.63 (0.06)	0.72 (0.05)
High Extraversion group	0.70 (0.07)	0.74 (0.06)	0.82 (0.06)

Table 6. Mean (SEM) eyeblink response latencies during pleasant (POS), neutral (NEU) and unpleasant (NEG) filmclips for the low and high Psychoticism groups

	POS	NEU	NEG
Low Psychoticism group	44.50 (2.71)	47.75 (2.76)	45.55 (1.27)
High Psychoticism group	53.23 (2.36)	54.32 (1.97)	45.37 (1.44)

towards a P × Valence interaction [$F(2,35) = 2.85$, $P = 0.07$ (linear component: $t = 2.21$, $P < 0.05$)]. Follow-up analyses by between-*S* *t*-tests revealed that low ($N = 19$) and high P ($N = 19$) groups differed significantly ($t = 2.60$, $P < 0.05$) only for POS filmclips, during which high P scorers responded more slowly than low P scorers (Table 6). The linear trend of modulation was significant ($t = 2.89$, $P < 0.01$) only for *S*s in the high P group, reflecting their tendency to respond more slowly during positive and neutral than during negative filmclips (Table 6).

Response amplitude. There was a main effect of Valence [$F(2,35) = 7.40$, $P < 0.01$]. As expected, startle amplitude for NEU filmclips was greater [$t(37) = 3.33$, $P < 0.01$; one-tailed] than for POS filmclips, but smaller [$t(37) = 2.59$, $P < 0.01$; one-tailed] than for NEG filmclips (linear component: $t = 3.84$, $P < 0.001$). The Pearson product–moment correlation between modulation (absolute scores) to POS and NEG filmclips respectively (each relative to NEU filmclips) was not significant ($r = 0.15$). Mean amplitude scores for POS, NEU and NEG filmclips are presented in Fig. 1.

There was a trend towards an E × N interaction [$F(1,29) = 3.68$, $P = 0.06$] and also towards an E × N × Valence interaction [$F(2,28) = 2.75$, $P = 0.08$]. Close inspection of the data, however, revealed that the assumption of homogeneity of variance was not upheld in this case (standard errors of the mean increased linearly with the means). The data, therefore, were subjected to a natural logarithmic transformation and re-analysed, revealing only a highly significant main effect of Valence [$F(2,28) = 19.48$, $P < 0.0001$]; as shown in Fig. 2, neither E nor N had any influence on startle modulation.

Response probability. There was a main effect of Valence [$F(2,35) = 6.95$, $P < 0.01$ (linear component: $t = 3.46$, $P < 0.001$; POS filmclips: 0.62 ± 0.05, NEU filmclips: 0.68 ± 0.04, NEG filmclips: 0.77 ± 0.03)]. Response probability for NEG filmclips was significantly higher than for NEU [$t(37) = 2.08$, $P < 0.05$] and POS [$t(37) = 3.63$, $P < 0.05$] filmclips, but the difference between NEU

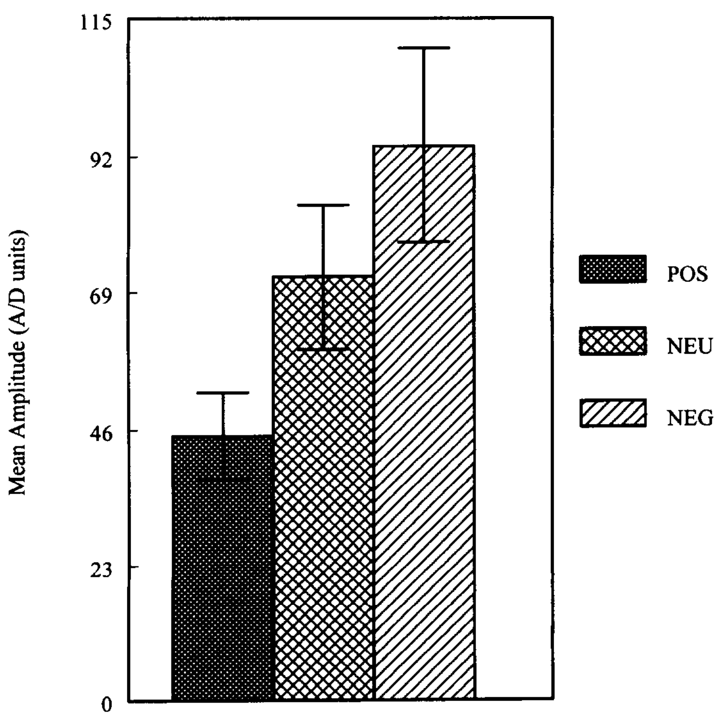

Fig. 1. Mean eyeblink response amplitudes error bars display ±SEM] for pleasant (POS), neutral (NEU) and unpleasant (NEG) filmclips.

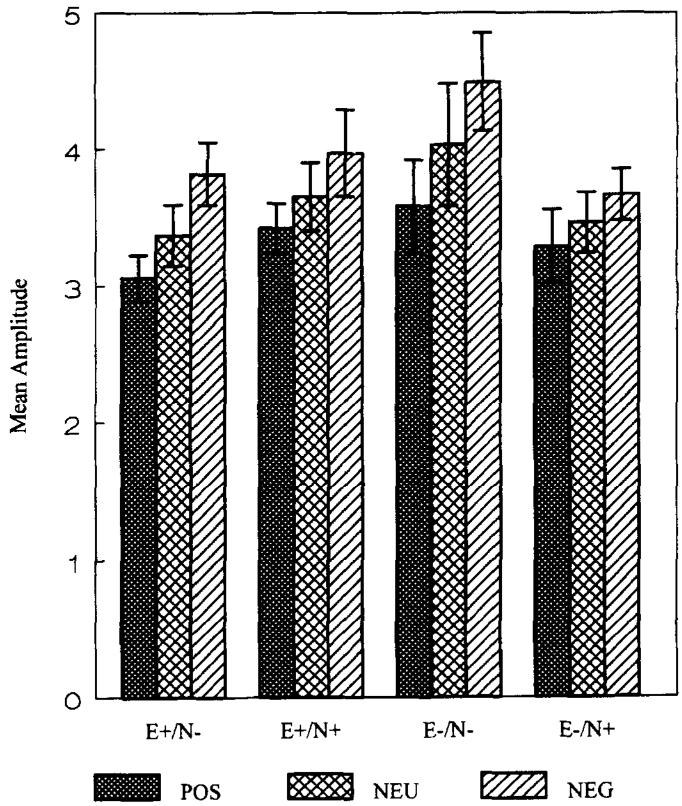

Fig. 2. Mean eyeblink response amplitudes (transformed scores; error bars display ±SEM) for pleasant (POS), neutral (NEU) and unpleasant (NEG) filmclips for the low and high extraversion (E− and E+) and neuroticism (N− and N+) groups.

and POS filmclips was not significant. The main effect of E [$F(1,31) = 5.27$, $P < 0.05$], indicated that extraverts ($N = 16$) had higher response probability than introverts ($N = 17$) (see Table 5).

Response magnitude. There was a main effect of Valence [$F(2,34) = 9.38$, $P < 0.01$ (linear component: $t = 4.39$, $P < 0.001$)]. As for startle amplitude and response probability, startle magnitude for NEU filmclips (55.28 ± 10.45) was greater [$t(37) = 3.56$, $P < 0.01$; one-tailed] than for POS filmclips (31.29 ± 6.49), but smaller [$t(37) = 3.09$, $P < 0.01$; one-tailed] than for NEG filmclips (72.82 ± 12.33). There were no effects of any of the personality variables on this measure.

DISCUSSION

No influence of any of the EPQ or TPQ variables was found on affective modulation of the startle reflex as measured by response amplitude or response magnitude in this study. The psychoticism (P) factor of the EPQ weakly influenced startle modulation as measured by response latency. Extraversion (E) exerted significant influence on baseline EMG and response probability.

On the basis of the behavioural effects of the anxiolytic drugs (for a review, see Gray, 1977), Gray (1976) postulated the existence of a system (the BIS) that, in response to threat, activates outputs of behavioural inhibition, increased vigilance and increased readiness for action (arousal). In rats, the latter, arousal, output of the BIS can be assessed by the potentiated startle response, i.e. the increment in whole-body startle that is induced by presentation, just prior to the startle stimulus, of an additional stimulus previously associated with footshock. Low doses of anti-anxiety drugs eliminate startle potentiation whilst leaving the basic startle response unchanged (for a review, see Davis, Falls, Campeau & Kim, 1993). The method introduced by Lang and his colleagues for measuring potentiation of the human startle response in the presence of aversive visual material presented on slides appears to be closely analogous to the potentiated startle paradigm in the rat, as supported by previous evidence that the degree of potentiation is related to trait fearfulness, presentation of relevant feared stimuli to phobic *S*s, anticipation of a noxious event and imagery of fearful situations (see Introduction). There is also a preliminary report that the magnitude of the human potentiated startle response, like that observed in the rat, is reduced by the anxiolytic drug, diazepam (Patrick, Berthot & Moore, 1993).

Thus, the potentiated startle response may be a way to measure the reactivity of the BIS in human *S*s, thus providing a test of links between the reactivity of the BIS and major dimensions of human personality. According to the hypothesis proposed by Gray (1976, 1982), such links should take the form of increasing BIS reactivity along the dimension of trait Anxiety, this trait being a rotation of Eysenck's dimension of Neuroticism (N) by approximately 30° in the direction of introversion. Eysenck and Eysenck (1985), while accepting the general lines of this hypothesis, suggest that high BIS reactivity should line up directly with increasing N. A previous test of these related predictions, using slides to modulate the startle response (Corr *et al.*, 1995b), provided moderately encouraging results: although there was no relation between the magnitude of the potentiated startle response and the Eysenckian dimensions, such a relationship, in the predicted direction, was found with Cloninger's (1988) Harm Avoidance scale, essentially an alternative measure of trait anxiety (Corr, Pickering & Gray, 1995a).

The procedure in the present study differed from that of Corr *et al.* (1995b): we used filmclips rather than slides so as to modulate the startle reflex. As we reported elsewhere (Kaviani, Gray, Checkley, Kumari, Corr & Wilson, 1995), the present set of filmclips provides a more powerful way of modulating the startle reflex than do slides, as assessed by the magnitude and statistical significance of the effects obtained and thus the sample size required for reliable results. The data shown here (Fig. 1) confirm the effectiveness of film material. In particular, it is possible to evaluate the magnitude and significance of startle potentiation and startle inhibition (by negative and positive affective stimuli, respectively) separately from each other; and furthermore, as we report here, the magnitude of these two modulation effects are uncorrelated across individuals ($r = 0.15$, n.s.). Thus, it could confidently be predicted, on both theoretical grounds and in the light of Corr *et al.*'s (1995b) earlier observations, that the potentiated startle response would be greater, the higher the N score (the Eysencks' prediction) or the higher the N and the lower the E score (Gray's prediction).

However, as shown in Fig. 2, this prediction was clearly disconfirmed: there was no significant effect of either personality dimension on the degree of startle modulation by negative (unpleasant) films; and even the direction of the observed differences is wrong, the lowest modulation occurring in the neurotic introverted group (E−N+), and the combined N+ groups showing slightly less modulation than the combined N−groups. In addition, we failed to replicate Corr *et al.*'s (1995b) finding with slides (since replicated with slides by Corr, Kumari, Wilson, Checkley & Gray, submitted) that scores on Cloninger's Harm Avoidance scale were related to startle potentiation by unpleasant slides: in the present study, we saw no relation between startle modulation as manipulated by filmclips and any of the TPQ scales.

The same general points can be made with respect to inhibition of startle reflex in the presence of pleasant (positive) films, although with less cogency, since this lacks the strong neurobiological data base that backs up the argument in respect of startle potentiation. Gray (1983, 1987) proposed that a second system, independent of the BIS, underlies responses to appetitive stimuli, i.e. those that signal the availability of reward or absence of punishment. He related individual differences in the reactivity of this Behavioural Approach System (BAS) to the dimension of Impulsivity, located orthogonally to trait Anxiety, and so representing a 30° rotation of Eysenckian E in the direction of high N. Eysenck and Eysenck (1985) accept the general lines of this hypothesis, but propose instead that individual differences in sensitivity to signals of reward line up directly with E. Corr *et al.* (1995b), using slides to modulate the startle reflex, failed to confirm either resulting predictions, that the degree of startle inhibition by positive slides would correlate with neurotic extraversion (Gray) or extraversion alone (Eysenck). They did, however, report a negative relationship between scores on the Harm Avoidance scale which could, with some strain, be incorporated within Gray's (1987) overall framework. Although this treats the BIS and BAS as independent brain systems, they have reciprocal inhibitory interactions (Gray & Smith, 1969); these interactions could lead to the results reported by Corr *et al.* (1995b), in which the same personality trait, high Harm Avoidance, was related both to high levels of startle potentiation by negative slides and to low levels of startle inhibition by positive slides. However, in the present study, we failed to observe any relation between startle modulation by positive films and any of the personality scales employed, so again disconfirming the predictions from Gray's (1983, 1987), and Eysenck and Eysenck's (1985) models.

Gray's (1970, 1991) general treatment of the major dimensions of personality as reflecting individual differences in sensitivity to various classes of reinforcers has received much empirical support over the years (e.g. Gupta, 1976; Gupta & Shukla, 1989; for a review, see Corr *et al.*, 1995a). The predictions tested here were strongly buttressed by previous theory and data, and the present method produces stronger startle modulation than that of Corr *et al.* (1995b). One might infer from this that personality influences startle modulation, as found by Corr *et al.* (1995b), only when the modulating material is weak. However, a principal aim of Gray's (1970, 1991) model of personality, like that of Eysenck's (1967), is to account for the observed relations between personality and psychopathology (e.g. anxiety or depression). It is difficult to see how personality could play such a strong role in determining psychopathology if it expresses itself only when environmental conditions leading to emotional responses are weak.

Nonetheless, some caveats should be entered concerning the findings presented in this article. The predictions tested were based on the assumptions that startle inhibition and startle potentiation index positive and negative emotions, respectively. While most of the findings (see Introduction) conform to these assumptions, some recent findings oppose them. For example, Balaban and Taussig (1994) observed startle potentiation during frightening slides, but startle magnitude during disgusting slides did not differ from that during the neutral slides. Another study from our laboratory (Kaviani, Gray, Checkley, Kumari, Corr & Wilson, submitted), using another film-set also containing two pleasant, two neutral and two unpleasant filmclips, found that only one of two unpleasant filmclips produced startle potentiation, relative to neutral, though both were rated as highly and equally unpleasant. These finding suggest that startle potentiation by visual modulating material does not necessarily index negative emotionality in general, and weaken the validity of startle paradigms as measures of positive and negative emotions. We need a better understanding of the processes involved in inhibition and potentiation of the startle reflex in human beings, before being able fully to interpret the findings reported here.

The present study was not designed to assess the effect of personality in specific emotions (such as fear/threat or disgust). The predictions from personality models such as Gray's might be tested more effectively, if paradigms more closely analogous to animal fear-potentiated startle paradigms, for example, involving threat of electric shock, are used. The pleasant and unpleasant filmclips used in the present study presumably involved a wide range of pleasant and unpleasant emotions, respectively.

There were other differences in the effects observed in Corr *et al.*'s (1995b) and the present study, respectively. First, we found a quadratic effect of Valence upon response latency, whereas Corr *et al.* found a linear effect that was significant only in low N/high E subjects. Second, Corr *et al.* observed an inverse relationship between the size of the modulation effect in response to positive and negative slides (perhaps accounting for the influence in their study, of Harm Avoidance on both), whereas here we found no relationship. Whether these differences are relevant to our major findings, as discussed above, is not known.

The major results of this experiment, then, are negative, though important. There were also, however, a number of positive findings that deserve comment.

As predicted, there was no difference between introverts and extraverts for baseline EMG activity during the first session. In the second session, however, introverts showed higher baseline activity than extraverts, suggesting a higher level of arousal in the former (Eysenck, 1967). All *S*s were tested in the first part of the day, when introverts have been found particularly to possess a higher level of arousal as compared to extraverts (Wilson, 1990). Response probability displayed complementary results to those obtained for baseline EMG activity. Higher baseline EMG activity results in a higher number of rejected responses (Corr *et al.*, 1995b) and, therefore, lower response probability in *S*s with higher baseline activity (i.e. introverts) than *S*s with lower baseline activity, i.e. in the present case, extraverts in the second session.

The finding that high as compared to low P *S*s showed a longer latency to response onset when probed during positive filmclips, although new, may be of theoretical significance. There is evidence that the dopaminergic system moderates reward motivation and pleasure (Di Chiara, 1995; Wise, 1982). Gray's (1987) model associates approach behaviour (BAS) with dopamine release. There is also evidence linking psychotic behaviour with dopamine release (see review by Gray, Feldon, Rawlins, Hemsley & Smith, 1991); and N. S. Gray, Pickering and Gray (1994) have recently reported direct evidence for a relationship between a measure of dopamine receptor binding in the brain and scores on the P scale. It is noteworthy that although Impulsiveness as an independently measured trait does correlate with E and N, it is much more aligned with P within Eysenck's later 'giant three' system (Costa & Mcrae, 1995; Eysenck, Barrett, Wilson & Jackson, 1992). Average correlations are 0.15 for E, 0.24 for N and 0.62 for P. Thus one might postulate a link between psychoticism and the BAS (as an alternative to the link with neurotic extraversion considered above). In that case, a possible interpretation is that high P *S*s were slower in responding to probes because they were more absorbed in positive filmclips (reward), in line with evidence that engaged attention to visual stimuli inhibits the latency of the acoustic startle response (Simons & Zelson, 1985). However, any such relation between P and reward sensitivity had no effect on startle modulation as measured by response amplitude, thus weakening this account. The fact that P interacted with response latency but not response amplitude suggests that these parameters may tap different processes. Note, however, that the effects of P on response latency were statistically weak, and require replication before being taken too seriously.

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