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CORRELATIONS BETWEEN NONVERBAL INTELLIGENCE AND NERVE CONDUCTION VELOCITIES IN RIGHT-HANDED MALE AND FEMALE SUBJECTS

FAIK BUDAK

Kocaeli University, Medical School
Department of Neurology
Edirne, Turkey

TUNCAY MÜGE FILIZ
PINAR TOPSEVER

Kocaeli University, Medical School
Department of Family Medicine
Edirne, Turkey

ÜNER TAN

Cukurova University, Medical School
Department of Physiology
Adana, Turkey

A neurological theory of intelligence suggesting a direct correlation between nerve conduction velocity and psychometric intelligence was tested. Cattell's Culture Fair Intelligence Test was used to asses the nonverbal intelligence (IQ) of subjects. The motor median nerve conduction velocity from right hand of males was positively correlated with IQ. In subjects with no familial sinistrality (FS–), the motor ulnar-nerve conduction velocity from the right and left hands

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Address correspondence to Prof. Dr. Üner Tan, Cukurova University, Medical School, Department of Physiology, Adana, Turkey. E-mail: unertan@cu.edu.tr

of males negatively correlated with IQ; there were inverse correlations between IQ and nerve conduction velocity (motor median nerve from right, sensory median nerve from right and left) in females. In subjects with familial sinistrality (FS+), IQ directly correlated with nerve conduction velocity from motor median (right and left), sensory median (right), and motor ulnar (right) nerves, but only in males. The speed hypothesis and neurological theory of intelligence were not supported by these results, which, in contrast, emphasized the importance of sex and familial sinistrality in any theory of intelligence.

Keywords brain, handedness, IQ, nerve conduction velocity, sex difference

Galton (1892) has suggested that intelligence could be reduced to the reaction time, and Eysenck (1986a, 1986b) has re-emphasized this concept and pointed out the importance of reaction time as an elementary measure of intelligence: the speed of information processing is a fundamental property of biological intelligence (the "speed hypothesis of intelligence"). Accordingly, the nonverbal IQ has been found to be directly correlated with hand speed in right- and left-handed subjects (Tan, 1989b, 1989c, 1990b, 1990c). Moreover, inverse relations between nonverbal IQ and the latencies of the Hoffman reflex (Tan, 1992a), and visual evoked potentials (Tan et al., 1993) were also reported in right- and left-handers.

According to the "Neurological Theory" of intelligence the correlation between reaction time and intelligence should be characterized in terms of (1) nerve conduction velocity, (2) the rate of decay of information in neural assemblies, and (3) oscillation in excitatory potential of individual neuronsor assemblies of neurons. Vernon and Mori (1989) found a significant correlation between IQ and nerve conduction velocity in the median nerve. However, Jensen (1991) did not find a significant correlation between peripheral nerve conduction velocity and IQ, and stated that the reasons for these discrepant results are unknown, but further attempts to replicate Vernon's and Mori's result should eventually resolve the issue.

As mentioned earlier, sex, handedness, and familial sinistrality are important factors in studies relating to intelligence (Tan, 1988b, 1989a, 1989d, 1990a, 1990d). Sex by family handedness interactions were also found to be of significance in differentiating performance on measures of cerebral laterality and spatial abilities. The aim of this study was to describe the relationships, if any, between IQ and nerve conduction velocity, familial sinistrality, and gender.

METHODS

Subjects and Hand Preference

The experiments were performed on 41 male and 29 female right-handed students between 18 to 21 years of age. They were healthy, devoid of neurological and psychiatric signs and symptoms. Hand preference was assessed using the Edinburgh Handedness Inventory (Oldfield, 1971). Geschwind scores (see Tan, 1988a) greater than zero with right hand writing indicated right-handedness. The subjects were asked for familial sinistrality, that is, if there were any left handedness in mother, father and/or siblings (1st degree familial sinistrality), or if one of the grandparents were left handed (2nd degree familial sinistrality). Subjects exhibiting no familial sinistrality were designated as FS–, and others as FS+.

Nerve Conduction Velocity

The skin temperature on the right hand and left arms was measured before recordings. Temperature was maintained above 32ºC. Motor and sensory nerve conduction velocities were determined on the median and ulnar nerves in both arms using conventional techniques (DeLisa & Mackenzie, 1983).

To measure the median nerve's motor nerve conduction velocity, the active surface electrode (recording) was placed one-half the distance between the metacarpphalangeal joint of the thumb and the midpoint of the distal wrist crease. The reference electrode was placed on the distal phalanx of the thumb. The ground electrode was between the recording and the stimulating electrodes. Stimulation (cathode) was applied with the cathode 8 cm proximal to the active electrode, between the flexor carpi radialis and palmaris longus tendons. Proximal stimulation was applied in the medial aspect of the antecubital space. Distal latency and motor nerve conduction velocity was then measured according to conventional methods.

To measure the median nerve's distal sensory nerve conduction velocity, ring electrodes were placed on the second and the third digits. The active and reference electrodes were placed 4 cm apart, mounted in a plastic bar, with the recording electrode proximal at the base of the digits. The ground electrode was between the pickup and stimulating electrodes. The stimulating cathode was applied 14 cm proximal from the active electrode, over the median nerve between the tendons of the palmaris longus and flexor carpi ulnaris. The anode was proximal. The latency from cathode to peak action potential, and forearm sensory nerve conduction velocity was then measured according to conventional methods.

To measure the ulnar nerve's motor nerve conduction velocity the active surface electrode was placed on the abductor digiti minimi on a point midway between the distal wrist crease and the crease at the end of the fifth digit. The reference electrode was on the fifth digit. The stimulating electrode (cathode) was applied 8 cm proximal to the active recording electrode and just over the flexor carpi ulnaris tendon. Measurements across the elbow were done with the elbow-flexed position.

To measure the ulnar nerve's distal sensory nerve conduction velocity, the active and reference electrodes were placed on the fifth digit with 4 cm separation. The active recording electrode was proximal at the base of the digit. The ground electrode was between the stimulating and recording electrodes. The stimulating electrodes were applied 14 cm proximally, just radial to the flexor carpi ulnaris. The cathode was distal. The ulnar nerve's forearm sensory nerve conduction velocity was then calculated using the ulnar nerve's distal sensory latency according to conventional methods.

Nonverbal Intelligence

Individual differences in spatial reasoning (nonverbal intelligence) were assessed using Cattell's Culture Fair Intelligence Test (Cattell, 1957). This test measures fluid intelligence and was designated to eliminate language and to provide an estimate of intelligence that is relatively free of cultural influences (see Cattell, 1971). This is a paper-and-pencil procedure and covers three levels: Scale 1, for ages 4 and to 8 and mentally retarded adults; Scale 2, for ages 8 to 13 and average adults; and Scale 3, for grades 10 to 16 and superior adults. In this study, Scale 3 (Form A) was used as a group test. Scale 3 consists of the following four time sections. These subtests were (1) Fluid (series): Select the item that completes the series; (2) Fluid (classification): Mark the one item in each raw that does not belong with the others; (3) Fluid (matrices): Mark the item that correctly completes the given matrix, or pattern; (4) Fluid (conditions): Insert a dot in one of the alternative designs so as to meet the same conditions indicated in the sample design. The raw scores were converted into IQs, according to a table for converting raw scores directly into intelligence quotients within in each age group. Fluid intelligence was considered as intellectual development due to primarily to biological factors (Horn & Cattell, 1966).

Cronbach (1970) divided general intelligence into two factors as verbal analytic and figural analytic, and included spatial ability in the latter. A second order general visualization factor represents spatial ability in Horn and Cattell's (1966) theory of fluid and crystallized ability. Scale 3 Form A in the Cattell's Culture Fair Intelligence Test measures the spatial ability of fluid intelligence. Performance in spatial tests has been recorded to be predictive for success in a wide range of technical areas, such as engineering, science, drafting, and design occupations (McGee, 1982).

RESULTS

In men ($N = 41$), IQ was found to be significantly correlated only with motor median NCV from the right ($r = .40$, $p = .01$) and left hands ($r = .31$, $p < .05$); there was no significant correlation for the sensory median NCV and IQ from the right ($p > .90$) and left hands ($p > .30$). There were also no significant correlations between IQ and ulnar NCVs ($p > .30$).

In women ($N = 29$), there were no statistically significant correlations between nerve conduction velocities and IQ in the total ($r = .14$ to $-.27$, $p > .20$).

In FS– men ($N = 21$), there were no significant correlations between IQ and nerve conduction velocities ($r = .08$ to $= .28$, $p > .25$). In FS– women ($N = 13$), there were different degrees of negative correlations between IQ and nerve conduction velocity: inverse correlation between IQ and motor median NCV from the right and left hands ($r = -.53$ to $-.65$, $p < .05$); inverse correlation between sensory median NCV from the right and left hands and IQ ($r = -.75$ to $-.78$, $p < .005$); no significant correlation between IQ and motor ulnar NCV ($r = .30$, $p > .10$).

In FS+ men ($N = 20$), there were positive correlations between IQ and the NCVs from the motor median ($r = .51$, $p < .01$) and sensory median nerves ($r = .35$, $p = .01$) from the right hand (no significant correlations from the left hand)—no significant correlations in the FS+ women.

DISCUSSION

The relationships between IQ and nerve conduction velocity were analyzed in males and females separately. The results were found to be sex-dependent. Vernon & Mori (1989) have not taken into account the sex of their subjects. The present results suggest that these authors would probably obtain quite different results if they had considered the males and females separately.

It has been frequently reported that there are sex-related differences in cognitive abilities. (Buffery & Gray, 1972; Carter-Saltzman, 1978; Casey & Brabeck, 1989; Corsi-Cabrera et al., 1989; Gordon, 1991; Linn & Petersen, 1985; McGee, 1982; Piazza, 1980; Roof & Havens, 1992, Sengstake & Chambers, 1991; Tinkcom et al., 1983; Vandenberg & Kuse, 1978; Voyer & Bryden, 1990). In accordance with the neurological theory of intelligence, IQ was found to be related to motor median NCV from right hand, but only in males. There was no significant correlation between IQ and NCV in females, suggesting the relation of IQ to NCV depends on sex. Testosterone and estrogen may be of importance in the direct correlation between IQ and nerve conduction velocities. Testosterone has indeed been frequently reported to exert neurotrophic effects (Gorski et al., 1978; Toran-Allerand, 1978; Kurz et al., 1986; Yu & Cao, 1991; Goudsmith et al., 1990). On the other hand there are studies indicating that testosterone is positively related to spatial abilities (Money & Alexander, 1966; Masica et al., 1969; Dawson, 1972; Hier & Crowley, 1982; Rovet & Netley, 1982; Christiansen & Knussmann, 1987). The studies in Tan's laboratories have also showed that there is a direct correlation between serum testosterone levels and nonverbal intelligence assessed by the Cattell's Culture Fair Intelligence Test, but only in the right-handed male subjects, not in females (Tan, 1990d, 1990e, 1990f; Tan & Akgün, 1992). In accordance with the speed hypothesis of intelligence, Tan (1991) has found that there is an inverse correlation between nonverbal IQ and the H-reflex latency, but only in males again (no correlation in females). These results supporting the present results indicate that testosterone may be beneficial for nonverbal intelligence as well as nerve conduction velocity in male subjects.

In general, an inverse correlation was found between IQ and NCV in the FS– men and women. This result did not support Vernon and Mori (1989) and Reed and Jensen (Jensen, 1991) who found a positive correlation and no significant correlation between IQ and nerve conduction velocity.

The male sex hormone testosterone may also contribute to the inverse relationship between nerve conduction velocity and IQ in FS– females. Accordingly, Tan (1990d) found that the right-hand skill (peg moving) is inversely correlated with serum testosterone levels in right-handed female subjects. There was also an inverse correlation between hand performance (dot filling) and serum testosterone levels in females (Tan, 1990e). Tan (1990f) has also reported that there is a significant negative linear correlation between nonverbal IQ and serum testosterone in females with consistent right-handedness (Tan, 1990g). Moreover, the amplitudes of P39 and N49 components of the somatosensory evoked potentials only from the left hemisphere were found to be negatively linearly correlated with testosterone in right-handed females (Tan, 1990h).

Another sex hormone, estrogen, does not appear to be a factor playing a role in the inverse relationship between IQ and NCV in FS– females. Accordingly, estradiol was found to be disadvantageous for right-hand preference in females (Tan, 1992b). This would be explained by improving of the left-hand skill with estrogen because the right-hand skill was found to be inversely correlated only with the left-hand skill in right handers (Tan & Kutlu, 1992). On the other hand, estrogen has been reported to be a neurotrophic factor, which may be protecting cholinergic neurons involved in learning and cognitive performance through the nerve growth factor (Cotton, 1994).

In contrast to FS– subjects, there was a positive linear correlation between IQ and NCV, but only in males. Here again, the importance of the genetic factors such as sex and FS becomes clear. The aforementioned considerations for the male and female total sample about the possible factors contributing to the direct IQ–NCV relationship may be emphasized here again. Thus, the genetically predetermined neural organization would play a role in the IQ-NCV relationships. Accordingly, evidence for genetically influenced spatial ability was provided by several authors (Ashton & Borecki, 1987; Bailey & Revelle, 1991; Eysenck, 1973; Jensen, 1972; Stafford, 1961; Bock & Kolakowski, 1973).

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