



Introduction

We investigated the hypothesis that specific suites of co-varying heritable temperament traits are associated with broad yet specific human neural systems. Personality is composed of two basic types of traits: traits that an individual acquires, dimensions of character; and traits with biological underpinnings, dimensions of temperament (Cloninger 1987). This paper examines only those traits the current literature associates with traits of temperament. Many traits of temperament are heritable, relatively stable across the life course and linked to specific gene pathways and/or hormone or neurotransmitter systems.

Dopamine and Norepinephrine (DA/NE)

Components of sensation-seeking associated with dopamine activity include: thrill, experience and adventure seeking; boredom susceptibility; and disinhibition (Zuckerman, 2005). Cloninger also associates novelty seeking with other traits, including exploratory excitability, impulsiveness, quick-temperedness, extravagance and disorderliness (e.g., Cloninger et al., 1991; 1994). Other traits linked to activity in the dopamine system include sex drive (Meston & Frohlic, 2000); mania and hypersocial behavior (e.g., Depue & Collins, 1999); enthusiasm (e.g., Goreman & Wesman, 1974; Zuckerman, 1994); lack of introspection (e.g., Cloninger et al., 1991; Ebstein et al., 1996; Gerbing, Ahadi & Patton, 1987); social dominance, energy, assertiveness, ambition, motivation and achievement striving (e.g., Depue & Collins, 1999; Wacker et al., 2006), exploration (Espejo, 1997); abstract intellectual exploration (DeYoung et al., 2002); cognitive flexibility (Ashby et al., 1999); plasticity (DeYoung et al., 2005); curiosity (e.g., Olson, Camp & Fuller, 1984); idea generation, and verbal and non-linguistic creativity (Flaherty, 2005).

Serotonin (5-HT)

Alleles of the serotonin system are associated with sociability (Golimbet et al., 2004), lower levels of anxiety, higher scores on a scale of hypomania and extroversion, and lower scores on a scale of "No Close Friends" (Golimbet et al 2004). Positive mood and sociability are associated with serotonin activity (e.g., Flory et al., 2004; Opbroek et al., 2002), as is religiosity (Borg et al., 2003), conformity (DeYoung et al., 2002), orderliness (DeYoung & Gray, 2005), conscientiousness (Manuck et al., 1998), concrete thinking (Zuckerman 1994), self-control (Manuck et al., 2000), sustained attention (Zuckerman 1994), low novelty seeking (Serretti et al., 2006) and figural and numeric creativity (Reuter et al., 2006)

Testosterone (T)

Traits currently linked with prenatal testosterone expression are heightened attention to detail, intensified focus, and restricted interests (e.g., Baron-Cohen et al., 2005; Knickmeyer et al., 2005). Testosterone activity is also associated with emotional containment (Dabbs & Dabbs, 2000), emotional flooding, particularly rage (Manning, 2002), social dominance, aggressiveness (e.g., Dabbs, 1990; Knickmeyer et al., 2005; Mazur et al., 1997), less social sensitivity (Baron-Cohen et al., 2005) and heightened spatial and mathematical acuity (Gerschwind & Galaburda, 1985).

Estrogen and Oxytocin (E/OT)

Verbal fluency and other language skills are linked with estrogen priming in the womb (e.g., Baron-Cohen et al., 2005; Knickmeyer et al., 2005; Manning, 2002). Empathy, nurturing, the drive to make social attachments, and other prosocial skills are associated with estrogen and oxytocin activity in humans and other mammal (e.g., Baron-Cohen, 2002; Kendrick, 2000, Pedersen et al., 1992; Taylor et al., 2000). Estrogen activity is also associated with contextual thinking (e.g., Baron-Cohen et al., 2005; Dabbs & Dabbs, 2000; Fisher, 1999), imagination (Fisher, 2009), and mental flexibility (Skuse et al., 1997).

Method

Participants

Data were collected on all four scales on an Internet dating site, Chemistry.com, regularly between 2006-2007 until reliability was obtained in a United States sample of 39,913 anonymous men and women. Participants completed demographic information, the FRI-NQ, and validity questions, with the goal of finding a romantic partner. Respondents ranged in age from 18 to 88 years ($M = 37.0$; $SD = 12.6$); 56.4% were female ($N = 22,521$); 89.6% ($N = 35,759$) were seeking an opposite-sex partner; and 45.2% ($N = 18,035$) had children. All individuals expressed all four temperament dimensions; yet individuals varied in the degree to which they expressed each.

Test Creation and Validation

The Fisher-Rich-Island Neurochemical Questionnaire (FRI-NQ) was created to measure temperament associated with four neural systems, DA/NE, 5HT, T, and E/OT. Items were modified to increase the internal consistency of the scales, while reducing inter-scale correlations through repeated administrations using a United States Internet dating site. The final instrument consists of four 14-item scales with four response options for each item: "Strongly disagree," "Disagree," "Agree," and "Strongly Agree." The response options were counted as 0 to 3, yielding total scores on each scale from 0 to 42. The FRI-NQ measure on an international dating site in 39 other countries, beginning in January 2008, and data to measure reliability were collected on 15,000 individuals in each of these translations: German, French, Spanish, English (Australian sample), and Swedish. The Cronbach's alpha internal consistency coefficient in the final US sample of 39,913 was .79 for the proposed dopamine/norepinephrine scale; .79 for the proposed serotonin scale; .80 for the proposed testosterone scale; and .78 for the proposed estrogen/oxytocin scale. The alpha coefficients reflect acceptable levels (ranging from .71 to .82) across the four scales in the other five countries. To establish the validity of the measure, data were collected from ten questions unassociated to the FRI-NQ measure, but related instead to either organizational or activation effects of these four proposed broad biological systems. These validity measures included: Gender composition; digit ratio; educational level; occupation; religious preference; political orientation; type of friends; degree of sexuality; book title preference; word usage (Fisher 2009; Fisher et al, in preparation).

Results

Validity tests were consistent with prediction. A subset of the validity tests is shown in Table 1. As predicted, men and participants who reported their occupation as engineering scored higher on the proposed T scale, women and participants who indicated they were teachers scored higher on E/OT. On the proposed 5HT scale, persons reporting a religious affiliation obtained the highest mean score, followed by persons describing themselves as "spiritual but not religious," with the lowest scores obtained by those describing themselves as agnostics or atheists. Persons describing their friends as "Adventurous" tended to score higher on the proposed DA/NE scale.

Table 1
Means and effect sizes for validity tests

Scale	Predicted to be associated with:	Means	Effect size (eta)	Statistic
T	Male gender	M = 26.83 F = 23.60 F = 26.94	0.305	t(39910) = 63.94
E/O	Female gender	M = 25.62	0.130	t(39910) = 26.16
T	Engineering (> Teaching)	Engr = 28.07 Tchr = 23.05	0.444	t(852) = 14.44
E/O	Teaching (>Engineering)	Tchr = 27.46 Engr = 24.82	0.254	t(852) = 7.68
5HT	Religiosity	Religion = 26.71 Spiritual = 24.80 None = 24.10 Adv friends = 27.14	0.222	F(4,39908) = 587.88
DA/NE	Adventurous friends	Others = 25.64	0.131	t(39911) = 26.35

Note: All effects are significant at $p < .001$.

Discussion

Temperament is mediated by many factors and can be only indirectly associated with neurochemical data. But the scales consistently demonstrated significant correlations in the predicted direction with many other neurochemically-mediated behaviors, providing strong evidence that we are measuring aspects of temperament associated with neurochemistry.

Reliability analysis revealed four scales with adequate internal consistency. Cronbach's alpha ranged from .78 to .80 in the American sample. These levels of internal consistency are acceptable but moderate, reflecting the multifaceted nature of the constructs measured. The cleanest factor structure for the 56 items occurs when four factors are extracted, with 53 of the 56 items loading on only one factor, and with all items showing their primary loading on the expected factor. This was consistent with our goal of constructing a measurement of four distinct temperament dimensions.

Applied Value

- Although other cross-cultural (i.e., biological underpinnings) measures of personality exist, they do not address the organizational and activation impact of neurochemistry on aspects of temperament. For example, the NEO-PI (Neuroticism-Extroversion-Openness-Personality Inventory) measures five personality constellations identified in humans cross-culturally and in nonhuman animals (Gosling 2001; McCrae & Costa 1997; McCrae 2002). The NEO-PI correlates positively with the FRI-NQ in significant ways (Island et al, in preparation)

Future Research

- Considerable statistical power was provided by our large sample, and the actual magnitude of most validity coefficients was small. Further analyses is warranted to evaluate the scales' cultural and lifespan sensitivity.
- Although temperament is mediated by many factors and can be only indirectly associated with neurochemical data, a study is currently underway to evaluate the individual genes and DNA variants associated with these temperament dimensions (Fisher, Silver et al, in preparation).

Table 2

Descriptive information by gender for the Validity Study sample

	Dopamine/Norepinephrine		Serotonin		Testosterone		Estrogen/Oxytocin	
	N (%)	M (SD)	N (%)	M (SD)	N (%)	M (SD)	N (%)	M (SD)
Males	17392 (27.1)	26.35 (4.87)	17392 (27.6)	26.01 (4.71)	17,391 (24.8)	26.83 (5.02)	17391 (20.4)	25.62 (4.99)
Females	22521 (25.1)	25.70 (4.82)	22521 (29.4)	26.00 (4.54)	22,521 (9.7)	23.60 (4.99)	22521 (35.8)	26.94 (5.00)
Total	39913 (26.0)	25.98 (4.85)	39913 (28.6)	26.00 (4.61)	39,912 (16.3)	25.00 (5.25)	33912 (29.1)	26.36 (5.04)

Percentages indicate prevalence, the proportion of participants scoring higher on the given scale than on the other three scales.

References

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