

HUSBAND-WIFE CORRELATIONS IN NEUROCOGNITIVE TEST PERFORMANCE

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ABSTRACT

Spousal correlations are known to exist for a number of physical and mental characteristics, among which general mental ability is one of the strongest. IQ tests have ordinarily been used in studies of assortative mating, but in neurocognitive tests, less frequently. In this study, we examined spousal correlations in 76 husband-wife pairs using a computerized neuropsychological test battery. Significant spousal correlations occurred in the two most highly g-loaded tests, shifting attention and symbol digit coding, but not in the other tests or in any of the reaction time measures. The correlation between husbands and wives on the neurocognitive index, a summary score based on the individual tests and analogous to the IQ score, was even higher ($r = .717$). The pattern of spousal correlation described in IQ tests is thus replicated in a battery of neuropsychological tests.

In a previous paper we reported positive correlations between first-degree relatives who were administered the CNT battery, and which occurred primarily in tests of complex information processing, SDC and SAT (Hervey, Greenfield, & Gualtieri, 2012). In this paper, we note that the same two tests contribute more strongly than any other tests to the high spousal correlation for neurocognition. There is a certain symmetry, then, between the cognitive skills that play into spouse selection and the cognitive skills that are inherited. A better word than symmetry might be *inevitability*.

The findings of these studies suggest that computerized neurocognitive testing is an appropriate tool for studies of the genetics of cognition, that measures of processing speed are particularly salient and that the CNT is a suitable instrument. The advantages of computerized neurocognitive tests like the CNT include speed and efficiency, standard administration, suitability for repeated measures and elimination of scoring and transcription errors. Tests that are Internet-based like the CNT are amenable to centralized data collection and have flexibility in administration in different settings, even permitting the collection of data from remote sources. In genetic studies of cognition, where large numbers of subjects are necessary this technology may also be inevitable.

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Mating, among humans and in other species, is not a random event. “Assortative mating” refers to the propensity of males and females to choose mates non-randomly, on the basis of shared or complementary characteristics. In studies of assortative mating, positive correlations between husbands and wives have been discovered in various traits. Among these are physical attributes, like height (Hasstedt, 1995) (Courtiol, Raymond, Godelle, & Ferdy, 2010) and weight (Silventoinen, Kaprio, Lahelma, Viken, & Rose, 2003); sociodemographic variables like race (Risch et al., 2009) and language preference (Nagoshi, Johnson, & Danko, 1990); ethnicity (Sebro, Hoffman, Lange, Rogus, & Risch, 2010), economic status (Torche, 2010) and education (Correia, 2003); and vulnerability to certain pathological conditions (Negri, Melica, Zuliani, & Smeraldi, 1979) (Speakman, Djafarian, Stewart, & Jackson, 2007) (Krueger, Moffitt, Caspi, Bleske, & Silva, 1998) (Norton et al., 2010) (van Grootheest, van den Berg, Cath, Willemsen, & Boomsma, 2008) (Constantino & Todd, 2005) (Konnov, Dobordzhginidze, Deev, & Gratsianskiĭ, 2010).

Assortative mating appears to occur for personality traits (Díaz-Morales, Quiroga Estévez, Escribano Barreno, & Delgado Prieto, 2009) (Farley & Davis, 1977), but to a lesser degree than that observed for physical traits, sociodemographic traits, intelligence, and attitudes and values (Merikangas, 1982) (Epstein & Guttman, 1984).

Spousal correlation or “homogamy” is more evident in studies of cognitive traits than other psychological traits (Zonderman, Vandenberg, Spuhler, & Fain, 1977) (Mascie-Taylor & Gibson, 1979) (Mascie-Taylor, 1989). Considering the various dimensions by which cognition can be measured, the highest spousal correlations are reported for general mental ability, or *g*. IQ, for example, seems to have a higher spousal correlation ($r =$ about +0.40) than any other behavioral trait and is higher than most physical traits (e.g., height, $r =$ +0.30) (Mascie-Taylor, 1989) (Jensen, 1998) (Nagoshi, Johnson, Yuen, & Ahern, 1986) (Nagoshi, Johnson, & Ahern, 1987). With respect to individual tests, for example the subtests of an IQ test battery, Jensen has noted that the correlation for spouses is largely a matter of *g*; that is, the degree to which cognitive tests show assortative mating is highly correlated with the tests’ loadings on the *g* factor.

As cognitive studies rely, with increasing frequency, on computerized test batteries rather than time and labor intensive paper-and-pencil tests, and on neuropsychological tests rather than conventional IQ tests, it is appropriate to explore whether similar patterns emerge when a computerized neurocognitive test battery is applied to areas of investigation that have hitherto been reliant on IQ measures.

METHOD

SUBJECTS

The NCNC database contains the records of >16000 individuals, patients or family members of patients at the North Carolina Neuropsychiatry Clinics in Chapel Hill, Raleigh or Charlotte. Every new patient at the Neuropsychiatry Clinics is administered a computerized neurocognitive test battery; family members are requested to take the test battery as well, in order to better understand the evaluation process. Patients and family members give written informed consent to allow their de-identified data to be used for purposes of

research and evaluation; they can take advantage of our website (www.ncneuropsych.com) to withdraw consent at any time.

The database was found to contain the records of 76 husband-wife pairs, parents of children who were referred as patients. All of the parents were in good health. Common conditions like hypertension, obesity, anxiety, depression and ADD were documented in some of the individuals, but none had a disabling medical or neuropsychiatric disorder. The demographic characteristics of the husbands and wives are given in Table 2.

NEUROCOGNITIVE EVALUATION: THE CNT BATTERY

The CNT battery is an updated version of a computerized test battery called CNS Vital Signs, developed by the author (TG) and introduced in 2003.(Gualtieri & Johnson, 2006) CNS Vital Signs is currently used by clinicians and researchers and has been applied in studies of patients with ADHD (Gualtieri & Johnson, 2008a), traumatic brain injury (Gualtieri & Johnson, 2008b), dementia (Gualtieri & Johnson, 2005), mood disorders (Iverson, Brooks, Langenecker, & Young, 2011) and other clinical conditions.(Brooks & Barlow, 2011) The CNT is identical to the original test battery, save these differences: standardization and scoring have been changed in accord with factor analysis of the tests and controlling for the effects of education; validity measures are incorporated as described in a companion paper; the new test is internet-based; and it is not a commercial product.

TABLE 1. THE COMPUTERIZED TEST BATTERY (CNT)

TEST		TIME	FACTOR
Verbal Memory	VBM	3	Memory
Visual Memory	VIM	3	
Finger Tapping	FTT	3	Motor speed and coordination
Symbol Digit Coding	SDC	4	Central Processing speed
Shifting Attention Test	SAT	3	
Stroop Test	ST	5	
Continuous Performance Test	RT		Effortful attention
	CPT	6	

The CNT battery contains eight tests that generate nine scores. Seven tests are the topic of this paper; the eighth, keyboard speed, is a new test that is still in development, introduced as an additional validity measure. The seven tests were originally chosen because they were thought to address distinct cognitive domains (Table 2).

The verbal memory (VBM) and visual memory (VIM) tests are adaptations of the Rey Auditory Verbal Learning Test and the Rey Visual Design Learning Test.(A. Rey, 1964)(Taylor, E.M., 1959) VBM and VIM are tests of recognition memory; they are administered at the beginning and the end of the battery, yielding scores for immediate and delayed memory. The finger tapping test (FTT) is administered in three 10 second segments to each hand. The symbol digit coding test (SDC) is based on the symbol digit modalities test.(Smith, 1982) The Stroop Test (ST) has three parts that generate simple and complex reaction times.(Stroop, 1935) Averaging the two complex reaction time scores from the Stroop test a "response time" (RT) score. The ST also generates an error score. The Shifting Attention Test (SAT) measures the subject's ability to shift from one instruction set to another quickly and accurately. Other computerized batteries, like the NES2, CogState and CANTAB have shifting attention tests. Color-shape tests like the SAT have also been used in cognitive imaging studies.(Le, Pardo, & Hu, 1998)(Nagahama et al., 1998) The SAT score is calculated by subtracting the number of errors from the number of correct responses. The Continuous Performance Test presents 40 targets (the letter "B") embedded among 160 non-target letters over a five minute interval.(Rosvold & Delgado, 1956)

The tests generate raw scores and standard scores. Scores are standardized by adjusting for age and education level. Raw scores were used in these studies.

DATA ANALYSIS

The data being normally distributed, performances of husbands and wives were correlated by Pearson product-moment. Variance was measured by univariate linear regression of wives' scores on husbands' scores.

RESULTS

The salient characteristics of the husbands and wives are presented in Table 2. Seventy-four of the couples were both white and two were both African-American. The H-W pairs were highly correlated for age and education level, but not for self-reported computer familiarity.

TABLE 2. CHARACTERISTICS OF HUSBANDS AND WIVES

	HUSBANDS		WIVES		PEARSON'S r	
	Mean	SD	Mean	SD	r	Sig.
N	76		76			
AGE	47.38	11.112	46.16	10.484	.813	0.000000
EDUC	16.53	2.411	16.31	1.965	.564	0.000016
COMPFAM	2.65	.561	2.69	.466	.063	0.664758

Significant correlations were found for the cognitive index score, the shifting attention tests and the symbol digit coding test, but not for any of the other tests and not for any of the reaction time measures. 51% of the variance in spouse A's cognitive index score was attributable to spouse B's score; 25% in the shifting attention test; and 8% in the symbol digit coding test.

TABLE 3. SPOUSAL CORRELATIONS FOR THE TESTS

	PEARSON'S r		LIN REG
	r	Sig.	r ²
INDEX SCORE	.717	0.000	0.514
SHIFTING ATTENTION TEST	.496	0.000	0.246
SYMBOL DIGIT CODING	.284	0.013	0.081
VERBAL MEMORY	.157	0.175	0.025
VISUAL MEMORY	.145	0.213	0.021
FINGER TAPPING TEST	.076	.515	0.006
CONTINUOUS PERFORMANCE TEST	.050	.676	0.003
STROOP ERRORS	-.048	0.68	0.002
STROOP RESPONSE TIME	-.030	0.797	0.001

DISCUSSION

Homogamy, or assortative mating (AM) is one of the ways Nature makes mate selection systematic. It is a fact of life not only for the animals but also in every human society. The large majority of mates resemble each other in a high number of traits: age, race, religion, ethnicity, social class, economic status, intellectual ability, education, personality traits, values and opinions, physical attractiveness, hobbies, previous marital status, occupation and various anthropometric measures, like height, weight and eye color and hair color. Spousal correlation is more evident in studies of cognition than physical characteristics or other psychological traits (Zonderman et al., 1977) (Mascie-Taylor & Gibson, 1979)(Mascie-Taylor, 1989)(Mascie-Taylor, 1989)(Mascie-Taylor, 1989).

Why does it happen? We don't really know. There are theories, of course: the *Genetic Similarity Theory*, that we are able to detect genetically similar organisms – from how they look and how they behave -- and “channel our altruistic behavior towards them.”(Rushton, 1989) That means that we prefer to invest in someone else's genes if we happen to have the same genes. Then, there is the *Sexual Imprinting Theory*, that we select mates who resemble our counter-sexual parent.(Bereczkei,T, Gyuris, P, & Weisfeld, GE, 2004) This happens even when we don't share their genes: adopted children, for example, prefer mates who resemble their counter-sexual adoptive parent. Then there is the simple argument that AM works. A certain degree of similarity between mates is said to enhance marital stability and fertility.(Bereczkei & Csanaky, 1996)(Bentler & Newcomb, 1978)(Mascie-Taylor, 1989)(Lucas et al., 2004)(Wilson & Cousins, 2003) Homogamy is the way that Nature preserves the stability of a species. It is also a way for new species to form, as organisms mate homogamously around some new and interesting mutation until they form an entirely new species.

Studies have consistently indicated that homogamy for mental ability reflects initial assortment (i.e., similarity at the time of marriage) rather than convergence (i.e., increasing similarity with time) (Watson et al., 2004) (Zonderman et al., 1977). Numerous studies from 1926 through 1979 have indicated spousal correlations for intelligence ranging from 0.12 to 0.76, with a weighted mean correlation of 0.44 (Johnson, Ahern, & Cole, 1980). With respect to individual tests, for example the subtests of an IQ test battery, it has been noted that the correlation for spouses is largely a matter of *g*; that is, the degree to which cognitive tests show assortative mating is highly correlated with the tests' loadings on the *g* factor (Jensen, 1998). In this study, a summary score based on the individual neurocognitive tests and analogous to an IQ score, demonstrated a much higher spousal correlation than any of the tests by themselves. Among the individual tests, shifting attention and symbol digit coding were significantly correlated; but none of the other tests were, nor were any of the reaction time measures.

The shifting attention and coding tests on the CNT load together as a single measure of the speed and efficiency of information processing, which is recognized to be a highly *g* loaded factor (Jensen, 1998). Studies in our clinics of 179 adults who were tested with the Wechsler scales and the CNT battery indicated a positive correlation between full scale IQ and the symbol digit coding test ($r = 0.465$, $P < 0001$) and with the shifting attention test ($r = 0.59$, $P < 0001$). (Gualtieri, CT & Hervey, AS, 2013)

Recent studies have been more interested in specific tests than measures of general mental ability. In two studies, one of 318 spouse pairs and one of 123, significant positive spousal correlations were observed for almost all cognitive variables except attention and psychomotor speed (Dufouil & Alépérovitch, 2000) (Zonderman et al., 1977). In our study, in contrast, we found a clear differentiation between tests of processing speed and other neuropsychological tests. Perhaps that is a function of the smaller number of spouse pairs, or possibly the fact that the parents in this sample have children with neuropsychiatric disorders. On the other hand, large *N*'s may artificially inflate the number of variables that are statistically significant. An *r* of 0.18 may be significant in a study of 123 subjects, but will only account for about 3% of variance attributable to that factor. And, if anything, the presence of illness in one spouse or another, or in the offspring, might work against the hypothesis of positive spousal correlation. The small number of husband-wife pairs in this study is a problem; the fact that our results are in accord with previous studies is re-assuring.

In a previous paper we reported positive correlations between first-degree relatives who were administered the CNT battery, and which occurred primarily in tests of complex information processing, SDC and SAT (Hervey, Greenfield, & Gualtieri, 2012). In this paper, we note that the same two tests contribute more strongly than any other tests to the high spousal correlation for neurocognition. There is a certain symmetry, then, between the cognitive skills that play into spouse selection and the cognitive skills that are inherited. A better word than symmetry might be *inevitability*.

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