Predicting Academic Skills by Neuropsychological Functions

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Abstract

Seventy-nine subjects were evaluated for cognitive deficits, and the results were then used to predict academic skills. We hypothesized that reading and spelling skills would be best predicted by auditory processing, while arithmetic skills would be best predicted by spatial perception. Results showed arithmetic significantly related to bilateral processing, spatial-perception, executive, and intellect skills. Reading and spelling skills depended upon auditory processing as predicted, but was also related to motor speed and spatial-tactile learning. The results suggested that academic skills map to neuropsychological functions in complex fashions.

Predicting Academic Skills by Neuropsychological Functions

There has long been interest in the relationship between patterns of cerebral functions and the ability to demonstrate the development of academic skills or behaviors. Many classic theories ofleaming disorders implicate problems in neuropsychological functioning with the development or demonstration of a significant learning disorder (e.g. Rouke, 1985; Rouke and Del Dotto, 1994). The nature of the neuropsychological dysfunction in arithmetic disorders has been described as bilaterally served (Batchelor, Gray and Dean, 1990), while reading disorders may depend more strongly on left hemisphere temporal sequencing functions. At the same time, not all learning disorders spring from cerebral dysfunction, and some theorists note the contribution of psychosocial factors and learning environment factors as being important to the development oflearning problems (White, Moffitt and Silva, 1992).

Another approach to understanding the relationship of neuropsychological functions to academic skills would be to assess brain-behavior functions directly, and then relate these findings to demonstrated levels of academic behaviors. Current knowledge in neuropsychology suggests that reading and academic skills would be best predicted by linguistic auditory processing skills, while mathematics skills would be optimally predicted by non-dominant hemisphere spatial-perceptual skills, with bilateral integration of those skills. However, research has sometimes suffered from the formation of learning disorder groups by the use of cutoff scores, while it seems consideration of such variables in a continuous fashion would be more useful. Also, some samples appear to be small, especially in regards to arithmetic disorders, at times with only twenty-five subjects or less.

With these questions in mind, a comparison was made between young adults performance on measures of academic skills (reading, arithmetic and spelling) while considering the neuropsychological underpinnings of the academic skills. Inparticular, the results of a comprehensive neuropsychological test battery was used to predict individuals' scores on an achievement battery.

Method

A sample of young adults (N = 79) were evaluated for a variety of cognitive and cerebral deficits, and the results of these neuropsychological evaluations were then used to develop a multiple regression analysis to optimally predict academic skills. The subjects were a mixed and heterogenous sample of mixed learning disorders, individuals suffering from dementia, cognitive disorders, vascular disorders, no demonstrable disorder, and some demonstrating other types of cerebral impairment. The average age of the subjects was 28.86 (SD = 11.98) and the sample was largely male (57.0%).

The subjects were administered comprehensive neuropsychological evaluations, with the Halstead-Reitan Neuropsychology Battery (HRNB). The battery was administered as described in Reitan and Wolfson (1993), with the results compared to the recently developed findings from Jarvis and Barth (1994). The Wechsler Adult Intelligence Scale - Revised (WAIS-R, Wechsler, 1981) was administered, followed by the Wide Range Achievement Test - Revised (WRAT-III, Wilkinson, 1993). The core aspects of the Halstead Battery followed, including the Category Test (computer version), Tactual Performance Test (TPT), Speech-Sounds Perception Test, Seashore Rhythm Test, Finger Tapping Test, and Trails A and B. The Aphasia Screening Test and the Sensory-Perceptual Examination were also administered in the battery.

Results

The initial stepwise regression was applied to the prediction of WRAT-3 scores on arithmetic. The regression resulted in moderate but significant correlation, R = .57. The scores predicting WRAT-3 arithmetic scores most strongly were Full Scale IQ, Trails B times, Tactual Performance Test (TPT) times for both hands, and Category Test errors, in order of contribution to the total correlation. Trails B samples visual spatial location skills, thought to be mediated by both non-dominant hemisphere skills and the ability to integrate visual stimuli with sequential motor demands. Table I summarizes these results for the prediction of arithmetic scores.

Variable	Std. Beta	R Square Change	Sig F Change
Full Scale IQ	.447	.419	.001
Trails B	-.297	.099	.001
TPT Both	.197	.025	.047
Category Test	-.220	.029	.028

The stepwise regression was also applied to both WRAT-3 reading standard scores and spelling standard scores. For reading, Full Scale IQ scores again yielded the most optimal prediction of reading recognition scores, followed by Finger Tapping Test scores for the non-dominant hand, the Speech Sounds Perception Test error score, and the TPT location score. Again, the multiple correlation was modest but significant, with R = .52. Table II summarizes the results of the prediction of the reading standard scores.

Variable	Std. Beta	R Square Change	Sig. F Change
Full Scale IQ	.603	.368	.001
Finger Tap (non-dom)	-.244	.056	.008
Speech-Sounds	-.289	.057	.005
TPT Location	.208	.037	.020

The optimal prediction of the spelling standard scores by the neuropsychological measures included, as in the earlier multiple regression analyses, Full Scale IQ, TPT time for both hands, Speech-Sounds Perception Test errors, and TPT time for the dominant hand. While highly similar to the multiple regression on reading scores, the regression analysis on the spelling scores appeared to also draw on tactile and kinesthetic abilities, as sampled by the TPT times. Table III describes the results of this analysis.

Variable	Std. Beta	R Square Change	Sig. F Change
Full Scale IQ	.544	.311	.001
TPT both	.220	.079	.002
Speech-Sounds	-.277	.049	.012
TPT dom	.187	.030	.045

Discussion

While general neuropsychological theories of learning disorders suggested patterns of impairment associated with particular abilities in academic skills, the current results appear to be more complex than most theories currently suggest. First of all, intellectual capacity or "g" held the strongest relationship in all measured areas of academic skills. Second, while arithmetic abilities did appear to demonstrate a significant relationship to non-dominant hemisphere functions, there was also evidence of a relationship of arithmetic abilities to integrating hemispherical functions and applying executive processing skills, as measured by TPT time for both hands and Category Test errors, respectively. These results bear some similarity to the findings of Batchelor, Gray and Dean (1990). Third, both reading and spelling skills related significantly to performance on the Speech-Sounds Perception Test, indicating functioning in this type of auditory speech processing skills is important to both reading and spelling. However, reading recognition appears to also relate significantly to non-dominant motor speed, and a measure of incident spatial recall. The significance of

these findings is unclear, although spelling abilities related significantly to TPT performance times in the both handed condition and the dominant hand condition. This suggests integrated and dominant parietal region analysis may be important for spelling skills.

Additional sampling of neuropsychological findings and the relationship of those skills could aid in understanding how robust these findings may be. The results do suggest a more integrated pattern of neuropsychological relationships and academic skills rather than simpler relationships. It is recommended that additional research investigate the relationships between neuropsychological functions and academic skills, particularly focusing on higher level academic skills, such as reading comprehension and writing skills.

References

Batchelor, Ervin S., Gray, Jeffrey W., and Dean, Raymond S. (1990). Neuropsychological aspects of arithmetic performance in learning disability. *The International Journal of Clinical Neuropsychology. 12*(2), 90-94.

Jarvis, Paul and Barth, Jeff (1994). *The Halstead-Reitan Neuropsychological Battery*. Psychological Assessment Resources, Odessa, Florida.

Reitan, Ralph and Wolfson, Deborah (1993). *The Halstead-Reitan Neuropsychological Test Battery. (2nd edition).* Neuropsychology Press, S. Tucson, Arizona.

Rourke, Byron P. and Del Dotto, Jere! E. (1994). *Leaming Disabilities: A Neuropsychological Perspective.* Sage Publications, Thousand Oaks, California

Rouke, Byron P. (1985). *Neuropsychology of Leaming Disabilities. Essentials of Subtype Analysis.* Guilford Press, New York, NY

White, Jennifer L.; Moffitt, Terrie E., and Silva, Phil A. (1992). Neuropsychological and socio-emotional correlates of specific-arithmetic disability. *Archives of Clinical Neuropsychology. 7,* 1-16.

Wilkinson, T. (1993). *The Wide Range Achievement Test - Third Edition. Manual*. Jastak Publishing, CT.