Human brain bioenergetics relate to cognitive ability

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Introduction

We recently reported a significant positive correlation between cerebral pH and measures of intellectual ability in young boys[1]. This relationship was strongest with measures of verbal ability, which also correlated (though less strongly) with Pi-containing ratios. In an effort further to characterise what relationships exist between brain biochemistry and cognitive ability, we obtained ^{31}P MRS spectra from the brains of 26 adult males along with data from psychometric tests of verbal fluency and speed of information processing.

Methods

Subjects Subjects comprised 42 boys[1] (124 ± 17 months) and 26 adult males (31 ± 8 y) who were volunteers drawn from the local Oxfordshire population with informed consent.

Spectroscopy We obtained ^{31}P MRS spectra at 2T, using a butterfly surface coil which sampled a region on either side of the intrahemispheric fissure composed largely of frontal lobe, with some contribution from parietal lobe[1]. Spectra were obtained across 4k data points on a duty cycle of 15 s. Following zero-filling, transformation with 6 Hz exponential line-broadening and base-line correction, peak areas were fitted using NMR1.

Psychometric testing We administered a battery of tests which included categorical and phonemic verbal fluency, the Symbol Digit Modalities Test (SDMT; both oral and written formats), inspection time (IT; a measure of quantal perceptual periodicity) and the Speed and Capacity of Language-Processing test (SCOLP).

Results

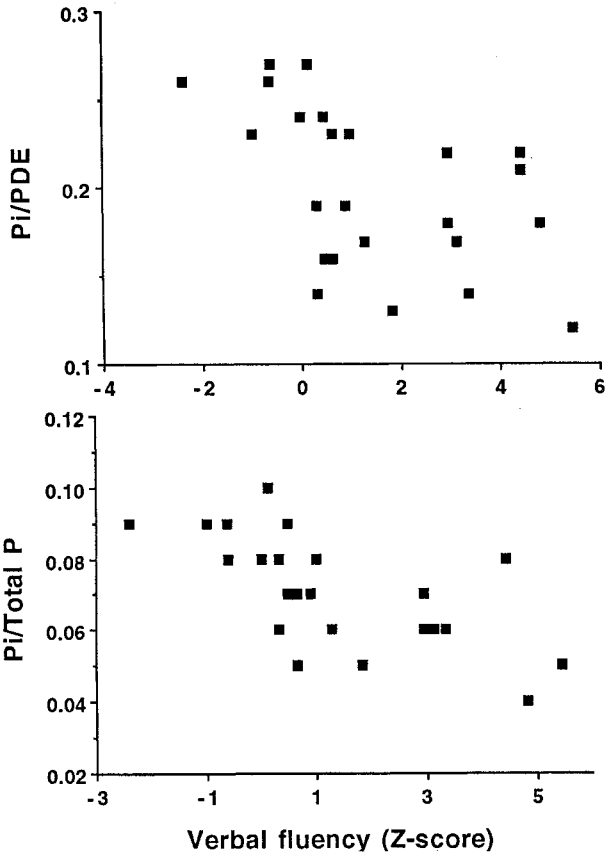
We found significant correlations ($p < 0.05$; Spearman's Rank) between Pi, ATP and PDE-containing ratios (Table 1; Fig 1; Table 2) and some measures of cognitive ability. The results in Table 1 and 2 suggest that other than the correlation between SDMT (written) and Pi/ATP, the relationship between Pi and PDE-containing ratios and tests of speed of information-processing in the verbal domain is more robust than similar measures in the non-verbal domain (*i.e.* SDMT, IT). Further, no significant relationship was found between the Spot-the Word subtest of the SCOLP (a lexical decision making task) and any ^{31}P ratio. Arguably, the latter test samples crystallised (Gc) cognitive ability[2] rather than fluid (Gf) ability.

Ratio	Test	p	rho
Pi/ATP	SDMT (written)	0.038 *	-0.49
	semantic fluency	0.030 *	-0.45
	verbal fluency	0.014 *	-0.51
Pi/PDE	SDMT (written)	0.061 NS	-0.44
	SDMT (oral)	0.069 NS	-0.43
	verbal fluency	0.004 **	-0.60
Pi/Total P	semantic fluency	0.042 *	-0.43
	verbal fluency	0.002 **	-0.65
PDE/ATP	speed of comprehension	0.024 *	-0.45
PDE/Total P	speed of comprehension	0.028 *	-0.44

Table 1. ^{31}P MRS correlations in adults

Ratio	Test	p	rho
Pi/PDE	VIQ	0.031	-0.33
	information	0.015	-0.38
	vocabulary	0.035	-0.33
	comprehension	0.039	-0.41

Table 2. ^{31}P MRS correlations in children



Discussion

In seeking to extend our previous finding of a significant relationship between cerebral pH and verbal ability in young boys, we have found a similar relationship in both adults and boys between various measures of information processing in the verbal domain and Pi-containing ratios. The level of Pi reflects the bioenergetic status of the brain.

Acknowledgements

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References

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