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Latent Inhibition and Openness to Experience in a high-achieving student population

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Abstract

Latent Inhibition (LI) is an attentional phenomenon in which repeated pre-exposure to a stimulus that is not reinforced retards future associability to that stimulus. LI adaptively allows the individual to categorize stimuli as relevant or irrelevant to goal attainment at a level below that of conscious awareness. Previous research has linked reduced LI with psychopathological conditions, such as acute schizophrenia and elevated scores on the Eysenck Personality Questionnaire Psychoticism Scale. We tested the hypothesis that reduced LI would be related to Openness to Experience, a dimension of Costa and McCrae's Five Factor Model of Personality, due to the association of Openness with flexible cognitive categorization. Results supported this hypothesis: the correlation between LI and Openness among high-achieving individuals was substantial and highly significant ($r = -0.44$, $P = 0.0001$) even when other relevant aspects of personality were held steady. Reduced LI may impart cognitive advantages in certain personality configurations. © 1999 Elsevier Science Ltd. All rights reserved.

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1. Introduction

When individuals are repeatedly exposed to a stimulus without consequence or reinforcement, they learn future associations to that stimulus more slowly. This phenomenon, known as latent inhibition (LI), has been extensively studied and appears robust across a

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variety of mammalian species, including mice, rabbits, cats, and humans (Lubow & Gewirtz, 1995). There are several explanations for the latent inhibition effect (Schmajuk, Lam & Gray, 1996). Weiner, Shadach, Tarrach and Kidron (1996) suggested that repeated pre-exposure to a non-reinforced stimulus allows the individual to process that stimulus at a preconscious level and to categorize it as currently irrelevant so that it may be consciously ignored. Pre-exposure without reinforcement reduces the novelty of the stimulus and its associated capacity to attract attention (Gray & McNaughton, 1996). This ability to ignore a non-reinforced stimulus is a biologically adaptive function of implicit attention (Lubow & Gewirtz, 1995) which allows an individual to 'gate', or keep out of conscious awareness stimuli irrelevant to survival or to present goal attainment.

Reduced latent inhibition is associated with increased dopaminergic activity in the mesolimbic system. Injections of the dopaminergic agonist *d*-amphetamine, which produce psychosis-like symptoms in humans, attenuate or abolish latent inhibition in both animals and humans (Gray, Pickering, Hemsley, Dawling & Gray, 1992). Standard neuroleptics, which reduce limbic dopamine levels and alleviate psychotic symptoms, produce increased latent inhibition (Peters & Joseph, 1993; Gray et al., 1992). In fact, this effect is so robust that researchers now use the LI animal paradigm to test the efficacy of new atypical antipsychotics such as clozapine (Moran, Fischer, Hitchcock & Moser, 1996) and olanzapine (Gosselin, Oberling & DiScala, 1996). Animal research has revealed that the nucleus accumbens, a portion of the ventral striatum, is the probable site of the dopamine release modulating LI (Gray et al., 1995).

Individual differences in LI among humans have been examined primarily in the context of mental disorder, such as the psychotic symptoms of schizophrenia (Baruch, Hemsley & Gray, 1988b; Gray et al., 1992; but also see Swerdlow, Braff, Hartston, Perry & Geyer, 1996) or the presence of relatively problematical personality traits. Baruch, Hemsley, and Gray (1988a) and Lubow, Ingberg-Sachs, Zalstein-Orda and Gewirtz (1992) both described a trend towards reduced latent inhibition in normal subjects who obtained comparatively high scores on the Eysenck Psychoticism Scale (Eysenck, Eysenck & Barrett, 1985). These studies suggest that differences in LI may be associated with normal, non-psychopathological variability in personality. The present study further investigated this premise by examining the relationship of latent inhibition and Openness to Experience—a dimension of Costa and McCrae's (1992) five factor personality model.

Openness is a high-order trait, associated with personality attributes such as imagination, creativity, intellectual curiosity, unconventional attitudes, and divergent thinking (McCrae, 1994). It is related to the 'permeability of consciousness' (McCrae & John, 1992) and a softening of the rigidity of mental categories (McCrae, 1994). If LI is a measure of the tendency to categorize stimuli at an implicit level of functioning, then LI and Openness might well be inversely related. We determined to investigate this possibility in a sample of high-achieving and productive individuals, controlling for variance in IQ [associated with Openness at approximately $r = 0.30$ (McCrae & Costa, 1985)], and additionally analyzing the influence of other traits, including Psychoticism.

2. Method

2.1. Participants

Ninety-one Harvard University students, ranging in age from 16 to 35 (mean = 20.69, SD = 3.22) participated in this study. Approximately two-thirds (n = 58) were randomly assigned to the pre-exposed (experimental) LI condition, and one-third (n = 33) were randomly assigned to the non-pre-exposed (control) LI condition.

2.2. Description of tasks

2.2.1. Latent inhibition task

Subjects in the pre-exposed condition were shown a two-part video version of the auditory latent inhibition task, constructed after Lubow et al. (1992): in part one, the pre-exposure phase, a list of 30 nonsense syllables (the *masking* material) was presented 5 times with no indication of the termination and start of each repetition. White noise (the *target stimulus*) was superimposed randomly 31 times over the course of the recording at approximately two-thirds the volume of the original recording. Subjects were given a masking task during this phase: they were told that the third nonsense syllable ('bim') would be their 'target syllable' and that their task was to determine how many times it was repeated.

In part two (the *test phase*), the recording was replayed while yellow disks arranged in rows on a black scoreboard were revealed individually on the video screen. The appearance of the yellow disks corresponded with the presentation of the *target stimulus* (white noise) which subjects heard along with the nonsense syllables through the earphones. Thirty-one yellow disks, each appearing prior to the offset of the white noise stimulus, were visible on the video scoreboard at the termination of the task. Subjects were asked to determine which auditory stimulus signaled the appearance of the yellow disks and to raise their hand when they believed a yellow disk was about to appear. When a subject correctly predicted the appearance of a yellow disk on three consecutive trials, the experimenter stopped the videotape and asked the subject to identify the rule. If the subject was able to state correctly the association between the yellow disks and the target stimulus, the task ended. If the subject answered incorrectly, the task continued until the correct response was given. The subject's score for the task (trials to rule identification) was determined by the number of yellow disks visible on the screen when the correct answer was given.

Subjects in the non-pre-exposed condition were shown an identical videotape, except that the white noise (*target stimulus*) was absent from the pre-exposure phase of the task.

2.2.2. IQ testing

Subjects completed one verbal test (Vocabulary) and one performance test (Block Design) from the Wechsler Adult Intelligence Scale-Revised (WAIS-R: Wechsler, 1981). Raw scores were scaled for age according to the WAIS-R Manual, then combined to form a composite score for each subject. IQ estimates compiled from this short form typically correlate at 0.906 with full-scale WAIS-R IQ scores (Brooker & Cyr, 1986).

2.2.3. Personality measurements

Subjects completed a booklet that contained two personality instruments. The *NEO Five-Factor Inventory* (NEO-FFI: Costa & McCrae, 1992) consists of 60 statements (e.g. 'My life is fast-paced.') which assess the subject across five broad domains of personality: Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Each question is rated by the subject on a five-point scale. The *Eysenck Personality Questionnaire* (EPQ: Eysenck et al., 1985) consists of 100 questions which measure personality across three domains: Extraversion, Neuroticism, and Psychoticism. The subject circles 'yes' or 'no' in response to whether each question applies to him or her.

2.3. Procedure

Prior to arrival at the lab, each subject was randomly assigned to either the experimental condition ($n = 58$) or the control condition ($n = 33$). Upon arrival, the subject was briefly interviewed by the experimenter, who noted the subject's age, sex, area of study interest, hand preference, and birth order. The experimenter also assessed the subject for overt signs of depression, anxiety, and other psychological conditions that might interfere with attention. All subjects read and signed an informed consent form prior to testing.

Subjects were tested individually. All subjects completed the latent inhibition task, during which they were seated in a quiet, semi-darkened room and told that they were participating in two auditory discrimination tasks. They were asked to don stereo earphones and were allowed to adjust the volume if necessary. Upon completion of the LI task, intelligence tests were administered to most subjects ($n = 82$), according to the availability of a trained test administrator. Subjects were then seated in a private lounge area and asked to complete the personality questionnaire booklet. Upon completion of the questionnaire, all subjects were debriefed and allowed to ask questions. They were asked not to discuss the details of the experiment until all subjects had been tested.

2.4. Statistical analysis

Results of the experiment were analyzed using StatView by Abacus (1992) and SPSS 6.1.3 for Windows (1995). Latent inhibition scores were distributed bimodally, rather than normally. Non-parametric tests are traditionally used in such a case, instead of *t*-tests (for example) although there is debate about the relative validity of the two approaches. *T*-tests are more powerful, and are arguably robust in the face of non-normality (Wilcox, 1992). We therefore report *t*-tests, adjusted for heterogeneity of variance where necessary, and non-parametric Mann–Whitney *U* tests.

3. Results

3.1. Personality and IQ testing

Mean scores on all tested personality variables were within one standard deviation of the norm for the general population of 16–20 year-olds, with the exception of Openness to

Experience, on which the Harvard students scored 1.12 standard deviations above normal (see Table 1). IQ scores (mean = 131, SD = 10.62) were approximately 2 standard deviations above the population mean of 100 (population SD = 15; Wechsler, 1981).

3.2. Latent inhibition

Comparison of number of trials to rule identification for the pre-exposed (mean = 18.2, SD = 10.3, $n = 58$) and non-pre-exposed (mean = 14.5, SD = 8.3, $n = 33$) groups indicated that individuals in the former condition learned the association between the white noise and the appearance of the yellow disks more slowly than did individuals in the latter, as expected ($t(89) = -1.741$, Cohen's $d = 0.398$, $P = 0.035$ one-tailed, adjusted for heterogeneity of variance; see Fig. 1). Scores within the pre-exposed group were bimodal, rather than continuous, as is typical (Baruch et al., 1988a): subjects tended to learn the association within the first 17 trials—or did not learn it at all. A conservative nonparametric test (Mann–Whitney U) was performed and also yielded a strong trend toward latent inhibition ($Z = -1.44$, $P = 0.074$, one-tailed). It should be noted, however, that the magnitude of the overall effect was a consequence of the intermingling of two clearly distinct groups, one characterized by intact LI, the other by its relative absence (as detailed later).

3.3. Latent inhibition, IQ, age and gender

IQ and number of trials to rule recognition were significantly correlated in the pre-exposed condition ($n = 55$, $r = -0.328$, $P = 0.015$), but not in the non-pre-exposed condition ($n = 27$, $r = -0.130$, $P = 0.518$). Neither age nor gender was significantly associated with LI score, in either condition.

3.4. LI and Openness to Experience

Subjects were divided into Low Openness ($n = 40$; mean = 29.25; SD = 3.11) and High Openness ($n = 51$; mean = 38.37; SD = 3.56) groups by median split. The difference in number

Table 1
Mean scores on IQ and personality variables

Variable	Mean	SD	Min.	Max.
IQ (WAIS-R)	130.98	10.62	100	151
Neuroticism (NEO)	22.35	10.68	1	48
Extraversion (NEO)	31.20	6.69	11	43
Openness (NEO)	34.36	5.66	21	46
Agreeableness (NEO)	31.31	7.62	6	46
Conscientiousness (NEO)	29.78	7.33	13	43
Extraversion (EPQ)	14.72	4.44	0	21
Neuroticism (EPQ)	11.53	6.13	0	23
Psychoticism (EPQ)	6.45	3.48	1	16

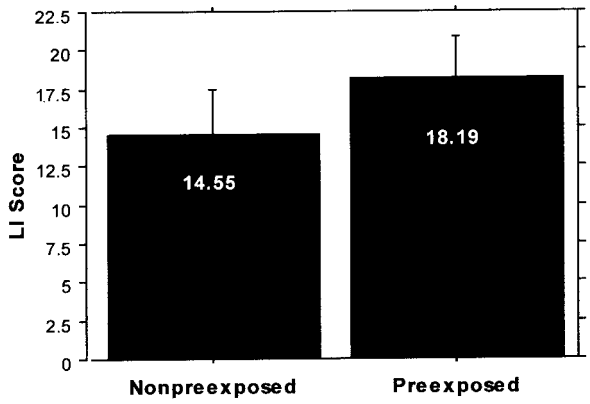

Fig. 1. Latent inhibition in the pre-exposed and non-pre-exposed conditions.

of trials to rule recognition in the pre-exposed condition between the Low Openness (n = 28, mean = 23.64, SD = 9.30) and High Openness (n = 30, mean = 13.10, SD = 8.44) groups was significant ($t(56) = 4.51$, $P < 0.001$, adjusted for heterogeneity of variance, d = 1.19) (see Fig. 2). A non-parametric test (Mann–Whitney U) yielded similar results ($Z = -4.08$, $P < 0.0001$). In order to rule out the possibility that High Openness subjects were simply more creative at guessing the LI rule, we compared the total number of incorrect guesses between High (mean = 0.167, SD = 0.379) and Low (mean = 0.643, SD = 1.129) Openness subjects in the pre-exposed condition. The results ($t(56) = 2.183$, P = 0.033) indicated that Low Openness subjects actually made significantly more incorrect guesses, suggesting that the LI results cannot be attributed to more fluent guessing in the High Openness subjects.

Subjects in the Low Openness group were characterized by a significant latent inhibition effect ($t(38) = -2.02$, P = 0.028 one-tailed and adjusted for heterogeneity, d = 0.60), as the pre-

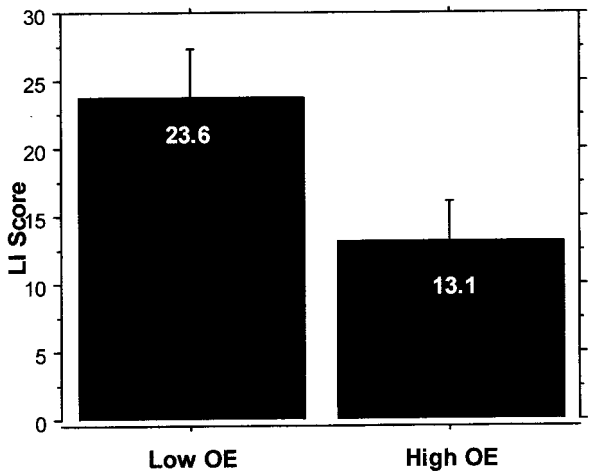

Fig. 2. Latent inhibition and openness to experience in the pre-exposed condition.

exposed members of that group took an average of 23.64 trials (SD = 9.30, $n = 28$) to rule recognition, while their non-exposed counterparts needed only 17.17 trials (SD = 9.27, $n = 12$; see Fig. 3). Subjects in the High Openness group, by contrast, did not manifest significant levels of latent inhibition ($t(46) = 0.02$, $P = 0.981$ adjusted, $d = 0.007$), as the pre-exposed subjects took an average of 13.10 trials (SD = 8.44, $n = 30$) to rule recognition while the non-pre-exposed subjects took 13.04 (SD = 7.47, $n = 21$; see Fig. 3). Similar results were obtained with nonparametric tests: Low Openness subjects demonstrated intact latent inhibition ($Z = -1.844$, $P = 0.033$ one-tailed) while High Openness subjects demonstrated reduced LI ($Z = -0.259$, $P = 0.398$ one-tailed).

Openness and number of trials to rule recognition were significantly correlated in the pre-exposed (experimental) condition ($r = -0.440$, $P = 0.0001$). This correlation remained essentially unchanged ($r = -0.442$) when IQ was partialed out, indicating that the relationship between LI and Openness was independent of IQ. Nonparametric tests revealed a similar negative correlation between Openness and LI scores (Spearman's $rho = -0.446$, $P = 0.0001$).

3.5. Latent inhibition and remaining personality variables

The correlations between the remaining personality variables and number of trials to rule recognition in the pre-exposed condition are listed in Table 2. Scores on the EPQ Psychoticism Scale and LI scores in the pre-exposed condition were correlated significantly ($r = -0.287$, $P = 0.043$). In addition, scores on the Extraversion Scale of the EPQ were also significantly related to pre-exposed LI scores ($r = -0.309$, $P = 0.029$). Although Openness was not significantly correlated with either Psychoticism ($r = 0.167$, $P = 0.147$) or Extraversion ($r = -0.023$, $P = 0.844$; see Table 3), a partial correlation analysis was conducted to determine whether the relationship between Openness to Experience and LI was due in part to the relationship between LI, Extraversion, and Psychoticism. When the effects of Psychoticism and Extraversion were controlled, the correlation between LI and Openness increased (partial $r = -0.451$, $P = 0.001$). Likewise, when the effects of Openness and Psychoticism were

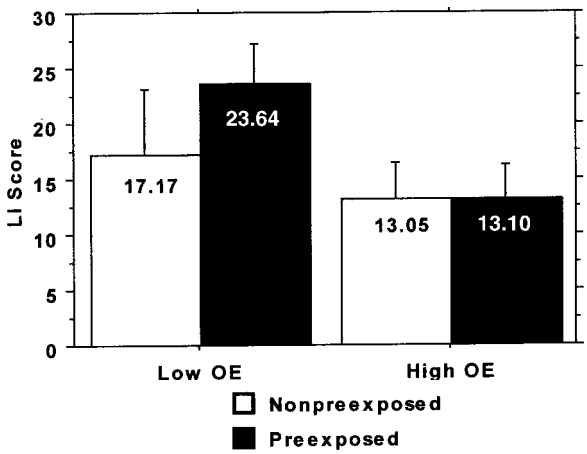

Fig. 3. Latent inhibition and openness (pre-exposed and non-pre-exposed conditions).

Table 2
Relationship of latent inhibition scores (pre-exposed condition) to other personality variables (**Bold** = significant at $P < 0.05$)

Variable	Pearson's *r*	*P*-value	Spearman's *rho*	*P*-value
Neuroticism-NEO	0.162	0.230	0.170	0.228
Extraversion-NEO	−0.184	0.192	−0.162	0.250
Agreeableness-NEO	−0.154	0.277	−0.126	0.373
Conscientiousness-NEO	0.027	0.847	0.038	0.788
Extraversion-EPQ	**−0.309**	**0.029**	**−0.361**	**0.010**
Neuroticism-EPQ	0.122	0.400	0.156	0.279
Psychoticism-EPQ	**−0.287**	**0.043**	−0.254	0.075
Lie Scale-EPQ	0.119	0.406	0.147	0.355

controlled, the correlation between Extraversion and LI increased (partial $r = -0.345$, $P = 0.016$). However, the partial correlation between Psychoticism and LI when the other variables were controlled decreased (partial $r = -0.230$, $P = 0.116$).

A stepwise regression (entry $P < 0.05$, removal $P < 0.10$) upon pre-exposed LI scores indicated that Openness and EPQ Extraversion, but not Psychoticism, predicted trials to recognition in the pre-exposed condition: Openness alone yielded an *R*-square of 0.228 ($R = 0.477$) ($F(1,48) = 14.19$, $P = 0.0005$), while Openness ($t(48) = -3.85$, $P = 0.0004$) and Extraversion ($t(48) = -2.40$, $P = 0.02$) jointly yielded an *R*-square of 0.312 ($R = 0.559$) ($F(2,47) = 10.69$, $P = 0.0001$). [Note: *R*-values reflect listwise deletion of cases in which Psychoticism scores ($n = 9$) were missing. This accounts for the difference between the stepwise analysis and the correlations reported above.]

4. Discussion

The data from this experiment indicate that healthy, highly intelligent subjects differing in trait Openness may also be characterized by differences in what appears to be a more fundamental cognitive/neurophysiological response to 'previously encountered' information. The size and significance of the relationship demonstrated between attenuated latent inhibition and Openness is substantial enough to provide justification for research into the direct links between Openness and potential neuropharmacological correlates suggested by current LI animal research. Although it would be overly simplistic to suggest a one-on-one relationship

Table 3
Correlation of openness with EPQ personality variables

Variable	*r*	*P*-value
Extraversion	−0.023	0.843
Neuroticism	−0.083	0.483
Psychoticism	0.167	0.147

between a personality dimension and a specific neural pathway, personality differences in Openness may be associated with baseline differences in the activity of the mesolimbic dopamine system. Detectable personality changes associated with Openness might be produced as a consequence of the pharmacological manipulation of the activity of this system.

It is of interest that the three personality dimensions related to attenuated LI share a characteristically *approach*-oriented response to novelty. All three variables demonstrate sizeable correlations with Zuckerman's Sensation Seeking Scales (SSS: Zuckerman, Eysenck & Eysenck, 1978): Openness is associated with the Novelty Seeking Subscale (McCrae, 1987), whereas Psychoticism and Extraversion are associated with Thrill-and-Adventure-Seeking (e.g. Goma-i-Freixanet, 1995), suggesting that further research using LI and personality include measures of sensation seeking.

Furthermore, the results of the stepwise regression analysis, in which Openness and Extraversion predicted LI scores, are suggestive of recent research on higher order personality variables. Digman (1997) examined factor correlations from 14 published studies of the Big Five and NEO personality scales, and found that two overreaching factors consistently emerged. One of the two factors, β, comprised Openness and Extraversion. The findings of the current study pose the possibility that the overarching factor β may be neurophysiologically defined, in part, by reductions in latent inhibition. That is, β may represent an attenuation in the tendency to precategorize stimuli as irrelevant, and a consequent propensity to perceive incoming stimuli as inherently interesting and novel.

The robust association between reduced LI and heightened Openness to Experience—associated with creativity and open-mindedness (McCrae, 1994)—suggests that under at least some circumstances reductions in LI may be advantageous, rather than pathological. The data from the present experiment also suggest that attenuated latent inhibition should not be described solely in terms of deficient attentional processing, or considered without qualification as a marker for the presence of mental disorder or tendency towards such disorder. Perhaps high Openness in the presence of high IQ is advantageous, as Berenbaum and Fujita (1994) have theorized, while in the absence of high levels of intelligence it is one factor that predisposes to psychosis. Reductions in LI may impart psychological or cognitive advantages to certain individuals depending on contextual personality considerations.

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