Arm Nerve Conduction Velocity (NCV), Brain NCV, Reaction Time, and Intelligence

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Two hundred California students, 18 to 25 years old, were tested for nerve conduction velocity (NCV) in the arm and in the visual pathway of the brain, simple and choice reaction times, and Raven's Progressive Matrices test for nonverbal intelligence. Contrary to a prediction based on theoretical grounds, and also to one study, arm NCV did not correlate with this intelligence measure. It also did not correlate consistently with the brain NCVs or with reaction time. In contrast, these brain NCVs do correlate positively (as predicted) with this measure of intelligence in this group of subjects and also in each of five electrophysiological studies of mentally retarded or demented subjects (relative to normal controls). A correct interpretation of these results should assist our understanding of the neurophysiological basis for human information processing and intelligence.

Nerve conduction velocity (NCV), the speed at which an impulse (action potential) travels along a nerve, is a basic physiological parameter and its measurement in various peripheral nerves is a standard neurological procedure. For a given nerve segment and recording technique, normal persons usually have NCV values which deviate from the mean by less than 10%; significantly low values usually indicate disease or trauma (e.g., Ma & Liveson, 1983; Oh, 1984). From extensive studies in mice (Hegmann, 1972, 1975, 1979; Hegmann, White, & Kater, 1973; Reed, 1983, 1988; White & Hegmann, 1974), NCV, like some other physiological parameters, has been shown to be partly determined by heredity. Narrow-sense heritability (from parent to offspring) was estimated to be .23 ± .05 in a strain of noninbred mice and is expected to be appreciably greater in humans (Reed, 1988).

The concept of possible correlations in normal mammals between peripheral NCV (PNCV) and various behaviors may have been first proposed by Hegmann in 1972 (see also his later papers, especially Hegmann, 1979) for mice. Francis Galton in the last century proposed that higher intelligence is a consequence of faster "mental speed" and suggested testing this belief by measuring reaction time. Although he was not successful in showing a correlation, the negative correlation between choice reaction time and IQ has now been shown in several laboratories (Vernon, 1987).

The concept of a correlation between PNCV and human intelligence may have been first suggested by Reed (1984). This correlation is expected if there is a correlation between PNCV and brain (cortical) NCV (BNCV) because faster BNCV should increase the speed that information (as action potentials) is moved along nerve axons from one region of the cerebral cortex to another. This increased speed, in turn, should increase the rate of information processing, which, in turn, appears to be associated with higher intelligence (Reed, 1988). The contrary sequence—decreased speed, decreased rate, and lower intelligence—should also occur.

The predicted positive correlation between BNCV and intelligence was found in each of five recent electrophysiological studies of mentally retarded or demented subjects. Each study found that normal age-matched controls had shorter visual evoked potential latencies (therefore, faster NCV) over the visual pathway (retina to thalamus to primary visual cortex) than did the retarded or demented subjects (Creel & Buehler, 1982; Gasser, Pietz, Schellberg, & Köhler, 1988; Korinthenberg, Ullrich, & Füllenkemper, 1988; Landi et al., 1987; Pollock et al., 1989). A positive visual pathway NCV–intelligence correlation ($r = .26$, $p < .002$) was also found in the normal subjects of the present study (Reed & Jensen, 1989, 1991). This BNCV–intelligence correlation is becoming well established. The question is to be investigated in the present study is the correlation between PNCV and BNCV and between PNCV and intelligence.

In addition to the present study, two studies have looked for a PNCV–IQ correlation. Vernon and Mori (1989) determined NCVs for three segments of the median nerve of the arm and a measure of intelligence in 85 Canadian university students. They found a significant positive correlation (.42) between an overall measure of these NCVs and intelligence. Barrett, Daum, and Eysenck (1990) measured median nerve NCV (of the hand-wrist region) and Raven's Advanced Progressive Matrices (RAPM) in 44 British adults. They found no correlation between the NCV and the RAPM score.

The present report is from a study designed to determine possible correlations between various NCVs, in both the peripheral nervous system (PNS) and the central nervous system (CNS), and a measure of intelligence. As noted previously, one result of this study has already been briefly reported. This report will present the results of testing NCV in the median nerve of the arm, various

reaction times, visual pathway (brain) NCV, and the Otis IQ equivalent of Raven's Progressive Matrices in 200 students in California. The students were from a university and two community colleges. Within populations, no significant correlations between the median nerve NCV and IQ or visual pathway NCV were found. In the total population there is a small negative correlation between median NCV and IQ, probably due to population stratification. Because of the potential importance of the subject matter—the neurophysiological basis of information processing and intelligence in normal and retarded individuals—the methodology of the present study is presented in detail.

SUBJECTS AND METHODS

Subjects
Students from three state-supported postsecondary educational institutions in the eastern San Francisco Bay region of California, who were male, between 18 and 25 years of age, of European ancestry, and in apparent good health, were invited to participate in the study. These institutions included one university (112 students) and two community colleges (88 students). These colleges are two-year institutions offering both vocational and academic courses. Unlike the university, they admit any high school graduate. Subjects were recruited through advertisements and notices and were paid for their participation. All gave their informed consent. Interviews and testing were carried out in the laboratory of the second author (A.R.J.) in 1987 and 1988.

Testing

Personal Data and Intelligence. Subjects were questioned on their age, health status, handedness (preferred hand for writing), visual acuity (all had good vision, some after correction by glasses), and were measured for height, weight, arm span, and head length. (Measurements were made while wearing indoor clothing, without shoes. Height and arm span (arms horizontal) were measured to the nearest centimeter; weight was measured to the nearest kilogram. Head length was measured to the nearest millimeter using a cephalometer caliper in the sagittal plane with the blunt tips at the glabella and opisthocranion (Olivier, 1969). The university students were given the Raven's Advanced Progressive Matrices test (Raven, 1983a) while the community college students were given the Raven's Standard Progressive Matrices (Raven, 1983b). (The latter test was thought to be appropriate for the less academically selected college students; the results showed that the advanced version would have been appropriate.) These tests were given without a time limit; most subjects took between 30 and 60 min. The Raven's scores were converted to equivalent Otis-Lennon IQ scores using a conversion from a different California college student population given all three tests (Jensen, Saccuzzo, & Larson, 1988).

Reaction Times. Four reaction times (RTs) were determined in one test session using the Jensen test console (Jensen, 1985). This apparatus consists of a panel of 8 button lights arranged in a semicircle, each 15 cm from a "home" button below them. The subject keeps the home button depressed (with the index finger of the preferred hand) until one or more of the 8 button lights is lighted and then, as quickly as possible, removes the finger from the home button and presses the (one) indicated light. The time from the light onset (stimulus) to the removal of the finger from the home button is the RT.

After practice sessions, the four RT tests (simple, choice-1, Oddman, choice-2) were given in this sequence. Each RT test consists of 20 (simple and choice RT) or 36 (Oddman) presentations. For each presentation, a warning sound is given and, after a random interval of 1 to 4 s, the light(s) come(s) on. For the simple RT, the light can come on only in one position. For choice-1 and choice-2 RT, the light can come on at any one of the 8 positions; it comes on in a different position in each trial. For the Oddman RT, three lights come on at once; one (the Oddman) of these three is more distant from the other two and is the one to be pressed. The next presentation has a different pattern; all possible light patterns, in random sequence, are presented. Presentations and scoring are controlled by a microcomputer. False responses were not scored, but such trials were repeated at the end of the series so that each subject had the same number of error-free responses. For each subject and RT test the value reported is the median (Jensen, 1985). For each subject, the difference between the Oddman RT median and the simple RT median, $O - S$, is calculated because, in this paradigm, this time period appears to be the most highly correlated with IQ scores (Jensen & Reed, 1990).

Visual Pathway NCVs. Two visual evoked potentials (VEP), N70 and P100 (Chiappa, 1983; Lowitzsch, 1989), following pattern reversal stimulation, were measured on a 2-channel test instrument (TD20, TECA Corp., Pleasantville, New York). Stimuli were black and white checkerboard patterns (consisting of squares 12.5 mm on a side, subtending a visual angle of 43° at 1 m), reversing at 2 Hz, presented on a video monitor (with visual angles of 14° by 18°). Luminance level was constant within and between trials and was in the usual clinical range (W. Adamson, personal communication, 1987).

Each subject was tested while seated comfortably in a quiet, darkened room, with both eyes open and 1 m distant from the center of the monitor (as measured horizontally). After cleaning the scalp with EEG scalp abrasive, standard EEG-type gold cup electrodes, filled with electrode paste, were applied to four sites: Oz, Fz, Cz, and Fpz (10–20 International System). Impedances at these sites were usually below 4 Kohms. Filters were set for a band pass of 2 to 100 Hz. Channel 1 was Oz (neg.) and Fz (pos.); Channel 2 was Cz (neg.) and Fz (pos.); Fpz was neutral. The difference between Channels 1 and 2, approximately equivalent to Oz − Cz, where Oz is over the occipital (visual) cortex and Cz is at the

vertex of the head (both in the sagittal plane), was used to detect N70 and P100. The subject was instructed to fixate on a spot in the center of the monitor. Typically 100 to 200 pattern reversals (50–100 s) were given for each of two trials, with a rest period of 2–3 min between tests. Artifactual potentials, from eyeblinks and other sources, were automatically rejected. The signal-averaged output (Oz − Cz) of each test was displayed on a screen and traced onto a chart in a strip printer. The N70 and P100 peaks, the first defined signals recorded at the visual cortex, were scored for latencies to the nearest millisecond by the first author (T.E.R.), using electronic cursor readings, and without knowledge of the subject's previous test scores. Only well-defined peaks were included; this requirement resulted in elimination of some subjects. The average of each subject's two scores for N70 and P100 was used; for this article both N70 and P100 mean latencies were required to be known. The N70 and P100 latencies (in milliseconds) were converted to corresponding visual pathway NCVs, V:N70 and V:P100, by dividing them into the subject's head length (in millimeters). This gives an approximate velocity, between the retina and the primary visual cortex, in meters per second. (These appear to be the first in vivo estimates for brain NCVs in normal humans.) Because head length should be approximately proportional to the length of the visual pathway, the *correlations* of these approximate visual NCVs with IQ should be a useful estimate of the true visual NCV–IQ correlation ($r_{xy} = r_{cxy}$, where x and y are variables and c is a constant).

Nerve Conduction Tests. NCVs were determined for the wrist-elbow segment of the median nerve of the arm of the preferred hand (for writing). This is a mixed nerve (motor and sensory) which has conduction velocities similar to upper limb sensory nerves (Oh, 1984). The aforementioned T20 test apparatus was used for both electrical stimulation and display and recording of the response. The skin over the wrist and elbow regions was lightly abraded with very fine sandpaper and cleaned with the recommended skin cleaner electrode paste. TECA Corp. stimulating/recording electrodes (a cathode and an anode, each 10 mm in diameter, with centers 30 mm apart, and set in a rigid plastic mount) were used, with each cathode distal to its paired anode. Impedances between electrodes were usually below 5 Kohms. The electrodes were connected (with 76 cm leads) to a preamplifier which connected with the TD20. TD20 filters were set for a band pass of 20 Hz to 2 kHz, with a 6dB/octave rolloff outside this band. A ground electrode was placed midway between the wrist and elbow sites over cleaned prepared skin. A thermistor probe was taped near this site to provide continuous skin temperature readings. Following the NCV measurements an oral temperature was taken.

After locating the subject's optimal stimulating and recording sites, the stimulating voltage was slowly increased to determine the lowest supramaximal stimulation level (the level beyond which the amplitude of the nerve action potential no longer increased in the display oscilloscope). (This level insures that

all of the nerve fibers of the median nerve are being stimulated. This procedure was well tolerated by the subjects; only 2 of 213 subjects found it painful.) Using this level, several (3–10 usually) stimulations, at 1 Hz, pulse duration 0.05 ms, were given. The responses were signal averaged and monitored on the screen. This procedure almost always yielded a very clear action potential with very little noise. Electronic cursors were positioned to measure the latencies (from time of stimulus) to the onset (first deviation from baseline), peak, and end (return to baseline) points of the nerve action potential. These data were printed on the strip recorder of the TD20. This procedure was repeated for a second set of values. The intercathode (center to center) distance on the arm was measured at the end of testing. Dividing this distance (in millimeters) by the mean of the two laten-cies (in milliseconds), for a given point of the action potential) gives the NCV for that point. Thus, three NCVs, onset, peak, and end, were obtained for each subject. Onset NCV and peak NCV are both commonly used in clinical work (Ma & Liveson, 1983; Oh, 1984) and measure the conduction speed in the fast-conducting (large diameter) nerve axons and the average-conducting (average diameter) nerve axons, respectively. Because it is easily measured in the same test session, end NCV was also determined; this is the speed of conduction of the slow-conducting (small diameter) axons.

To correct for the known effects of temperature on NCV (Ma & Liveson, 1983; Oh, 1984), as well as for other possibly important covariates, multiple regression of each of the three NCVs on arm temperature, oral temperature, height, weight, arm span, and age was carried out on the total population. For each NCV the regression coefficients for arm temperature and oral temperature were both significant (at the .01 level and below) and positive. No other coeffi-cients were significant at the .02 level in any of the three regressions. The effects of the two temperatures were removed by regressing each subject to the popula-tion temperature means.

Reliability of NCVs. Fourteen subjects were tested again, several days to several weeks after their first test, to determine the repeatability of the NCV values.

RESULTS

Table 1 gives the means and standard deviations for age, physical measurements, and IQ for the two student groups and the total population. As expected, the only large difference is in the equivalent Otis-Lennon IQ scores. The mean for the community college group is 111.6 while that for the university group is 124.0, differing at the .001 level. (All *p* values are two-tailed). Both means reflect some "ceiling effect" (Table 1). As expected for these selected populations, both standard deviations are reduced from the normal value of 16, being 9.4 and 8.3, respectively. All other mean differences are small and/or nonsignificant. The community college students appear to be slightly larger in size.

TABLE 1
Description of Subjects

Source	N	Age* (Yrs)		Height* (cm)		Weight (kg)		Arm Span[a] (cm)		Right Handed (%)	Arm Temperature (°C)		Oral Temperature*** (°C)		IQ Score[b] Equivalent***	
		M	SD	M	SD	M	SD	M	SD	M	M	SD	M	SD	M	SD
Community College	88	20.0	1.9	179.6	6.5	75.7	10.3	181.3	7.6	83.0	32.80	.96	36.89	.24	111.6	9.4
University	112	20.6	2.1	177.2	8.1	73.3	10.8	178.9	8.9	83.0	32.59	1.12	36.76	.28	124.0	8.3
Total	200	20.3	2.0	178.3	7.5	74.3	10.6	180.0	8.4	83.0	32.68	1.06	36.81	.27	118.53	10.7

Note. All subjects were white male students (community college or university), 18 to 25 years of age, from the Eastern San Francisco Bay area of California.

[a]Exact $p = .0498$. [b]Otis-Lennon IQ equivalent of Raven's Progressive Matrices score (Jensen, Saccuzzo, & Larson, 1988). Two college students and nine university students had the highest possible Raven scores, consequently, these scores show some "ceiling effect".
*$p < .05$. **$p < .01$. ***$p < .001$ (significant two-tailed differences between means of the two student groups).

Mean values for the three nerve conduction velocities, corrected for arm skin temperature and oral temperature, and peak amplitude of nerve action potential (measured peak to peak; Oh, 1984), corrected for weight, are presented in Table 2. For each velocity the community college students are slightly but significantly ($p < .01$) faster than the university students. The mean amplitudes do not differ significantly. The onset and peak NCV means ($\pm$ *SE*) of the total population, 67.9 $\pm$ .3 and 57.2 $\pm$ .2 m/s, respectively, agree reasonably well with values reported in the literature for adults. Oh (1984) reports values of 64.5 $\pm$ .7 and 56.0 $\pm$ .5 for this segment of the median nerve using similar stimulation and recording for an older population (40 normal adults 20–60 years of age). The mean amplitude for the total population, 38.0 $\pm$ 1.2 μvolts, also agrees reasonably well with the value of 32.0 $\pm$ 2.6 reported by Oh (1984). Repeat determinations of peak velocity (corrected for arm temperature) in 14 subjects gave a mean subject difference (repeat NCV − original NCV) value of .89 $\pm$ .42 (*SE*) m/s, considerably less than the values reported by Ma and Liveson (1983). The correlation between the subject's repeat and original NCVs was .63 ($p = .017$).

The correlations for community college students between the three velocities and peak amplitude with reaction times, visual pathway NCVs, and IQ score are given in Table 3 (p. 42). Since 32 correlations are reported, single correlations significant at only the .05 level are likely Type 1 errors and are disregarded here. Peak and end NCVs appear to be positively correlated with simple and choice RTs (contrary to expectation) but not with other variables. Peak amplitude does not show a definite correlation with any variable. Most importantly, the visual pathway NCVs and IQ do not show any significant correlations with the NCVs or amplitude; the correlations with IQ are all remarkably low (absolute values less than .10).

In Table 4 (p. 43) the corresponding correlations for university students are given. In contrast to the community college students, there are no NCV correlations but peak amplitude appears to show a consistent, but low, negative correlation with all the RTs. Again, there is no correlation between the NCVs or amplitude and visual tract NCVs and IQ.

Since the community college students have a higher mean NCV and a lower mean IQ than do the university students, one could predict that NCV–IQ correlations in the combined sample (both groups together) would be negative. This is what was found: The correlations with onset, peak, and end NCVs are −.14, −.16, −.17, respectively, the last two being significant at the .05 level.

DISCUSSION

The close agreement of our mean arm NCVs and peak amplitude with the values reported in the literature (Oh, 1984) for the same nerve segment and technique, and our smaller standard deviations (4.2 vs. 4.3 and 2.8 vs. 3.3, for onset and peak NCVs, respectively), suggests that the NCV technique was satisfactory.

TABLE 2

Median Nerve (Arm) Conduction Velocities and Peak Amplitude

| Source | Median Nerve Conduction Velocities | | | | | | Peak Amplitude | |
| | Onset** | | Peak** | | End** | | | |
	M ± SE	SD	M ± SE	SD	M ± SE	SD	M ± SE	SD
Community College	68.96 ± .46	4.17	57.85 ± .27	2.53	50.41 ± .23	2.19	35.64 ± 1.56	14.6
University	67.11 ± .40	4.08	56.76 ± .28	2.94	49.34 ± .27	2.82	39.77 ± 1.66	17.6
Total	67.93 ± .31	4.21	57.24 ± .20	2.82	49.81 ± .18	2.61	37.95 ± 1.16	16.4

Note. Conduction velocities, for the wrist-elbow segment, corrected for arm temperature and oral temperature, are in a m/s. Nerve peak amplitudes, corrected for weight, are in μvolts. All stimulations are supramaximal; values are for the mean of two series of stimulations. Student numbers are as in Table 1, except for onset velocity: 82 from Community College, 103 from University. *P* values are as in Table 1.

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TABLE 3
Correlations in Community College Students Between Median Nerve (Arm) Conduction Velocities (NCVs) and Reaction Times, Visual Pathway (Brain) NCVs, and IQ Score

| Median Nerve NCV | Reaction Times[a] | | | | | Visual Pathway NCVs[b] | | |
	Simple	Choice-1	Choice-2	Oddman	O-S	V:N70	V:P100	IQ
Onset velocity	+.209	+.070	+.120	+.003	−.090	+.004	+.118	+.038
Peak velocity	+.314**	+.215*	+.244*	+.182	+.053	−.002	+.218	−.081
End velocity	+.344***	+.247*	+.266*	+.198	+.056	−.024	+.180	−.093
Peak amplitude	+.266*	+.094	+.102	+.077	−.022	−.044	+.137	+.011

Note. P values are as in Table 1; NCVs and amplitude are as in Table 2. Number of correlated pairs varies from 73 to 88.
[a] Reaction times (RT) measured on the Jensen apparatus (Jensen, 1985). See text for descriptions. Mean RTs in milliseconds, beginning with Simple RT, are: 265, 309, 322, 458, 193, respectively ($N = 88$, SD from 24 to 57).
[b] Approximate estimates (see text): V:N70: headlength/N70 latency V:P100: headlength/P100 latency, where N70 and P100 are short-latency visual evoked potentials evoked by pattern-reversal stimulation (Chiappa, 1983; Lowitzsch, 1989). See text for details. $M(SD) = 2.77(.15)$ and $1.99(.098)$ m/s, respectively.

TABLE 4

Correlations in University Students Between Median Nerve (Arm) Conduction Velocities (NCVs) and Reaction Times, Visual Pathway NCVs, and IQ Score

| Median Nerve NCV | Reaction Times | | | | | Visual Pathway NCVs | | IQ |
	Simple	Choice-1	Choice-2	Oddman	O–S	V:N70	V:P100	
Onset velocity	+.112	–.057	–.011	+.003	–.049	–.220	–.205	–.074
Peak velocity	+.029	–.093	–.072	–.095	–.114	–.184	–.111	–.038
End velocity	–.002	–.095	–.087	–.088	–.091	–.143	–.065	–.047
Peak amplitude	–.217*	–.189*	–.212*	–.210*	–.113	+.002	–.089	–.026

Note. P values are as in Table 1; NCVs and amplitude are as in Table 2. Number of correlated pairs varies from 77–112 (median nerve NCV–IQ pairs, 103–112). Reaction times are as in Table 3, except $M = 275, 321, 334, 463,$ and 188 ms, respectively ($N = 112, SD$ 32–69). Visual pathway NCVs are as in Table 3, except $M(SD) = 2.77(.15)$ and $2.01(.088)$, respectively.

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The mean peak amplitude of 38 μV, with a *SD* of 16 μV, shows that almost all signals are well above the amplifier noise level of about 5 μV (Ma & Liveson, 1983), even before signal averaging further reduces this level.

The main result of this study is the lack of correlation, within the two groups, between any arm NCV and the IQ score. The small negative correlation found in the total sample appears to be a simple consequence of population stratification (college students have a higher mean NCV and a lower mean IQ than university students). Therefore, the prediction of a positive correlation between peripheral NCV and intelligence (Reed, 1984) was not confirmed. This lack of correlation is further supported by two other nonsignificant NCV correlations (within groups): (a) *visual pathway NCVs* which, being within the brain, are expected to correlate positively with intelligence if brain NCV is a component of the rate of information processing; an earlier report from this project found such a visual NCV–IQ correlation ($r = .26, p = .0017$; Reed & Jensen, 1989, 1991); and (b) *Oddman RT* and (*Oddman − Simple*) *RT,* both of which have been shown to correlate negatively with intelligence (Jensen & Reed, 1990). The relatively low variation among subjects in arm NCV (coefficient of variation for peak NCV, *SD/M,* is .045) might prevent detection of very small correlations with IQ, but this variation for visual NCV (V:P100) is even smaller (.044) and this was adequate to detect an IQ correlation ($r = .26, p = .0017$).

Our arm NCV correlation results contrast sharply with those of Vernon and Mori (1989). Testing 85 Canadian university students (summer students, age range 18 to 42 years [$M = 24.5$], with a mean WAIS equivalent IQ of 107) for peak NCV in three different segments of the median nerve, with supramaximal stimulation, they found an overall NCV–IQ correlation of .42 ($p < .01$). This correlation was between the first principal component for the three NCVs and the corresponding component for the 10 mental subtests (called "IQ"). Although their subjects differ in mean age and IQ from ours, the NCV techniques were generally similar and it is not obvious why the results differ. There were several technical differences between studies in NCV testing: We measured one median nerve segment (wrist-elbow), controlled both arm temperature and oral temperature statistically, and stimulated with 0.05 ms pulses, whereas Vernon and Mori measured wrist-finger, wrist-elbow, wrist-axilla segments and physically controlled the arm temperature within a rather wide range (32–35°C). Their pulses were 0.2 ms, their "average" NCV was a weighted mean of the 3 NCVs, and their wrist-finger NCV was apparently (exact values not given) well above the reported values for this segment (Ma & Liveson, 1983; Oh, 1984). These differences in technique, however, should not produce the large difference in correlation (.42 vs. "not different from zero"). Our IQ score, while not ideal (we had a "ceiling effect"; 11 subjects had the highest possible Raven scores), was adequate, even with our restricted IQ range, to show the expected negative correlation with Oddman RT values (Jensen & Reed, 1990) and it had a very

significant positive correlation with visual pathway NCVs. These study dif-
ferences are puzzling.

The other reported NCV–IQ correlation (Barrett et al., 1990) tested 44 British
adults, 18 to 41 years of age; an unspecified number were from an employment
agency. They were given Raven's Advanced Progressive Matrices in a 20-minute
period, the 30 males having a mean score of 13.2 while the 14 females had a
mean of 15.6. The subjects were tested for four peak NCVs of the sensory
median nerve of the hand-wrist region (both hands) using *sub*maximal stimula-
tion. No significant correlation between NCVs and the Raven's score were
found. This negative finding agrees with our findings but its interpretation is
open to some question. Barrett et al. did not use the supramaximal stimulation
customary for NCV studies (Ma & Liveson, 1983; Oh, 1984); their stimulation
was only 1 or 2 mA above threshold. Without supramaximal stimulation, an
unknown and probably varying proportion of nerve axons of the nerve (each
axon conducting at a different speed) is excited at each stimulation, and then only
in the large diameter axons (Kandel & Schwartz, 1985), giving an atypical NCV.
Further, their sample size is relatively small so that their negative finding has
little statistical power.

The small but consistent difference between our two subject groups in mean
NCVs, in favor of the community college students, was unexpected. This might
be due to the slightly larger body size of these students (although not detectable
in the regression analysis), because larger size should be associated with larger
nerve axons which will conduct more rapidly (Reed, 1988). A more interesting
possibility is suggested by extensive NCV studies in mice (Reed, 1988) which
showed that the number of cage mates after weaning correlates positively and
very significantly ($p < .0001$) with NCV. An obvious consequence of increased
crowding is increased social and physical stimulation. On the average, communi-
ty college students are probably more physically active than are university stu-
dents (some were sports majors, whereas none of the latter were) and this greater
stimulation may lead to increased NCV. Further support for this possibility
comes from the finding that the NCV in the median nerve of thè arm of the
dominant (more active) hand appears to be slightly faster than the NCV in the
other arm (Ma & Liveson, 1983).

The quite different patterns of NCV–amplitude correlations with reaction
times in our two groups have no obvious explanation. Within each group there is
some consistency, for example, positive NCV–RT correlations in community
college students, negative peak amplitude–RT correlations in university stu-
dents. One could speculate that group differences in level of physical activity
again might be a factor, but we have no evidence for this.

In conclusion, with a sample size of 200, this study failed to confirm the
predicted positive correlation between peripheral nerve conduction velocity and a
standard measure of nonverbal intelligence. This NCV also failed to correlate

with a brain NCV or with certain reaction times, each of which shows correlation with intelligence. If these findings are correct, there appears to be a basic difference between peripheral NCV and visual pathway (the latter being in the brain but not in the cerebral cortex) NCV. Only the visual NCV appears to reflect the NCV of the cerebral cortex which is important in information processing. Resolving these issues will be important for understanding the neurophysiological basis for human information processing and intelligence (Reed, 1984, 1988).

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