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HYPNOTIC SUSCEPTIBILITY: *Multidimensional Relationships With Cloninger's Tridimensional Personality Questionnaire, COMT Polymorphisms, Absorption, and Attentional Characteristics*[1]

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Abstract: One hundred and seven healthy volunteers were administered Cloninger's Tridimensional Personality Questionnaire (TPQ), the Differential Attentional Processes Inventory (DAPI), the Tellegen Absorption Scale (TAS), and the Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C). Polymorphisms of catechol O-methyltransferase (COMT), an enzyme involved in dopamine metabolism, were assessed. Highly hypnotizable subjects self-reported greater TPQ persistence, absorption, and focused attentional abilities. Hierarchical multiple regression analyses found that TPQ persistence, COMT, TAS, and the DAPI attentional scales explained 43.8% of the variance in women and 29% in men. Membership was correctly discriminated for the more extreme low (62.1%) and highly (81.5%) hypnotizable groups. These results suggest that highly hypnotizable persons have a more effective frontolimbic attentional system and further suggest the involvement of dopaminergic systems in hypnotizability.

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Responsiveness to hypnosis is as stable over time as any personality trait, its stability rivaling that of IQ (Morgan, Johnson, & Hilgard, 1974; Piccione, Hilgard, & Zimbardo, 1989). This stability suggests that underlying genetic and neurophysiological factors, as well as socio-environmental factors, contribute to hypnotic susceptibility (Horton & Crawford, in press). Research has, over many decades, concentrated on identifying the abilities, propensities, and characteristics underlying hypnotic susceptibility in an attempt to construct a theory of how they interact. Hypnosis often involves an amplification of focused attention and a reallocation of attention. In the literature, we find evidence for a hypothesized link between hypnotizability and sustained attentional and disattentional abilities (Crawford, Brown, & Moon, 1993; Tellegen & Atkinson, 1974) and cognitive flexibility (Crawford, 1989; Crawford & Allen, 1983). The present multivariate study extends this research to evaluate relationships between hypnotic susceptibility and Cloninger's Tridimensional Personality Questionnaire (TPQ; Cloninger, 1987), something not yet reported in the literature. To determine its predictability along with several previously investigated measures of attentional and absorptive abilities, we examined the Differential Attentional Processes Inventory (DAPI; Crawford, Brown, et al., 1993; Grumbles & Crawford, 1981) and the Tellegen Absorption Scale (TAS; Tellegen, 1982; Tellegen & Atkinson, 1974). In a hierarchical multiple regression, we assessed the additional predictive value of catechol O-methyltransferase (COMT) polymorphisms, shown to be associated with hypnotizability in the same participants (Lichtenberg, Bachner-Melman, Gritsenko, & Ebstein, 2000). Finally, we assessed for possible gender differences in significant predictors of hypnotic susceptibility.

Genetic Factors Associated with Hypnotic Susceptibility

Hypnotic susceptibility has been shown to have a genetic component (Lichtenberg et al., 2000; Morgan, 1973; Morgan, Hilgard, & Davert, 1970). Morgan et al. (1970; see also Morgan, 1973) found in 80 families with at least one set of twins that there was a significant intraclass correlation of .63 ($n = 35$, $p = .001$) for monozygotic twins but no significant correlation for same-sex dizygotic twin pairs and other fraternal pairs. Bauman and Bul' (1981) found a hypnotizability concordance rate of 78.3% in 60 pairs of twins in Russia. A familial component in hypnotizability is supported by Wallace and Persanyi's (1989) findings that college students with sinistral relatives were lower in hypnotic responsiveness, as were also the sinistral relatives when tested.

In the past 10 years, behavioral genetics has shown exciting relationships between genetic factors and cognitive processes. Our group recently reported the first study (Lichtenberg et al., 2000) examining

the genetic underpinnings of hypnotic susceptibility by evaluating COMT, a genotype that predicts performance on prefrontal executive cognition and working memory tasks (for review, see Weinberger et al., 2001). COMT is involved in the metabolic degradation of dopamine (Karoum, Chrapusta, & Egan, 1994). The methionine (met) allele is associated with better frontal lobe functioning, as measured by the Wisconsin Card Sorting Test (WCST), than the valine (val) genotypes in healthy (Egan et al., 2001; Malhotra et al., 2002) and schizophrenic patients and their siblings (Egan et al.). Of possible relevance, high hypnotizables were found, in a small study, to perform better than lows on the WCST (Aikens & Ray, 2001).

When 107 participants were tested for the high/low enzyme activity COMT polymorphisms, Lichtenberg et al. (2000) found a significant difference between the COMT val/val, val/met, and met/met genotypes on hypnotizability. Individuals with COMT val/val genotypes were significantly lower in hypnotizability than those with val/met or met/met COMT genotypes. Unexplained is that these relationships were present in the total and female sample but not the male sample. Our finding that lows were more likely to fall within the COMT val/val genotype provides further support to the theoretical models of Crawford and her associates (Crawford, 1994; Crawford & Gruzelier, 1992) that low hypnotizability is associated with poorer attentional and inhibitory processing associated with the prefrontal cortex.

Tridimensional Personality Questionnaire

Given the above, of particular relevance are personality measures that are considered by some researchers to be neurogenetically based. To our knowledge the relationships between the TPQ (Cloninger, 1987) and hypnotic susceptibility have not yet been addressed. The TPQ draws on human and animal work to suggest that behavior is mediated by certain neurotransmitters that underlie four basic and largely heritable dimensions: novelty seeking, harm avoidance, reward dependence, and persistence (e.g., Hansenne & Ansseau, 1999; Hennig, Toll, Schonlau, Rohrmann, & Netter, 2000). Cloninger and associates (1987; Cloninger, Svrakic, & Przybeck, 1993; Heath, Cloninger, & Martin, 1994) postulate that these basic temperament traits are heritable emotional dispositions that interact with the environment. Of particular interest to our present study are persistence and novelty seeking.

Persistence. The TPQ persistence dimension is characterized by a tendency to persevere despite frustration instead of becoming discouraged and giving up when expectations are not immediately satisfied (Cloninger et al., 1993). A sample question is, ''I am usually so

determined that I continue to work long after other people have given up.'' Although yet to be tested directly, higher scoring on persistence suggests a stronger goal-directed behavior, something that has been associated with the prefrontal cortex (Grafman, 2002). Thus, it is of interest that COMT and serotonin polymorphisms jointly interact with TPQ persistence (Benjamin et al., 2000). Given this, we proposed that persistence would be predictive of hypnotic susceptibility. Whether TPQ persistence is related to absorption and attentional abilities was open to investigation.

A potentially similar scale is strength of excitation, one of the three major dimensions of the Strelau Temperament Inventory (STI; Strelau, 1983), which is defined as the ''ability to do long-lasting and intensive work, speed of recovery after fatigue and intensive activity, persistence and ease in coping with obstacles'' (p.116). Crawford, Brown, et al. (1993) found this construct to be unrelated to hypnotic susceptibility and point out that others (e.g., Ruch, Anglietner, & Strelau, 1991) find psychometric problems with the STI and suggest the use of new or revised scales, as is done herein.

Sensation seeking. A link between hypnotizability and sensation seeking is reported in research (Johnston & Jaremko, 1979; Lyons, 1984; Zuckerman, Bone, Neary, Mangelsdorff, & Brustman, 1972; but see Kumar, Pekala, & Cummings, 1996). Observed differences across these studies may possibly be due to small sample sizes, different measures, and/or only a global multidimensional measure of sensation seeking being used.

The TPQ novelty-seeking dimension is viewed as ''a heritable bias in the activation or initiation of behaviors such as frequent exploratory activity in response to novelty, impulsive decision making, extravagance in approach to cues of reward, quick loss of temper, and active avoidance of frustration'' (Svrakic, Przybeck, Whitehead, & Cloninger, 1999, p. 248). People scoring high on this trait enjoy exploring new environments, which they may describe as thrilling. They are impulsive, risk-taking (with or without control), excitable, and quick-tempered. The TPQ novelty-seeking dimension is strongly convergent with Zuckerman's (1993, 1994) construct of sensation seeking but extends it conceptually by examining different aspects of it in four subscales. Specifically, the subscales that comprise the TPQ novelty-seeking measure are: (a) exploratory excitability versus stoic rigidity (sample question: ''When nothing new is happening, I usually start looking for something that is thrilling or exciting''); (b) impulsivity versus reflection (e.g., ''I often follow my instincts, hunches or intuition without thinking through all the details''); (c) extravagance versus reserve (all of these questions deal with attitudes towards spending habits, e.g., ''Because I so often spend too much money on impulse, it is

hard for me to save money—even for special plans like a vacation''); and (d) disorderliness versus regimentation (e.g., ''I like it when people can do whatever they want without strict rules and regulations''). By considering the four subscales, we hope to clarify which is predictive of hypnotic susceptibility.

Other TPQ scales. Two other TPQ scales were not anticipated to be predictive of hypnotic susceptibility. Harm avoidance is described as ''a tendency to respond intensely to previously established signals of aversive stimuli and to learn passively to avoid punishment, novelty, and frustrative nonreward'' (Christodoulou & Rosen, 1995, p. 1307). Reward dependence is defined as ''a tendency to respond intensely to signals of reward (especially social reward) and to maintain behavior previously associated with reward or with relief from punishment'' (Christodoulou & Rosen, 1995, p. 1307). Neither of these constructs has been measured in conjunction with hypnotizability, and there is little theoretical evidence to suggest there should be a relationship.

Sustained and Absorptive Attentional Abilities

Highly hypnotizable persons are proposed to possess superior abilities to sustain attention over time without disturbances from distractions (e.g., Crawford, Brown, et al., 1993) and to become more deeply absorbed in their environmental surroundings (Tellegen & Atkinson, 1974). Crawford and associates (Crawford, 1994; Crawford & Gruzelier, 1992) proposed a model of hypnosis according to which highly hypnotizable persons possess a stronger attentional filtering system associated with the far fronto-limbic attentional system than do lows. Highs' superior ability to eliminate the perception of pain (for a review, see Hilgard & Hilgard, 1994) is thought to be due to their more effective frontal inhibitory/attentional system (for reviews, see Crawford, 1994, 2001; Crawford & Gruzelier, 1992; Crawford, Knebel, Vendemia, Horton, & Lamas, 1999; but see Miller & Bowers, 1993, for an alternative theoretical perspective). The ability to engage in cognitive inhibition, as demonstrated with negative priming, correlates positively with hypnotic susceptibility (David & Brown, 2002; David, King, & Borckardt, 2001). Schnyer and Allen (1995) report electrophysiological findings that support the ability of highly hypnotizable participants to sustain focused attention outside of hypnosis. Highs may demonstrate faster reaction times than lows in simple response (Braffman & Kirsch, 2001) and decision making (Crawford & Allen, 1983; Crawford, Kapelis, & Harrison, 1995; Mészáros, Crawford, Szabó, Nagy-Kovács, & Révész, 1989) tasks. Further, they show increased afterimage persistence (Atkinson & Crawford, 1992; Wallace, 1979) and greater ability to detect embedded words among letters (Wallace,

Allen, & Weber, 1994), which also suggest enhanced attentional abilities.

One aspect of attentional abilities is absorption, described by Tellegen and Atkinson (1974, p. 268) as ''a disposition for having episodes of 'total' attention that fully engaged one's representational (i.e., perceptual, enactive, imaginative, and ideational) resources.''

The construct is generally measured using the TAS and is a fairly reliable correlate (e.g., Hoyt et al., 1989; Tellegen & Atkinson, 1974; Zachariae, Jørgensen, & Christensen, 2000; for a review, see Roche & McConkey, 1990) and predictor (Dixon, LaBelle, & Laurence, 1996) of hypnotizability. Related to absorption, but without the altered state of consciousness component as is found in the TAS, the DAPI's subscale of extremely focused attention (Crawford, Brown, et al., 1993; Lyons & Crawford, 1997) or total score (Kallio, Revonsuo, Hämäläinen, Markela, & Gruzelier, 2001) correlates with hypnotizability. In the present study, we wished to determine if these scales added significantly to the prediction of hypnotizability, above and beyond persistence and COMT, in our hierarchical multiple regressions for both the total sample and for women and men separately.

Aims of the Present Study

Using multivariate approaches to assess how well hypnotic susceptibility is related to and can be predicted by Cloninger's TPQ, COMT polymorphisms, absorption, and attentional characteristics, the present study extended prior research in four respects. First, we examined the relationships between Cloninger's TPQ scales and hypnotic susceptibility, something not previously reported in the literature. We expected positive relationships between hypnotic susceptibility and the TPQ scale of persistence, a measure of sustained goal-directed behavior. Second, unlike prior research assessing sensation seeking and hypnotizability that examined a general sensation seeking style, we were able to assess four dimensions of novelty seeking to determine whether hypnotizability related more to some aspects than others. Third, we included prior self-report measures of attentional abilities, as assessed by the TAS and the DAPI, to determine how they predicted hypnotic susceptibility. Finally, because this is an extension of prior work (Lichtenberg et al., 2000) using the same participants, we included COMT, previously found to correlate with hypnotizability within this sample and to be associated with prefrontal executive functioning (Weinberger et al., 2001), to determine its predictive ability in multiple regressions with the other measures. Because women showed the COMT relationship whereas men did not (Lichtenberg et al.), we felt it important to assess for gender differences. Unlike most prior research that used only university students, we included participants from the general population, aged 18 to 71 years.

METHOD

Participants

Participants were 107 (49 men) unpaid volunteers, aged 18–71 years (*Mean* = 33.47). They were recruited by advertisements at a university campus in Jerusalem, announcements in local newspapers, and word of mouth.

Instruments

The Stanford Hypnotic Susceptibility Scale, Form C (SHSS:C). The SHSS:C (Weitzenhoffer & Hilgard, 1962) is a standardized 12-item measure of an individual's response to suggestions following a hypnotic induction. The suggestions are offered in order of increasing difficulty and include lowering of an outstretched hand while imagining holding a heavy weight, hypnotic dreaming, age regression to the fifth and second grades, auditory hallucinations, negative visual hallucinations, and more (Hilgard, 1965). Each suggestion carried out successfully (as judged by the hypnotist according to objective criteria) is counted as a point. The SHSS:C was administered in English or Hebrew, depending on the mother tongue of the participant. Individual SHSS:C administration lasted about 45 minutes.

The Tridimensional Personality Questionnaire. The TPQ (Cloninger, 1987; see also Cloninger, Przybeck, Svrakic, & Wetzel, 1994) is a self-report inventory composed of 100 yes/no questions that assesses four personality dimensions: novelty seeking (total plus four subscales: exploratory excitability vs. stoic rigidity; impulsivity vs. reflection; extravagance vs. reserve; and disorderliness vs. regimentation); reward dependence (total score plus three subscales: sentimentality vs. insensitiveness; attachment vs. detachment; and dependence vs. independence); harm avoidance (total score plus four subscales: anticipatory worry vs. uninhibited optimism; fear of uncertainty vs. confidence; shyness with strangers vs. gregariousness; and fatigability and asthenia vs. rigor); and persistence. Cloninger's (1994) factor analysis shows that a four-factor model accounts for 58% to 65% of the variance. Alpha Cronbach values, measures of internal consistency based on average interitem correlations, have been shown to be .75 for novelty seeking, .83 for harm avoidance, .73 for reward dependence, and .57 for persistence (Cloninger et al., 1994).

The Tellegen Absorption Scale (TAS). This questionnaire is from Tellegen's Multidimensional Personality Questionnaire (Tellegen, 1982; Tellegen & Atkinson, 1974) and contains 34 self-descriptive statements with true or false answers. Sample questions include ''I like to watch cloud shapes change in the sky,'' or ''If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a

good movie or story does.'' The internal reliability consistency coefficient alpha is .88 and test-retest reliability is .91 (Tellegen, 1982).

The Differential Attention Processes Inventory (DAPI). The DAPI (Crawford, Brown, et al., 1993) contains 40 self-descriptive statements relating to experiences of focused attention and ignoring of distractions, as well as experiences of carrying out two tasks simultaneously. Participants were asked to rate themselves as to the degree to which they typically can carry out the activities on a seven-point scale of 1 (*not at all*) to 7 (*always*). Four factor analytically derived scales have been noted: moderately focused attention (8 items), an individual's perceived ability to sustain moderately focused attention with distractions around; extremely focused attention (12 items) that assesses one's perceived proclivity to engage one's total attentional resources to the task at hand without awareness of outside stimuli; dual attention to tasks (cognitive-cognitive, 4 items); and dual attention to tasks (cognitive-physical, 5 items) (Crawford, Brown, et al., 1993; Yanchar, 1983). Yanchar reported a .88 alpha estimate of internal consistency. For our sample, Cronbach alphas were .84 for extremely focused attention, .86 for moderately focused attention, .71 for cognitive-physical, and .88 for cognitive-cognitive.

Procedure

Upon arrival, participants signed a consent form and then completed a number of questionnaires, including the TPQ, TAS, and DAPI. Fewer participants filled out the TAS and DAPI, because they were not initially included in the research. After completing the questionnaires, respondents were evaluated by a semistructured interview to establish the absence of axis-I psychopathology as defined in the DSM-IV (American Psychiatric Association, 1994). None were rejected. Finally, participants were individually administered the SHSS:C by one of the authors (PL), who was blind to the participants' questionnaire responses at that time.

After hypnotizability testing, blood was drawn by antecubital venipuncture from each subject. The COMT polymorphism was genotyped as previously described (Eisenberg et al., 1999). DNA was extracted from frozen blood using a Qiamp kit (Qiagen). Each individual was typed for high and low COMT activity (val/met polymorphism). For further details, see Lichtenberg et al. (2000).

RESULTS

Mean Differences between Men and Women

As is usually observed (e.g., Hilgard, 1965), men and women did not differ in hypnotic susceptibility. There were no significant gender

Table 1
Means and SDs for Hypnotic Susceptibility and Attention/Personality Measures: Men, Women, and Total

Measure	Men			Women			Total		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
SHSS:C	49	5.67	2.86	58	5.84	2.77	107	5.77	2.80
TAS	43	18.44	8.76	51	19.96	7.54	94	19.23	8.07
DAPI Scales									
Moderately Focused	42	4.07	1.21	50	4.00	0.98	92	4.02	1.07
Extremely Focused	42	3.35	0.96	50	3.49	0.81	92	3.43	0.88
Dual: 2 Cognitive	42	2.75	1.37	50	2.40	1.10	92	2.55	1.23
Dual: Cognitive Phys.	42	5.11	0.85	50	5.15	1.00	92	5.14	0.93
TPQ Scales									
Persistence	48	5.69	2.04	56	4.98	2.70	104	5.29	2.43
Novelty Seeking total	48	17.10	6.34	56	17.41	5.89	104	17.34	6.09
Impulsive/Reflective	48	5.19	2.11	56	5.40	1.93	104	3.43	2.36
Excitability/Rigidity	48	5.19	2.11	56	5.39	1.92	104	5.30	2.00
Extravagance/Reserve	48	3.96	1.64	56	4.07	1.71	104	4.04	1.72
Disorderliness/Regimt.	48	4.79	2.32	56	4.34	2.11	104	4.57	2.21
Harm Avoidance	48	12.83	7.71	56	15.02	6.54	104	14.10	7.19
Reward Dependence	48	12.77	3.63	56	14.09	4.35	104	13.44	4.07

differences on any of the measures employed. The means and standard deviations for men and women separately and together are presented in Table 1. There were no differences in the distribution of COMT polymorphisms within the men and women.

Correlations between Measures

Correlations between measures for the total sample are provided in Table 2. As predicted, the TPQ persistence scale correlated positively with hypnotic susceptibility. Persistence did not correlate with TAS or the DAPI scales. Yet, hypnotic susceptibility scores correlated significantly with absorption (TAS), extremely focused and moderately focused attentional abilities, and with dual attention for physical and cognitive tasks (DAPI). The relationship between hypnotic susceptibility and the TPQ novelty-seeking subscales were not significant. Since relationships between novelty seeking and other measures for men and women are sometimes different in the literature (e.g., Ball, Farnill, & Wangeman, 1984), we examined them separately herein. Men showed a significantly positive relationship between hypnotic susceptibility and the TPQ novelty-seeking subscale of impulsivity versus reflection ($r = .295$, $p = .042$), whereas women did not ($r = .07$). The presence of COMT val/val homozygosity correlated significantly with

Table 2
Correlations between Measures for All Participants

	TAS	DAP1	DAP2	DAP3	DAP4	Persistence	NS1	NS2	NS3	NS4	Reward	Harm	COMT
SHSS:C	.35***	.21*	.32**	.18	.27**	.27**	.09	.18	.08	.15	−.00	.09	.30**
TAS	–	.52***	.29**	.24*	.09	.17	.06	−.01	.04	.13	−.12	.07	−.08
DAP1		–	.27**	.29**	.12	.12	.06	.09	.15	.15	−.12	.07	−.08
DAP2			–	.49***	.28**	.05	.12	.19	.13	.16	−.05	−.17	−.01
DAP3				–	.49***	.01	.14	−.09	.27**	.09	.06	−.07	.09
DAP4					–	.08	.12	−.04	.09	−.04	.06	−.15	.09
Persistence						–	.15	.02	.07	.12	.05	−.01	.04
NS1							–	.33***	.32***	.45***	.23*	−.22*	−.03
NS2								–	.38***	.47***	.16	−.07	−.02
NS3									–	.31***	.35***	−.16	.07
NS4										–	0.9	−.17	.03
Reward											–	.13	.09
Harm													−.02

Note. SHSS:C = Stanford Hypnotic Susceptibility Scale, Form C; TAS = Tellegen Absorption Scale. Differential Attentional Processes Inventory subscales: DAPI1 = Extremely Focused Attention; DAPI2 = Moderately Focused Attention; DAPI3 = Dual Attention Two Cognitive; DAPI4 = Dual Attention Physical and Cognitive. Tridimensional Personality Questionnaire subscales: Persistence; NS1 = novel seeking exploratory excitability vs. stoic rigidity; NS2 = novel seeking impulsivity vs. reflection; NS3 = novel seeking extravagance vs. reserve; NS4 = novel seeking disorderliness vs. regimentation; Reward = Reward Dependence; Harm = Harm Avoidance. COMT = COMT val/val vs. val/met and met/met.
*$p < .05$; **$p < .01$; ***$p < .001$.

the SHSS:C for the total sample ($r = .297$, $p < .002$) and women ($r = .375$, $p < .005$) but not significantly for men ($r = .208$, $p > .15$). With TPQ impulsivity, COMT val/val homozygosity correlated positively for men ($r = .306$, $p < .05$) and negatively for women ($r = -.279$, $p < .05$). COMT did not correlate significantly with any other measures.

Factor Analytic Evaluation

To assess the multidimensional relationship between the personality and attention measures, the intercorrelations for the total sample were factor analyzed using principal components analysis and Kaiser's normalized varimax orthogonal rotation. Employment of Kaiser's criterion of factor acceptability (associated eigenvalue greater than one) yielded six factors. Solutions of lower dimensionality and scree plots were examined, and a four-factor solution was most meaningful. Loadings on these four factors are shown in Table 3. The factors were interpreted by examination of the variables with ''high'' loadings (above .40 or below −.40).

The first factor, which accounted for 25.81% of the variance, can be entitled moderately sustained and dual task attention in a complex environment with limited interference from competing stimuli. Replicating Crawford, Brown, et al. (1993), high loadings were found on the DAPI subscales of moderately focused attention, dual attention for two cognitive tasks, and dual attention for a cognitive and physical task.

The second factor, which accounted for 14.23% of the variance, can be entitled deeply involved and absorptive sustained attention. High loadings were found for the TAS, the DAPI subscale of extremely focused, sustained attention, and the TPQ persistence scale.

Table 3
Factor Analysis of Hypnotizability, TPQ Measures, and Attentional Measures

Measures	1	2	3	4	Communalities
Hypnotizability	.36	.61	−.10	.23	.56
TPQ: Persistence	−.12	.57	−.01	.13	.35
TPQ: Novelty Seeking	.03	.27	.78	.36	.80
TPQ: Reward Dependence	.00	−.07	.04	.86	.74
TPQ: Harm Avoidance	−.15	.25	−.78	.20	.73
Tellegen Absorption Scale	.19	.74	.00	−.25	.64
DAPI: Extremely Focused	.21	.65	.08	−.29	.56
DAPI: Moderately Focused	.70	.25	.25	−.14	.63
DAPI: Physical-Cognitive	.75	−.03	−.05	.21	.61
DAPI: Cognitive-Cognitive	.75	.12	.08	−.14	.61
Eigenvalues	2.58	1.42	1.17	1.05	
% of Variance	25.81	14.23	11.71	10.51	

Of particular theoretical relevance, hypnotic susceptibility loaded strongly (.61) on this factor.

The third factor, which accounted for 11.71% of the variance, represents an active involvement in one's environment. The TPQ novelty-seeking scale loaded positively, whereas the TPQ harm-avoidance scale loaded negatively. Reward dependence characterizes the fourth factor, which accounted for 10.51% of the variance, with less loading with novelty seeking.

Regression Estimates for Predicting Hypnotic Susceptibility

A hierarchical multiple regression was performed between the SHSS:C as the dependent variable and the independent variables of TPQ persistence, COMT, DAPI extremely focused attention, DAPI moderate and dual attention scales (collapsed based upon the above factor structure), TAS, and TPQ impulsivity versus reflectivity. Since correlated measures may impact a multiple regression (Tabachnick & Fidell, 2000), the factors and correlations presented previously guided us in the choice of independent variables to be submitted within each block.

Table 4
Hierarchical Multiple Regression Predicting Hypnotic Susceptibility for Total Sample (N = 92–107)

Independent Variables	Beta	$p =$	R^2	R^2 Change	F Change	$p =$
Model 1 ($F = 7.94$, $p = .001$)						
TPQ Persistence	.258	.011				
COMT	.284	.005				
Model			.154	.154	7.94	.001
Model 2 ($F = 7.03$, $p < .001$)						
TPQ Persistence	.232	.019				
COMT	.303	.002				
DAPI Extremely Focused	.208	.036				
Model			.197	.042	4.548	.036
Model 3 ($F = 6.997$, $p < .001$)						
Persistence	.197	.033				
COMT	.285	.003				
DAPI Extremely Focused	−.015	.887				
Tellegen Absorption Scale	.285	.009				
DAPI Moderate + Dual Scales	.209	.034				
TPQ Impulsivity	.168	.066				
Model			.336	.139	5.791	.001

Note. BETA is standardized coefficient. R^2 values are unadjusted. Significance of the increment is shown at each step.

Table 4 displays the regression estimates for predicting hypnotic susceptibility for the total sample. Within each block, all variables were entered simultaneously. For Models 1 and 2, we find that TPQ persistence, COMT, and DAPI extremely focused contribute significantly to predicting hypnotic susceptibility. In Model 3, TAS and the DAPI moderate and dual scales contribute significantly, and TPQ impulsivity is marginal. While TPQ persistence and COMT remain in the model, the DAPI extremely focused attention scale drops out due to its shared variance with the TAS. The multiple regression analysis predicted 33.6% of the variance.

We performed exploratory multiple regressions on women and men separately (Tables 5 and 6). The women were fairly similar to the total sample, but the men were not. Specifically, for the women, the significant independent variables predicting hypnotic susceptibility were persistence, COMT, and the DAPI moderate and dual scales but not the TAS. For the men, the only significant predictor was the TAS, whereas the DAPI extremely focused attention scale showed a marginal contribution. The multiple regression analyses predicted 43.8% of the variance for the women and 29% for the men.

Table 5
Hierarchical Multiple Regression Predicting Hypnotic Susceptibility in Women (N = 50–58)

Independent Variables	Beta	$p =$	R^2	R^2 Change	F Change	$p =$
Model 1 ($F = 8.358$, $p = .001$)						
TPQ Persistence	.364	.007				
COMT	.325	.015				
Model			.271	.271	8.358	.001
Model 2 ($F = 6.043$, $p = .002$)						
TPQ Persistence	.345	.011				
COMT	.343	.011				
DAPI Extremely Focused	.147	.26				
Model			.292	.021	1.302	.26
Model 3 ($F = 5.324$, $p < .001$)						
Persistence	.302	.021				
COMT	.310	.019				
DAPI Extremely Focused	−.024	.858				
Tellegen Absorption Scale	.159	.246				
DAPI Moderate + Dual Scales	.343	.01				
TPQ Impulsivity	.143	.256				
Model			.438	.146	3.554	.022

Note. BETA is standardized coefficient. R^2 values are unadjusted. Significance of the increment is shown at each step.

Table 6
Hierarchical Multiple Regression Predicting Hypnotic Susceptibility in Men (N = 42–49)

Independent Variables	Beta	$p =$	R^2	R^2 Change	F Change	$p =$
Model 1 ($F = 1.204$, $p = .311$)						
TPQ Persistence	.122	.439				
COMT	.223	.163				
Model			.058	.058	1.204	.311
Model 2 ($F = 1.800$, $p = .164$)						
TPQ Persistence	.080	.607				
COMT	.229	.142				
DAPI Extremely Focused	.261	.098				
Model			.290	.066	2.876	.098
Model 3 ($F = 2.384$, $p = .049$)						
Persistence	.123	.409				
COMT	.241	.136				
DAPI Extremely Focused	−.051	.772				
Tellegen Absorption Scale	.411	.040				
DAPI Moderate + Dual Scales	.093	.560				
TPQ Impulsivity	.205	.19				
Model			.290	.166	2.723	.059

Note. BETA is standardized coefficient. R^2 values are unadjusted. Significance of the increment is shown at each step.

Discriminant Analysis of Low, Medium, and High Hypnotizables

To substantiate the degree to which those variables entered into the multiple regression could differentiate between low (SHSS:C 0–3, $n = 28$, $M = 2.00$, $SD = 1.05$), medium (SHSS:C 4–7, $n = 46$, $M = 5.80$, $SD = 1.07$), and high (SHSS:C 8–12, $n = 33$, $M = 8.91$, $SD = 0.91$) hypnotizable groups, a discriminant analysis was performed, Wilks's Lambda = .627, $X^2(16) = 38.96$, $p < .001$. Overall, 60% of the participants were correctly classified: 81.5% of the highs, 62.1% of the lows, and 41.2% of the mediums.

DISCUSSION

Within a multivariate framework, this study found relationships between hypnotizability and focused attentional abilities, as previously observed, and extended it to relationships between hypnotizability, certain personality traits as measured by the TPQ, and COMT polymorphisms. Multiple regression analyses found TPQ persistence, COMT, TAS, and the DAPI attentional scales to contribute significantly to predicting hypnotic susceptibility. Unexpected gender differences were observed: the multiple regression analyses explained more of the

variance for women (43.8%) than men (29%). For men, only the TAS was a significant predictor, whereas for women it was not a significant predictor. Of particular theoretical relevance is that membership was correctly discriminated for the more extreme low (62.1%) and highly (81.5%) hypnotizable groups. Unlike prior studies that have predominantly involved only young adults who are usually in a university setting, we examined a much broader age range (18–71 years) within the general population.

Persistence and Attentional Abilities as Predictors of Hypnotic Susceptibility

Most important, we found that the TPQ factor of persistence loaded with hypnotizability and measures of deeply involved and absorptive sustained attentional factor and was highly predictive of hypnotizability in the multiple regressions (total and women, but not men). This new finding in the literature provides further support to the proposal that hypnotizability is associated with effective executive control and monitoring. This complex system includes many different functions usually associated with frontal lobe activity in conjunction with other areas of the brain, such as sustaining, concentrating, sharing, suppressing, switching, preparing, and setting attention (Stuss, Shallice, Alexander, & Picton, 1995).

William James in his *Principles of Psychology* (1890) wrote of two types of attention: voluntary attention that is intentional and directed and involuntary attention that is automatic and unconscious, which were further elaborated upon within the context of hypnosis by Hilgard (1977). We propose that each of these, although not necessarily directly related to one another as seen in our study, is a major contributor to the ability to enter a hypnotic state. Interesting gender differences emerged in our exploratory multiple regressions that require further investigation.

Persistence is more likely the former, effortful and directed attention, as it refers to the perseverance in remaining on task and attaining one's goals, even in the face of adversity or failure. Such unwavering goal-directed behaviors also involve sustained motivation. Interestingly, in recent years, motivation has been associated with dopaminergic systems (McAllister, 2000), the prefrontal cortex (Grafman, 2002; Pribram, 1991; Watanabe, Hikosaka, Sakagami, & Shirakawa, 2002), and the anterior cingulate cortex (for review, see Paus, 2001). In the first study to examine the brain circuitry of persistence, Gusnard et al. (2003) demonstrated that persistence may be linked to specific areas in the lateral orbital and medial prefrontal cortex and the ventral striatum, a well known circuit associated with ''prediction and reward as well as emotional motor control'' (p. 3484). Whereas individuals low on TPQ persistence showed decreased activation, those high on TPQ persistence showed more

> . . . activation of the putative reward circuitry (ventral striatum, ventral prefrontal cortex) under conditions of low extrinsic arousal . . . [which] would seem to make sense if Persistence is related to the ability to generate and maintain arousal and motivation internally, in the absence of immediate external reward (p. 3481).

Such findings reinforce the importance of studying individual differences in hypnotic susceptibility, as well, with modern functional neuroimaging. If individuals high in persistence see less arousing situations as ''more intrinsically motivating, arousing, and rewarding,'' as suggested by Gusnard et al., then it follows that they may also be more highly absorbed and attentive to their environments, as found in the present research.

Absorption in internal and external environments as defined by the TAS is similar to what Kaplan (2001) referred to as ''fascination,'' a type of attention that involves control without effort or possibly control out of awareness. To be deeply fascinated and absorbed in something, be it the sunset or a suggested hallucination (e.g., hearing a voice that is not present) during hypnosis, may call upon frontal lobe inhibition of potential distractions and intruding thoughts. It is what Bowers (1978; see also Shames & Bowers, 1992) has referred to as ''effortless experiencing.'' The perceived fading of generalized reality orientation (Shor, 1959), something Fromm (1992) called ''ego receptivity,'' is a hallmark of the hypnotic experience. The increase of symbolic, primary-process mentation observed sometimes during hypnosis might well be effortlessly controlled ''topographic regression'' (see Nash, 1992, for an excellent discussion). Future neuroimaging research may help resolve whether ''effortless experiencing'' is really effortless or if it involves prefrontal cortex activation.

The DAPI extremely focused attention scale, although not correlating with persistence, did correlate with the TAS and hypnotizability. It loaded on the same factor as persistence and the TAS, and was a hypnotizability predictor, albeit weakly, for women. A stronger predictor was the dual attention and moderately focused attention scales for the women but not the men. The DAPI extremely focused attention subscale assesses one's perceived ability to engage total attentional resources to the task at hand and ignore distracting outside stimuli so that they are out of one's conscious awareness. This latter ability may involve both directed, effortful attention and effortless disattention, the latter being a decision prior to conscious perception that something is not important. Neurophysiological evidence for the importance of disattention in hypnosis is suggested by the presence of an enhanced contingent variation in the prefrontal region prior to a regularly delivered painful stimulus during successful hypnotic analgesia (Crawford et al., 1998).

An additional finding herein is that the impulsiveness subscale of the TPQ novelty-seeking score correlated with hypnotizability for men

but not women, although it was a poor predictor in the multiple regression analyses. The three other TPQ novelty-seeking scales did not correlate.

Dopamine transmission may play a role, though certainly not an exclusive one, in the novelty-seeking trait. Some genetic studies have shown that novelty seeking may be related to polymorphisms of the D4DR gene, which are involved in the genetics of dopamine receptor subtypes (Benjamin et al., 1996; Ebstein, et al., 1996; Ebstein, Nemanov, Klotz, Gritsenko, & Belmaker, 1997; Ekelund, Lichtermann, Järvelin, & Peltonen, 1999). This finding has not always been replicated (Sullivan, et al., 1998). A possible role for dopaminergic mechanisms has also been suggested by neurophysiological paradigms (prepulse inhibition; see Hutchison, Wood, & Swift, 1999).

In light of earlier work (e.g., Pribram, 1991) and cognitive neuroscience's recent and continuing elucidation of the many subtle complexities of the frontal lobes and its involvement in attention, inhibition, working memory, and executive functioning (e.g., Stuss et al., 1995; Stuss & Knight, 2002), our findings emphasize the need to expand our search for correlates of hypnotic susceptibility and take greater advantage of the rich neurophysiological theories of brain functioning. Further, knowledge of different architectural features of the prefrontal cortex and their varying associated functions, with different afferent and efferent connections to other regions of the brain, may assist us in developing predictive models for hypnotic susceptibility. Relationships between frontal lobe functioning and hypnotizability, as well as shifts in executive and monitoring functions during hypnosis, are evidenced in neuropsychological (e.g., Aikins & Ray, 2001; Kallio et al., 2001), evoked potential (e.g., Crawford et al., 1998; Kaiser, Barker, Haenschel, Baldeweg, & Gruzelier, 1997), and cerebral metabolism (e.g., Crawford, Gur, Skolnick, Gur, & Benson, 1993; Crawford et al., 2000; Rainville, Duncan, Price, Carrier, & Bushnell, 1997) studies.

In a review summarizing a convergence of neuropsychological and event-related potential evidence, Gruzelier (1998) posited that the first stage of the hypnotic induction process activates attentional networks involving thalamocortical and parieto-frontal systems. Dopaminergic neurotransmitter systems have been implicated in attentional abilities (for a review, see Arnsten, 1997). Parkinson's disease patients show impaired performance in some executive functions including attention processes (set shifting), reflecting deterioration of the basal ganglia frontal lobes circuitry due to drop out of nigral dopaminergic neurons (Hayes, Davidson, Keele, & Rafal, 1998; Tamaru, 1997). Low-dose bromocriptine, a D2 dopamine receptor agonist, when given to patients with traumatic brain injury, was found to improve performance on some tasks thought to be subserved by prefrontal function in dual-task performance (McDowell, Whyte, & D'Esposito, 1998).

Genetic Underpinnings to Hypnotic Susceptibility

The COMT gene was a strong predictor of hypnotizability for women, but not men, in the present study (and as reported earlier in Lichtenberg et al., 2000). This gender difference is not explainable at present but certainly worthy of further investigation, and may be due in part to the lack of very highly hypnotizable men in our study. The gene that controls for the production of COMT, an enzyme involved in the clearance of catecholamines (including dopamine), has been connected to disorders that may involve disturbances in attention, such as in ADHD (Eisenberg et al., 1999), obsessive compulsive disorder (Karayiorgou et al., 1997), and schizophrenia (Weinberger et al., 2001). Further, the COMT met allele is associated with prefrontal executive functioning (Egan et al., 2001; Malhotra et al., 2002; Weinberger et al.). When the polymorphism that produces less functional enzyme is present, leading to a slower metabolism and higher levels of dopamine, hypnotizability scores are higher among women but not men (Lichtenberg et al., 2000). Other research findings also indicate the involvement of dopaminergic systems. Speigel and King (1992) found that cerebrospinal fluid levels of homovanillic acid (HVA), a metabolite of dopamine, correlated with hypnotizability. Interestingly, the anterior cingulate cortex, which in several brain imaging studies of hypnosis was shown to be selectively activated during the hypnotic state (Crawford et al., 2000; Halligan, Athwal, Oakley, & Frackowiak, 2000; Rainville et al., 1997; Szechtman, Woody, Bowers, & Nahmias, 1998), receives dopaminergic innervation from the ventral tegmental nucleus (Raz & Shapiro, 2002). Further, the prefrontal cortex, known to be involved in dopaminergic systems, shows shifts in activation patterns in highly hypnotizable individuals during hypnotic analgesia (Crawford, Gur, et al., 1993; Crawford et al., 1998, 2000).

Limitations

Although this study breaks new ground by assessing multidimensional relationships of hypnotizability with COMT and neurogenetically-based personality characteristics along with attentional abilities in a broad age range of adults, there are certainly limitations to the current study that should be considered. Within this broad range, we had more young adults and only sampled a few adults between 50 and 71 years. Even when we removed the latter group, the results remained essentially the same. Future research might emphasize, for example, testing older adults and more from lower socio-economic levels.

Whether due to cultural differences or unknown sampling problems, there was a lack of very highly hypnotizable individuals. The highest SHSS:C score was 11 for women and 10 for men (out of 12 possible). We administered the questionnaires prior to all other interviews and hypnotic testing but still within the context of hypnosis. The effects of absorption on hypnotizability are shown to be mediated by

expectancy by some (e.g., Kirsch & Council, 1992; Kirsch, Silva, Comey & Reed, 1995) but not others (e.g., Nadon, Hoyt, Register, & Kihlstrom, 1991; Zachariae et al., 2000).

Future Research Directions

Despite these caveats, results from the present study still make a unique contribution, because participants were recruited from a more general population and not limited to an undergraduate university population, and because COMT and a neurogenetically-based personality test were incorporated. In the past few years, common genetic polymorphisms have been identified that contribute to the determination of personality traits. Here we suggest that a fertile field for further investigation is the relation between hypnotizability, personality traits, attentional abilities, frontal lobe functioning, dopaminergic tone, and genetic polymorphisms. We hope that this study will encourage the investigation of the relationship between hypnotizability and neurogenetically-based characteristics, as well as their relationship to neurotransmitter systems and the numerous genetic polymorphisms that have been identified in recent years.

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Hypnotische Susceptibilität: Multidimensionale Beziehungen mit Clonigers Dreidimensionalem Persönlichkeitsfragebogen, COMPT Polymorphismen, Absorption und Aufmerksamkeitseigenschaften.

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Zusammenfassung: Cloningers Dreidimensionaler Persönlichkeitsfragebogen (TPQ), das Differential Attentional Process Inventory (DAPI), die Tellegen Absorption Scale (TAS) und die Stanford Hypnotic Susceptibility Scale, Form C wurden 107 gesunden Freiwilligen vorgelegt. Polymorphismen von Catechol-O-Methyltransferase (COMT) wurden bestimmt. Dabei handelt es sich um ein Enzym, das am Dopaminmetabolismus beteiligt ist. In hohem Maße hypnosefähige Versuchspersonen berichteten größere TPQ-Ausdauer, Absorption und höhere Fähigkeit zu fokussierter Aufmerksamkeit. Hierarchische multiple

Regressionsanalysen bestätigten, dass TPQ-Ausdauer, COMT, TAS und die DAPI-Aufmerksamkeitsskalen 43.8 % der Varianz bei Frauen und 29% bei Männern erklärten. Die Zugehörigkeit konnte korrekt unterschieden werden bei den besonders wenig (61.2%) sowie bei den besonders gut (81.5%) hypnosefähigen Versuchspersonen. Diese Ergebnisse legen nahe, dass besonders gut hypnosefähige Versuchspersonen über ein effektiveres frontolimbisches Aufmerksamkeitssystem verfügen und deuten drauf hin, dass dopaminerge Systeme bei der Hypnosefähigkeit eine Rolle spielen.

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La sensibilité hypnotique: relations multidimensionnelles avec le questionnaire tridimensionnel de personnalité de Cloninger, et les caractéristiques de polymorphisme COMT, d'absorption, et attentionnelles.

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Résumé: Cent sept volontaires en bonne santé ont répondu au questionnaire de personnalité de tridimensionnel de Cloninger (TPQ), à l'inventaire différentiel du processus Attentionel (DAPI), à la balance d'absorption de Tellegen (TAS), et la balance hypnotique de susceptibilité de Stanford, la forme C (SHSS:c). Des métabolites de la catéchol O-methytransferase (COMT), une enzyme impliquée dans le métabolisme de dopamine, ont été évalués. Les sujets fortement hypnotisables ont présenté une plus grande persistance de TPQ, d'absorption, et ont focalisé des capacités attentionnelles. Les analyses de régressions hiérarchiques multiples ont permis de constater la persistance de TPQ, le COMT, le TAS, et les balances d'attentionnelles de DAPI ont expliqué la variation 43,8% et 29% chez les hommes. L'appartenance à chacun des groupes a correctement été distinguée pour les sujets du groupe très faiblement hypnotisable (62,1%) et celui fortement (81,5%) hypnotisable. Ces résultats suggèrent que les personnes fortement hypnotisables ont un système attentionnel fronto-limbique plus efficace évoquant ainsi la participation des systèmes dopaminergiques dans l' hypnotisabilité.

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La susceptibilidad hipnótica: Relaciones multidimensional con el Cuestionario Tridimensional de Personalidad de Cloninger, polimorfismos COMT, absorción, y características de atención

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Resumen: Administramos a 107 voluntarios saludables el Cuestionario Tridimensional de Personalidad de Cloninger (TPQ), el Inventario de

Procesos Diferenciales de Atención (DAPI), la Escala de Absorción de Tellegen (TAS), y la Escala de Susceptibilidad Hipnótica de Stanford, Forma C (SHSS:C). Evaluamos también polimorfismos de catecol O-methytransferasa (COMT), una enzima involucrada en el metabolismo de la dopamina. Los sujetos muy hipnotizables tuvieron mayor persistencia TPQ, absorción, y capacidades para enfocar la atención. Análisis jerárquicos de regresión múltiple mostraron que la persistencia TPQ, y las escalas COMT, TAS, y de atención explicaron 43.8% de la varianza en mujeres y 29% en hombres. Se categorizó correctamente correctamente a los grupos más extremos de hipnotizabilidad baja (62.1%) y alta (81.5%). Estos resultados sugieren que las personas altamente hypnotizables tienen un sistema atencional frontolímbico más eficaz y además sugieren la involucración de los sistemas dopaminérgicos en la hipnotizabilidad.

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