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Openness and extraversion are associated with reduced latent inhibition: replication and commentary

Jordan B. Peterson[a,*], Kathleen W. Smith[a], Shelley Carson[b]

[a]Department of Psychology, University of Toronto, 100 St. George Street, Toronto, Ontario, Canada M5S 3G3
[b]Department of Psychology, Harvard University, Cambridge, MA, USA

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Abstract

Latent inhibition (LI) is a preconscious gating mechanism that allows animals with complex nervous systems to ignore stimuli previously experienced as irrelevant. Decreased LI has been associated with dopaminergic agonist intoxication and schizophrenic conditions. We previously demonstrated reductions in LI among individuals characterized by higher levels of trait Openness and Extraversion. This study replicates our previous findings, using another university student sample (Total $N=79$). Participants characterized by decreased LI ($N=23$) were significantly more Open (Mean = 36.7, S.D. = 5.4; $N=23$) and Extraverted (Mean = 31.4, S.D. = 7.1) than those who manifested intact LI ($N=54$; Openness Mean = 33.7, S.D. = 7.1, $t=1.80$, $P<0.04$, $d=0.44$; Extraverted Mean = 28.2, S.D. = 6.6, $t=1.85$, $P<0.04$, $d=0.46$). The two groups were better differentiated, however, by the simple additive combination of z-scored Extraversion and Openness, deemed Plasticity ($P<0.01$, $d=0.57$). Differences between the two groups also emerged with regards to Gough's Creative Personality Scale [J. Pers. Soc. Psychol. 37 (1979) 1398], with the Low LI group scoring higher than the High LI group ($P<0.03$, $d=0.46$). © 2002 Published by Elsevier Science Ltd.

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The roaring of lions, the howling of wolves,
the raging of the stormy sea, and the destructive sword,
are portions of eternity, too great for the eye of man.

William Blake, Proverbs of Hell, in *The Prophetic Books*

* Corresponding author. Tel.: +1-416-978-7619; fax: +1-416-978-4811.
E-mail address: jpeterson@psych.utoronto.ca (J.B. Peterson).

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Because the natural environment is complex beyond description (Medin & Aguilar, 1999), "what can be ignored" is a more important issue than "what should be attended to." In consequence, organisms with complex nervous systems appear to have evolved a gating mechanism that allows them to cease responding to stimuli with no apparent motivational or emotional value. Novel stimuli automatically attract attention (Gray, 1982; Peterson, 1999). When such stimuli are presented repeatedly in the absence of subsequent reinforcement, however, they lose their initial valence (Gray & McNaughton, 1996). Such loss has classically been considered a consequence of habituation, but might more aptly be considered the outcome of exploration and classification, at least in the case of more complex objects, events and situations (Peterson, 1999).

The phenomenon of attenuated attention, attendant upon repeated exposure, has been termed latent inhibition or LI (Lubow, 1989). The capacity for latent inhibition characterizes a number of mammalian species, and its biological underpinnings have been extensively studied (Lubow & Gewirtz, 1995). Rats treated with dopaminergic agonists such as amphetamine, which heighten attention, show decrements in latent inhibition (Weiner, Lubow, & Feldon, 1988), while humans and animals treated with dopaminergic antagonists—frequently used as antipsychotics—show enhanced LI (Shadach, Feldon, & Weiner, 1999; Weiner & Feldon, 1987). In keeping with the psychopharmacological findings, reductions in LI have generally been associated with psychopathological predispositions in humans theoretically characterized by abnormalities of dopaminergic neurotransmission—most particularly with schizophrenia and its associated features and conditions (Baruch, Hemsley, & Gray, 1988a, 1988b; Lubow & Gewirtz, 1995; Serra, Jones, Toone, & Gray, 2001). We have recently produced evidence, however, that reductions in LI are also associated with heightened levels of the two big five traits Openness (from the NEO-FFI; Costa & McCrae, 1992) and Extraversion (from the Eysenck Personality Questionnaire; Eysenck, S.B.G., Eysenck, H.J & Barrett, 1985), in a high-achieving student sample (Peterson & Carson, 2000). This might not be considered surprising, from a perspective dually informed by trait personality research and behavioral neuropharmacology.

First, extraversion has been associated in principle with increased activity in the ventral tegmental area dopamine projections—which are directly involved in coding incentive motivation, associated with exploratory behavior and positive affect (Ashby, Isen & Turken, 1999; Depue & Collins, 1999; Panksepp, 1999)—and has been appropriately alternately conceptualized as surgency (Goldberg, 1992) or positive emotionality (Tellegen, 1985). Openness, in turn, has been associated with intellect (Goldberg, 1992), with creativity, aesthetic, religious and philosophical tendencies (King, Walker, & Broyles, 1996; McCrae, 1996, 1999) and, more specifically, with "breadth, depth and permeability of consciousness" and "the recurrent need to enlarge and examine experience" (McCrae & Costa, 1997). This makes openness sound very much like the philosophical or abstract analog of exploratory behavior, concretely expressed as part of extraversion. It is therefore of great interest to note that the dopaminergic VTA projections extend not only to the mesolimbic systems that mediate incentive reward, approach and exploratory behavior, but also to the prefrontal cortex, critically involved in planning and thinking—processes that may be profitably viewed as abstracted exploratory behavior (Granit, 1977; Panksepp, 1999; Peterson, 1999). So perhaps extraversion and openness might be viewed as aspects of a more basic exploratory tendency (DeYoung, Peterson, & Higgins, in press), in its somewhat separable concrete behavioral and abstract intellectual manifestations.

Digman's (1997) examination of the higher-order factor structure of big five trait personality models lends credence to such a suggestion. Digman analyzed patterns of factor correlations from 14 published studies, and found that extraversion covaried positively and specifically with trait openness—while agreeableness, emotional stability (reversed neuroticism), and conscientiousness covaried consistently together, in a similar fashion. We have recently replicated his analysis in two separate samples (DeYoung et al., in press), arguing that the extraversion/openness dimension might well be regarded as plasticity, and that agreeableness/emotional stability/conscientiousness might be regarded as stability (following Grossberg, 1987). Grossberg argued, in short, that any complex neural network had to be composed of an element that maintained the stability of categorical structures, and another element that slowly updated those structures, to account for ongoing environmental transformation (see also Peterson, 1999). These notions appear in keeping with Digman's descriptions of his higher-order traits. He suggested that the stability element (which he termed *alpha*) might be regarded as a ''socialization'' factor, serving as a measure of such things as impulse control and restraint, while the plasticity element (which he termed *beta*) might be considered a measure of the tendency towards full experience (Maslow, 1950) and personal growth.

The central idea underlying our research program is therefore that individuals characterized by increased plasticity (extraversion and openness) retain higher post-exposure access to the range of complex possibilities laying dormant in so-called ''familiar'' environments. This heightened access is the subjective concomitant of decreased latent inhibition, which allows the plastic person increased incentive-reward-tagged appreciation for hidden or latent information (Peterson, 1999). Such decreases in LI may have pathological consequences, as in the case of schizophrenia or its associated conditions (perhaps in individuals whose higher-order cognitive processes are also impaired, and who thus become involuntarily ''flooded'' by an excess of affectively tagged information), or may constitute a precondition for creative thinking (in individuals who have the cognitive resources to ''edit'' or otherwise constrain (Stokes, 2001) their broader range of meaningful experience).

We therefore attempted to determine if the combination of extraversion and openness (''plasticity'') was associated with reduced LI in a more typical student population (our previous work was conducted on Harvard undergraduates), using the NEO-FFI (Costa & McCrae, 1992). We also administered Gough's (1979) Creative Personality Scale, as a measure logically convergent with both plasticity and openness, as well as two WAIS-R IQ scales (Wechsler, 1981), to control for the potential confounding effect of IQ on LI (which is arguably a cognitive as well as a motivational task).

1. Method

1.1. Participants

Seventy-nine university students, age 18–40 (mean 22.2, S.D. 3.5), were recruited by signs on campus, or through a sign-up sheet circulated in a class. Fifty-nine were female; 20 were male. Our previous investigation (Peterson & Carson, 2000) had already demonstrated that the LI task performed as expected in a similar population (with the pre-exposed group taking significantly more trials to rule identification than the non-pre-exposed group). In consequence, we maximized power by assigning all participants to the pre-exposed (experimental) LI condition only. Each participant was paid $10.

1.2. Description of tasks

1.2.1. Latent inhibition task

Subjects were shown a two-part video version of the auditory latent inhibition task, constructed after Lubow, Ingberg-Sachs, Zalstein-Orda, and Gewirtz (1992):

In part one, the pre-exposure phase, there was no visual component; participants heard a list of 30 nonsense syllables (the *masking* material), repeated five times. Short white noise bursts (the *target stimulus*) were superimposed randomly 31 times over this recording, at approximately 2/3 the volume of the nonsense syllables. Subjects were given a masking task during this phase. They were told that the third nonsense syllable (‘‘bim’’) would be their ‘‘target syllable.’’ Their task was to determine how many times ‘‘bim’’ was repeated.

In part two, the test phase, the nonsense syllable/white-noise recording was replayed while yellow disks arranged in rows on a black scoreboard appeared one by one on the video screen. The appearance of the yellow disks corresponded with the presentation of the white noise target stimulus. 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 five consecutive trials, the experimenter stopped the videotape and asked the subject to identify the rule. If the subject guessed correctly, the task ended. If the subject was wrong, the task continued. 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. Possible scores ranged from 6 to 31.

1.2.2. Personality inventories

Participants completed the NEO Five Factor Inventory (FFI), Form S (Costa & McCrae, 1992). The inventory consists of 60 statements, such as ‘‘I really enjoy talking to people’’; for each statement, participants rated themselves on a five-point scale ranging from Strongly Disagree to Strongly Agree.

Participants also completed the Creative Personality Scale (Gough, 1979). The scale consists of a 30 adjective checklist, derived from analysis of the personality of evidently creative individuals, composed of such items as ‘‘capable’’ or ‘‘sincere.’’ Participants check all adjectives that apply to them (Gough, 1979). Eighteen of these adjectives are scored as contributing one point each; the other 12 are scored by subtracting one point each. Items that are not chosen are not scored. The possible range of scores is -12 to $+18$.

1.2.3. Intelligence measures

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. Results

Means and SDs for the five FFI subscales, the two higher-order Big Five constructs, the Creative Personality Scale, and the two WAIS-R subscales are presented in Table 1. Data for Block Design scores were unusable for 11 subjects, due to an intermittently malfunctioning stopwatch, later detected. Data for Vocabulary scores were unreliable for 16 subjects who spoke English fluently, but not as a first language. Zero-order correlations between the personality and IQ measures are presented in Table 2.

Subjects were divided into low ($\leqslant$20 trials, $n=23$) and high ($\geqslant$25 trials, $n=54$) LI groups, based on the natural split in the bimodal LI distribution (Fig. 1). This split occurred in precisely the same location as specified in our previous study (Peterson & Carson, 2000).

There were no significant age or gender-related differences in LI. Table 3 contains means, S.D.s, independent-sample t-test statistics and Cohen's d effect size estimates for LI group differences for the NEO-FFI scales, the two higher-order Big Five constructs ("Plasticity" and "Stability"), the Creative Personality Scale and the two WAIS-R subscale scores. Plasticity was constructed by averaging z-scored Extraversion and Openness. Stability was constructed by averaging z-scored Agreeableness, Conscientiousness and (Neuroticism $\times -1$).

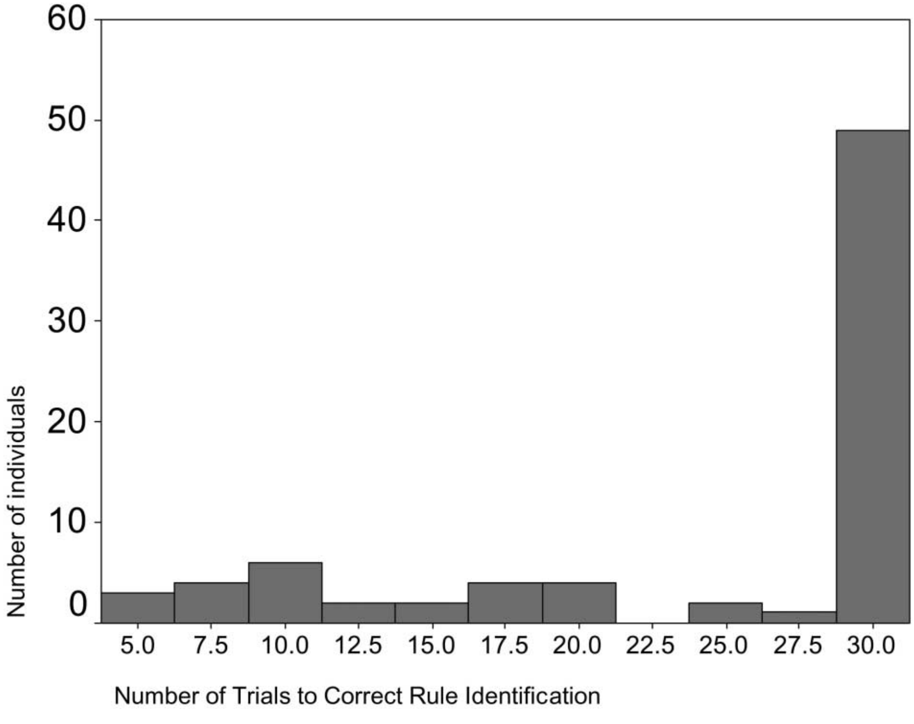

Fig. 1. LI score histogram illustrating natural breakpoint.

The LI groups differed significantly, with participants characterized by lower LI scores producing significantly higher self-ratings, in order of magnitude, for openness, extraversion, creative personality and plasticity (Cohen's d ~ranging from 0.45 to 0.55). Fig. 2 presents z-scored means and standard errors for the significant differences.

Table 1
Numbers, means and standard deviations for personality and IQ measures

	N	*M*	S.D.
Agreeableness	79	31.2	6.12
Conscientiousness	79	31.6	6.96
Neuroticism	79	22.4	9.61
Openness	79	34.4	6.73
Extraversion	79	29.2	6.79
Plasticity	79	0.0	0.79
Stability	79	0.0	2.26
Creative PS	79	7.3	3.99
WAIS Block Design	68	13.0	2.38
WAIS Vocabulary	63	14.8	2.17

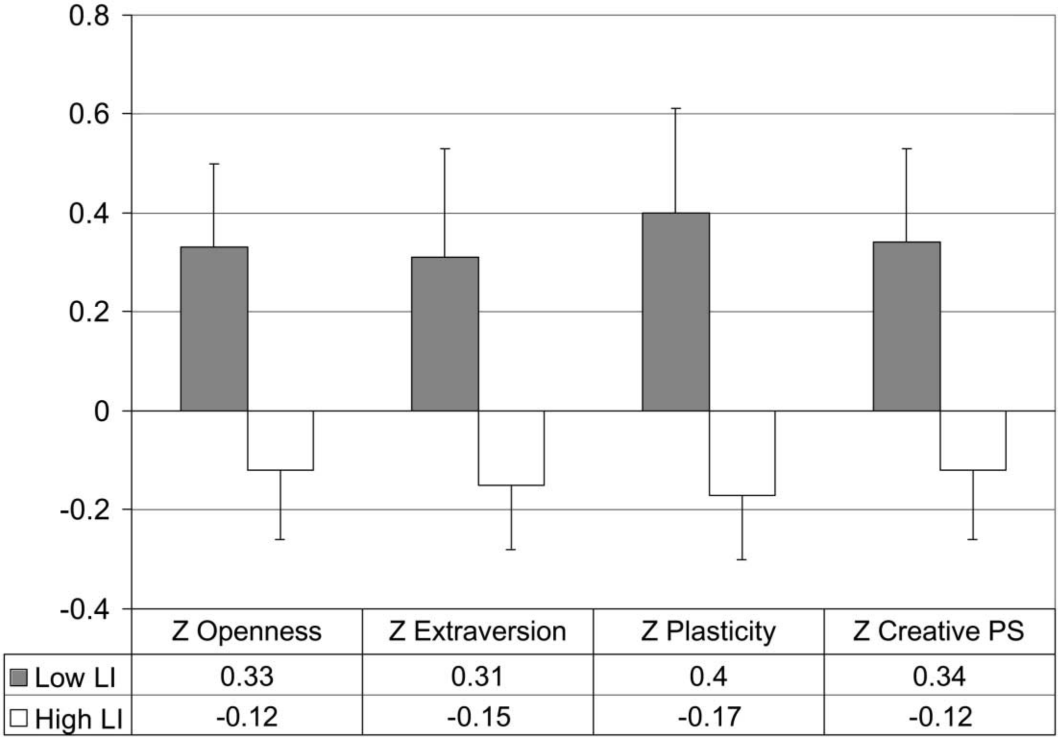

Fig. 2. Z-scored means and standard errors for significantly different personality measures. All P values < 0.05 (one-tailed).

Table 2
Zero-order correlations between measures of personality and IQ

	C	N	O	E	Pl	St	CPS	W-BD	W-Voc[a]
Agreeableness									
r	0.274**	−0.304**	0.135	0.256*	0.247*	0.699**	0.124	−0.088	0.132
p	0.007	0.003	0.118	0.011	0.014	0.001	0.138	0.238	0.15
N	79	79	79	79	79	79	79	68	63
Conscientiousness									
r		−0.472**	0.13	0.242*	0.235*	0.773**	0.141	0.174	−0.023
p		0.001	0.127	0.016	0.019	0.001	0.108	0.078	0.428
N		79	79	79	79	79	79	68	63
Neuroticism									
r			−0.12	−0.449**	−0.359**	−0.786**	−0.346**	−0.073	−0.105
p			0.146	0.001	0.001	0.001	0.001	0.278	0.207
N			79	79	79	79	79	68	63
Openness									
r				0.253*	0.792**	0.17	0.451**	0.203*	0.383**
p				0.012	0.0010	0.067	0.001	0.049	0.001
N				79	79	79	79	68	63
Extraversion									
r					0.792**	0.419**	0.402**	0.015	0.135
p					0.001	0.001	0.001	0.452	0.146
N					79	79	79	68	63
Plasticity									
r						0.372**	0.539**	0.141	0.321**
p						0.001	0.001	0.126	0.005
N						79	79	68	63
Stability									
r							0.271**	0.072	0.095
p							0.008	0.281	0.23
N							79	68	63
Creative PS									
r								−0.077	0.362**
p								0.266	0.002
N								68	63
WAIS Block Design									
r									0.215
p									0.058
N									55

[a] W-Voc, WAIS-R Vocabulary.
* Correlation is significant at the 0.05 level, one-tailed.
** Correlation is significant at the 0.01 level, one-tailed.

3. Discussion

Results from this study were, if anything, clearer than those of our initial study—particularly with regards to the contribution of extraversion. This was perhaps due to the increased *N* (79 in this study in the post-exposure LI condition, compared to 58 in the original). It therefore seems

Table 3
LI Group independent samples *t*-test and descriptive statistics

	LI group	*N*	Mean	S.D.	*t*	df	One-tail *P*	*d*
Agreeableness	Low	23	31.5	7.5	*0.35*	*33*	0.73	0.10
	High	54	30.9	5.5				
Conscientiousness	Low	23	31.8	8.0	0.18	75	0.86	0.05
	High	54	31.5	6.7				
Neuroticism	Low	23	21.3	9.7	−0.71	75	0.48	−0.18
	High	54	23.0	9.7				
Openness	Low	**23**	**36.7**	**5.4**	**1.8**	**75**	**0.04**	**0.44**
	High	**54**	**33.7**	**7.1**				
Extraversion	Low	**23**	**31.4**	**7.1**	**1.85**	**75**	**0.04**	**0.46**
	High	**54**	**28.2**	**6.6**				
Plasticity	Low	**23**	**0.319**	**0.81**	**2.33**	**75**	**0.01**	**0.57**
	High	**54**	**−0.131**	**0.76**				
Stability	Low	23	0.19	2.4	0.57	75	0.57	0.14
	High	54	−0.14	2.2				
Creative PS	Low	**23**	**8.60**	**3.6**	**1.88**	**75**	**0.03**	**0.46**
	High	**54**	**6.70**	**4.1**				
WAIS Block Design	Low	20	12.8	2.8	−0.55	64	0.59	−0.15
	High	46	13.2	2.2				
WAIS Vocabulary	Low	19	15.0	1.9	0.28	59	0.78	0.08
	High	42	14.8	2.3				

reasonable to conclude that decreased LI may be associated with personality configurations that are non-pathological, or even positive, as well as serving as a potential risk factor or marker for psychosis. What might be the advantages, as well as the disadvantages, of decreased LI?

We know that the DA system underlies exploratory response to novelty, and that LI appears to be a dopamine-dependent phenomenon, as discussed previously. Furthermore, we know that decreased LI can be associated with pathology, that such decreases can be elicited by corticosterone, a primary stress hormone, and that heightened levels of stress might produce the "sensory flooding" characteristic of psychosis (Shalev, Feldon, & Weiner, 1998). Finally, it appears that decreased LI is associated with creative personality (present study) and with creative achievement (at least in populations characterized by outstanding academic performance) (Carson, Peterson, & Higgins, submitted).

So perhaps we could hypothesize something like this: under stressful conditions, or in personality configurations characterized by increased novelty-sensitivity, approach behavior, and DA activity, decreased LI is associated with increased permeability and flexibility of functional cognitive and perceptual category [see Barsalou (1983) for a discussion of such categories]. Imagine a situation where current plans are not producing desired outcomes—a situation where current categories of perception and cognition are in error, from the pragmatic perspective. Something anomalous or novel emerges as a consequence (Peterson, 1999), and drives exploratory behavior. Stress or trait-dependent decreased LI, under such circumstances, could produce increased signal (as well as noise), with regards to the erroneous pattern of behavior and the anomaly that it produced. This might offer the organism, currently enmeshed in the consequences of mistaken presuppositions, the possibility of gathering new information, where nothing but categorical certainty once existed. Decreased LI might therefore be regarded as advantageous, in that it allows for the perception of more unlikely, radical and numerous options for reconsideration, but disadvantageous in that the stressed or approach-oriented person risks "drowning in possibility," to use Kierkegaard's phrase. So what might distinguish the person who derives advantage, from a broader range of possibilities, from the one who risks submersion?

Berenbaum and Fujita (1994) have suggested that the combination of high openness and low intelligence might be associated with schizophrenia. We have found, in the same vein, that the combination of high IQ and low LI powerfully predicts creative achievement (Carson et al., 2002). We are also currently investigating the possibility that increased working memory might serve a similar function. First, working memory capability is assessed by measuring the number of independent elements that can simultaneously be tracked and manipulated (Petrides, 2000). This means at least in theory that broader working memory capacity might be useful for dealing with the broader array of affectively tagged stimuli that emerges as a consequence of reduced latent inhibition. Second, there is evidence for relatively specific working memory and attention deficits among schizophrenics and schizotypes (Elvevag & Goldberg, 2000; Kenny et al., 1999; Kirrane & Siever, 2000).

This would make the individual predisposed to schizophrenia suffering, in principle, from the pathological and possibly synergistic combination of excess experiential, ideational or associational variability, and a decrement in methods of selecting from that excess, while the healthy, open and creative individual would be characterized by a broader gate and careful post-experience selection and culling. So, we have an operationalized quasi-Darwinian approach to the problem of psychosis and creativity [as originally suggested by Campbell (1960) and Simonton (1999)]. There are many mutations in the real world, but most of them are harmful, or fatal. Likewise, many alternative modes of perception and cognition can be applied to a given problem, but most of them are useless, or counterproductive. The mutation problem is solved by selection: the environment culls the failures, and allows the successes to breed. The analogous perception problem is solved by higher-order cognition. Many possibilities emerge as a consequence of decreased LI. These are culled by careful consideration and analysis of the likely real-world environmental consequences of implementing them. Under optimal conditions, most are eliminated from further consideration. In the absence of such culling, however, the "mutations" overpower the functional categories, and the person begins to enact his or her pathological ideas.

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