Cognitive Abilities Underpin Academic Performance: Australian Secondary School Study (2014)

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NEUROMITE RESEARCH

BACKGROUND

Cognitive ability is one of the most frequently investigated individual differences in psychology and management. There is vast evidence and research demonstrating that tests measuring cognitive ability predicts a number of important real-world outcomes such as academic achievement, on-the-job performance and vocational training.

Cognitive ability is often categorised as either fluid or crystallised. Fluid ability represents novel or abstract problem solving capability and the ability to think and reason logically independent of previous knowledge. In contrast, crystallised ability is associated with learned or acculturated knowledge and experience. Crystallised ability measures have been found to be predictors of academic performance (as measured by grades)[1]. For instance, among secondary school students, cognitive ability has been shown to correlate positively with academic performance. In a 5 year longitudinal study of over 70,000 British school children, moderate to strong correlations between a CAT (standardised cognitive ability test measuring numerical, verbal and abstract reasoning) and total grade, and between CAT and students' best 8 exam scores were found[1]. Such correlations are expected as common crystallised ability measures such as verbal or numerical ability tests are closely aligned to English and Math subjects in terms of content.

Turning to fluid abilities in educational contexts, three broad abilities are perceived to be important. These include attention, memory and executive functioning. It is believed that such abilities are critical for the acquisition and understanding of school subjects. For example, if students are unable to attend to learning material at the right time and in the right way, they are likely to have learning difficulties. If a student cannot control their attention, interfering information will not be filtered out and learning will be impaired. As a result of poor attention, or inadequate control over attention, academic performance will likely suffer.

Many classroom tasks such as listening, reading comprehension, written expression, and mental arithmetic require students to constantly use their working memory. Students need to retrieve memorised information under conditions that include task inference (e.g., recalling similar but incorrect information), self-disruption (e.g., mind chatter, holding interesting but irrelevant thoughts, or emotional perturbation), or classroom distraction (e.g., noise, cross-talk, or socialising). Without sufficient memory ability, students face reoccurring difficultly when learning and recalling school material.

Many factors influence student attention and working memory, such as motivation, anxiety, and fatigue. If, for any reason, a student's attention is disturbed, their opportunity to learn is diminished because attention is essential to maintain information in working memory[2]. Effective acquisition and utilisation of many skills at school require executive functioning capabilities to direct attention, memorise, and control impulses and distractions. Success depends on students' ability to plan, organise and prioritise tasks, materials, and information, separate main ideas from details, think flexibly, and monitor their progress.

In contrast to crystallised abilities, innate or fluid abilities suffer from a paucity of quality research in general and, in particular, in educational settings. For example, very little is known about various attention types (e.g., alertness, vigilance, sustained attention, selective attention, focused attention, spatial attention and divided attention) and their relationship with student scholastic performance. Most of the educational research on attention is based on clinically diagnosed students with ADD and ADHD as opposed to students in general. The effect of combining attention and memory to determine their joint relationship with academic performance is largely missing from the literature. Measurement methods have focused on low reliability measures such as teacher ratings of students' attention (via a questionnaire or a survey). Very few studies have used performance based measures of attention abilities using psychometrically validated tests, as opposed to observational ratings.

AIM: The present study aimed to explore the association of fluid abilities, attention and memory, with academic performance in grade 9 students. Abilities assessed in the study were chosen based on student curricular requirements, cognitive developmental and maturation theory.

METHOD

Ninety-eight grade 9 students from a GPS school in Brisbane's metropolitan region undertook a 50 minute test battery assessing their (1) Alertness, (2) Sustained attention, (3) Verbal working memory, (4) Divided attention, and (5) Planning. Testing was conducted using Schuhfried Australia's Vienna Test System (VTS)* - a computer based psychological assessment platform. All VTS tests are **psychometrically** sound (strong construct validity and reliability, standardised administration and immediate reporting). A range of academic achievement data was collected: (a) GPA (grade point average - overall global score across all subjects), (b) NAPLAN (Reading, Spelling, Grammar, Writing, and Numeracy) , and (c) ICAS - The International Competitions and Assessments for Schools (English and Science). Data analysis was carried out using correlations and regression in SPSS.

* VTS tests comply with DIN 33430, the ITC guidelines and the Standards for Educational and Psychological Testing of the American Educational Research Association. Schuhfried is listed under the Australian Psychological Society as an endorsed psychological test publisher and supplier.

RESULTS

Correlation Between Cognitive Abilities and Academic Scores

Ability / Variable	Correlations – Bolded correlations are significant at p < .05							
	GPA	NAPLAN (Read)	NAPLAN (Spell)	NAPLAN (Grammar)	NAPLAN (Write)	NAPLAN (Numeracy)	ICAS (Science)	ICAS (English)
Verbal Memory Capacity	**0.44**	**0.38**	**0.34**	**0.39**	**0.31**	**0.52**	**0.40**	**0.35**
Verbal Memory Quality	**0.30**	**0.22**	0.12	**0.27**	**0.51**	**0.24**	**0.24**	0.17
Divided Attention Capacity	**0.55**	**0.53**	**0.35**	**0.50**	**0.37**	**0.48**	**0.36**	**0.54**
Divided Attention Quality	**0.37**	0.19	0.12	**0.27**	**0.30**	**0.22**	0.12	0.21
Tower of London – Planning Ability	**0.22**	0.20	0.05	**0.26**	0.14	0.08	0.03	0.21
Visual Alertness (Speed of Response)	**0.28**	0.14	0.21	0.20	**0.36**	**0.26**	0.20	0.09
Sustained Attention Capacity	**0.21**	0.06	0.05	0.15	0.17	0.07	0.04	0.10

The table above demonstrates that:

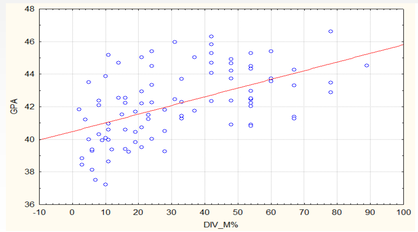
1. All of the cognitive abilities are positively associated with multiple academic areas, suggesting that such abilities are closely related to academic performance.
2. Memory, attention, planning, alertness and sustained attention are positively correlated with students' GPA scores. The better the score on these abilities the higher the GPA score.
3. Divided Attention Capacity and Verbal Memory Capacity show strong positive relationships with every academic measure.
4. NAPLAN's five measures of numeracy and literacy are strongly related to memory and divided attention, plus planning ability for grammar and visual alertness for writing and numeracy.
5. Alertness and sustained attention have lower positive correlations across most of the academic measures**.

** This is expected as these two 'basic' (low order) abilities are first to develop in early childhood based on the cognitive milestone and sequence of ability development research. However, both are critical in attainment of more complex abilities such as divided attention and verbal memory.

Regression Analysis

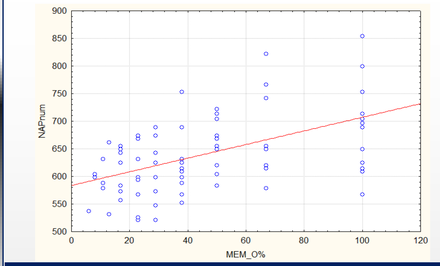
Multiple regression analysis was used to test if the cognitive abilities significantly predicted academic school performance. The results of the regression for the global academic score (GPA) indicate that cognitive abilities explain 38.1% of the variance (**R^2=.38, F(7,73)=6.42, p<.001**). It was found that divided attention capacity was the strongest factor in predicting GPA (B = .43, p<.01).

Scatterplot - Divided Attention Capacity and GPA Scores



The scatter plot shows a significantly positive correlation (R=0.55, R^2 = 0.30) between students' divided attention capacity and GPA scores. Middle and high school curriculum demands a high degree of attention switching and processing of multiple information sources simultaneously (e.g., Listening to the teacher, synthesising visual and auditory information whilst taking notes). Students who can switch attention effectively between concurrently occurring tasks will be best equipped to learn and perform well in exams.

Scatterplot - Verbal WM and NAPLAN (Numeracy)



The scatter plot shows a significantly positive correlation (R=0.52, R^2 = 0.27) between verbal working memory capacity and NAPLAN (Numeracy). Mathematical competence entails a variety of complex skills that encompass different problem solving, content and procedures (e.g., Algebra, geometry, arithmetic). In older students, complex tasks such as multi-step procedures in multi-digit arithmetic, word problem solving and numerical estimation all require good working memory or mental workspace which deals with controlling, regulating and maintaining relevant information.

CONCLUSION

The current study shows that there is strong evidence to suggest that cognitive (fluid) abilities underpin academic success. The capacity of a student to perform well at school is strongly associated with divided attention, verbal memory, alertness, planning ability and sustained attention. Whilst the study was based on correlation analysis, it cannot be said with certainty that cognitive ability drives academic success. However, current research suggests that attention and memory are important underpinning abilities for a range of academic, occupational, and life outcomes. The authors' are involved in ongoing research, on the development of fluid cognitive abilities and corresponding improvement in academic scores.

The practical implications of this study for students and teachers, are focused on recognising the importance of cognitive abilities and taking action to use and improve them. We should not only focus on academic content of learning but, in addition, set about to understand the importance of cognitive abilities and work directly to improve such abilities, especially weaknesses. The benefits to the students are likely to be apparent with resultant improvements in academic areas such as literacy, numeracy, and science.

With an assessment of key cognitive abilities such as attention, memory, planning ability, alertness and sustained attention, teachers will gain insights into the profile of student abilities. A correct assessment will give teachers accurate information about their students' ability strengths and weaknesses and the impact of those on their scholastic progression. As a result, teachers will be better equipped to modify the content and delivery of instructions or lesson plans to students who may have attention or memory based difficulties. For example, for students with:

- Divided attention issues, provide short, simple, and sequential directions, one at a time to reduce the demand on self-regulated attentional shifting and control. Students can better follow directions, under a poor divided attention ability, when they have to pay attention to and remember only one instruction at a time.

- Verbal memory concerns, use known visual cues (e.g., pictures, or class rules) when learning new verbal material because it will activate student's prior knowledge. Modelling new tasks or skills at normal speed, slow speed, and then with narration will enhance comprehension and retention.

REFERENCES

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