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The stroop test and its relationship to academic performance and general behaviour of young students

Anthony Imbrosciano
University of Notre Dame Australia, aimbrosciano@nd.edu.au

Richard G. Berlach
University of Notre Dame Australia, rberlach@nd.edu.au

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Title: **THE STROOP TEST AND ITS RELATIONSHIP TO ACADEMIC PERFORMANCE AND GENERAL BEHAVIOUR OF YOUNG STUDENTS**

Authors:

Dr Anthony Imbrosciano is a Senior Lecturer in Philosophy and Education at the University of Notre Dame Australia. His interests in Education include Philosophy of Education, Character Development, and Learning Theory. In Philosophy, his interests include the History of Philosophy, Logic and Epistemology, and Philosophical Psychology. A graduate of the University of Sydney, he completed his doctorate on Soren Kierkegaard and his views concerning the education of character.

Telephone: (08) 9433-0663
Email: aimbrosciano@nd.edu.au

Dr Richard G. Berlach is an Assoc. Prof. in Education at The University of Notre Dame Australia. He holds qualifications in education, psychology, and theology. Main research interests lie in the areas of self-concept formation; tertiary level teaching strategies; and student-centred learning styles. Principal interests include teaching Education units in the disciplines of human learning, pedagogy and child development; teaching post-graduate units in self-concept; engaging in Professional Teaching Practice at undergraduate level; and supervising students completing Honours, Master, and Doctoral thesis studies.

Telephone: (08) 9433-0151
Email: rberlach@nd.edu.au

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THE STROOP TEST AND ITS RELATIONSHIP TO ACADEMIC PERFORMANCE AND GENERAL BEHAVIOUR OF YOUNG STUDENTS

Anthony Imbrosciano & Richard G. Berlach
The University of Notre Dame Australia

Abstract

The test developed by Stroop some seventy years ago is used, among other purposes, as an indicator of attention disorder and general mood fluctuations. The present research attempted to determine whether a correlation existed between the Stroop Test, student ability as defined by a standardised IQ test, and general classroom behaviour. This study involved 87 year three students, across four schools in Perth, Western Australia. Independent variables included socio-economic level, gender, and school type (government or private). Results indicated a strong positive correlation of IQ and Stroop Test Ranking with Socio-economic status. No significant differences were found between IQ and Stroop by type of school, nor were any significant differences found with regard to gender. Results suggest that the Stroop Test may be a powerful predictive instrument with regard to students' academic performance and general behaviour rankings.

THE STROOP TEST: A REVIEW OF RELATED LITERATURE

The "Stroop Test" or "Stroop Effect" is named after psychologist John Ridley Stroop who first identified the phenomenon in his PhD work in the 1930s.[1] Since that time, over 700 articles have made reference to this formative work of Stroop.[2] Among other uses, the test is seen as being a valuable identifier of Attention Deficit Hyperactivity Disorder (ADHD)[3]. With the recent advances in brain-based research, an attempt has been made to better understand the Effect through exploration of its immediate neurological environment.

The challenge of the task is to focus on one particular feature (language), while blocking out another (colour). Colour words are presented in the congruent mode (e.g. the word 'red' written in a red colour) or the incongruent mode (e.g. the word 'red' written in a different colour). In the incongruent mode, the instruction is given to read column-wise, and name the colour in which the word is written (Table 1).

Table 1: The Stroop Test[3] (As colour printing is not available, the colour in which the word has been written is indicated in brackets after each word).

Red (Blue)	**Blue (Red)**	**Yellow (Green)**	**Green (Yellow)**
Blue (Green)	**Green (Yellow)**	**Yellow (Green)**	**Red (Blue)**
Green (Red)	**Red (Blue)**	**Blue (Yellow)**	**Green (Blue)**
Red (Yellow)	**Yellow (Red)**	**Red (Green)**	**Green (Blue)**
Green (Blue)	**Blue (Red)**	**Red (Yellow)**	**Yellow (Green)**
Blue (Red)	**Green (Blue)**	**Blue (Yellow)**	**Red (Red)**
Red (Green)	**Blue (Red)**	**Red (Blue)**	**Yellow (Blue)**

Subjects are timed on the 28 word task, the score being the time taken to complete the reading. Errors are pointed out to participants and must be corrected as they proceed, though this proves to be rarely necessary, as participants tend to self-correct.

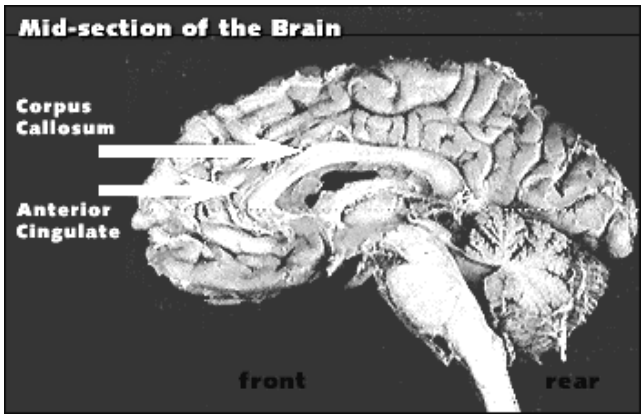
The test is normally preceded by a "trial run", in which subjects are asked to read the words written in black ink (the congruent version). The difference between their time on this round is then compared with their time on the incongruent round to produce a ratio - the differential being the score.

Colour blindness does not affect test reliability as the test is predicated on incongruence, and not whether the colours are correctly identified. If a person has come to associate colour x as being y, and names it y, then incongruence will still occur.

The "Stroop Effect", as it has come to be known, is created by the words themselves having a strong influence over one's ability to say the colour. The interference between the different information received by the brain – what the words say as opposed to the colour in which they are written – causes a problem in the ability to remain focused on the task at hand. The incongruency between the word and colour is also associated with the speed of processing, in that word processing is much faster than colour processing.[4] Thus, in a situation of incongruency, the word information arrives earlier than the colour information, resulting in confusion at the time of decision making. The subject must technically wait for the colour information to arrive, which lags behind the word information, while feeling pressured to complete the naming as quickly as possible.

One neurological theory that has been forwarded to explain the problem has concentrated on a part of the brain known as the anterior cingulate, seen below (Table 1):[5]

Table 1:



A midsagittal view of the right hemisphere i.e. a cross-section through the middle of the brain.

The anterior cingulate lies between the right and left halves of the frontal lobes of the brain, and is also thought to be involved in a wide range of thought processes and emotional responses. This is thought to be the region of the brain that is responsible for selecting an appropriate response, when given two conflicting conditions. It also resides just above the limbic system, deep in the cortex. It has been suggested that it is the limbic system which drives more impulsive behaviours, whereas the cortex drives more rational/thoughtful behaviours. As such, the anterior cingulate is thought to be a very important region, acting as a hemispheric conduit mediating between left and right brain, and limbic and cerebral functions.[6]

Bush, Frazier et.al (1999) stated: "The anterior cingulate cognitive division (ACcd) plays a central role in attentional processing by: (1) modulating stimulus selection (i.e. focusing attention) and/or (2) mediating response selection."[7] These researchers hypothesised that an anterior cingulate dysfunction contributes to producing the core features of ADHD, namely inattention and impulsivity, and noted the generally poor performance of subjects with ADHD on the Stroop Test, which they describe as an "attentional/cognitive interference task known to recruit the ACcd". Their research confirmed this hypothesis and reported a distinct lack of ACcd activity in the case of ADHD subjects. Positron Emission Topography studies have also shown activation of frontal tissue during the performance of the Stroop Test.[8] This supports the contention that dysfunction in the ACcd may cause attention to be more easily diverted.

It should be emphasised that difficulty with completing the test does not immediately suggest that the reader has an attention problem, such as ADHD. It is, however, one indicator, which would invite further investigation, and is commonly used as such.[9]

Lohr (1995)[10] also suggested that a connection exists between affective disorders and attentional dysfunction. In his research, he examined the influence of depression on attentional function, giving the Stroop Test to patients diagnosed with severe depression. He found that these patients performed significantly poorly when compared to normal controls ($p < .0001$). Given the proximity of the anterior cingulate to the limbic system, and given that the limbic system is the part of the brain that appears to be most directly involved with human emotion-regulation problems of

the most crucial mood centres, Lohr's findings raise some interesting possibilities regarding the connections between Stroop Test performance, and affective factors. The only difficulty here is the emergence of a possible contradiction. The anterior cingulate appears to become *more* active when the subject is sad, yet based on the findings of Bush, Frazier et. al. appears to be less active during Stroop Test performance.

Possible connections between the Stroop effect and emotionality have also been investigated by Hoover, Kuck et. al (1996).[11] These researchers investigated four classes of words: emotional colour-related, emotional non-colour-related, colour-related and non-emotional, and non-colour related. They found that colour-relatedness had an effect on Stroop Test response time, but that emotionality did not. This, of course, relates only to associations between words and the emotions that they represent, and does not necessarily translate into emotions personally felt by the individual.

The previously cited study followed up on that of McKenna and Sharma (1995)[12] who conducted four experiments. In each, participants were given appropriate stimuli and asked to name the colour in which they were presented. In the fourth experiment, however, neutral words such as "pilot", "pulse", "fourth", and "barrel", were contrasted with negative emotional words, such as "fail", "angry", "cancer", and "murder", and also with positive emotional words, such as "glad", "hope", "peace", and "happy". McKenna and Sharma found that interference occurred with the negative emotional words, but not the positive ones.

Other researchers have looked into what has become known as the "Reversed Stroop Effect", which refers to attempts to counter or negate the delay between word processing and colour processing speed. Glaser & Glaser (1982)[13] postulated that if the colour preceded the word in a display, this should allow the colour sufficient lead time to reach the decision mechanism before the word information. This should then negate the Stroop Effect. However, they found that when the colour was presented 400 milliseconds before the word, this "Reversed Stroop Effect" did not arise, suggesting that the speed of processing to account for the Stroop Effect is insufficient.

Dunbar and MacLeod (1984)[14] tried to create a Reversed Stroop Effect by experimenting with words in unusual formats (e.g. upside down, backwards), arguing that this would slow subjects sufficiently to negate the slowing down in the Stroop Effect. Somewhat surprisingly, this also did not work. Other researchers, however, have had success in creating the "Reversed Stroop Effect" (e.g. Melara & Mounts, 1993).[15]

Clearly, the effect identified by Stroop so many years ago has not yet been crystallised in the body of available research. Further, its relationship to many other variables remains unexplored. The purpose of the present study is to determine if a correlational relationship exists between Stroop scores, academic performance and general behaviour of *circa* 8-9 year old children. The identification of such a relationship could give researchers and practitioners greater insight into the nature of learning processes.

PARTICIPANTS

This study involved 87 year three students, across four schools, in Perth, Western Australia. Year three students (approx. 8-9 years olds) were chosen as this age cohort was keen to participate, seeing the activities as 'fun'; sufficiently sophisticated to understand the tasks presented; and as yet unaffected by the complexities of adolescence. The four schools were chosen to investigate possible socio-economic differences (SES), as well as differences between the government and non-government education sector. Both non-government schools were Catholic, and together with the government schools, were selected using convenience sampling techniques within predetermined SES areas. The following profile was thus created:

A. A government school in a lower SES area.
B. A non-government/Catholic school in the same lower SES area.
C. A government school in a higher SES area.
D. A non-government/Catholic school in the same higher SES area.

The SES factor was determined by reference to AUS-STATS, a census-derived database maintained by the Australian Bureau of Statistics. The median earnings of individuals in the lower SES area was found to be $300-$399, which is also the Western Australian median. The median for the higher SES area was $400-$499, well above the State's median. The selection of schools within areas was confirmed by reference to supportive demographic data.[16] (Table 1)

Table 1.
Demographic Data by Socio-Economic Area

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	Area 1 (lower SES)	Area 2 (Higher SES)
Average price of houses	$103,000	$386,000
Percentage of Rental Properties	43%	14%
Median Weekly Rent	$68	$203
Most common educational level	Skilled vocational	Bachelor Degree
Most common occupations	1. Clerical/Sales/Service 2. Tradespersons 3. Labourers	1. Professionals 2. Clerical/Sales/Service 3. Associate Professionals

It is evident from these demographics, that the schools were located in radically different SES areas. Moreover, each of the schools reported that the vast majority of their students resided within a catchment area similar in profile to that of the suburb in which the school was located. The overall profile is presented in Table 2.

Table 2
Profile of Participating Students

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School	Subjects	SES	School Type	Gender
A	21	L	NG	12M-9F

B	19	L	G	12M-7F
C	23	H	NG	10M-13F
D	24	H	G	11M-13F
Total	87	40-L, 47-H	43-G, 44-NG	45M-42F

L=lower; H=higher; G=government; NG=non-government; M=male; F=female

METHODOLOGY

Early in the year, the students were given a standardised cognitive ability ("IQ") test for *circa* eight years of age (Smith and Hagues, 1993)[17]. The test items required no linguistic proficiency, this removing this skill as a confounding variable. The test was entirely visual-spatial in nature and comprised 40 items, with students being allowed 20 minutes to complete it. Once scored, students in each class were ranked according to their performance, to produce an "IQ Rank". Teachers were not informed of the results so as not to set into motion a self-fulfilling prophecy.

At the same time, the students were given the Stroop Test, as described earlier. Their time on the test was recorded, and the students were assigned a "Stroop Rank" score according to their performance. Again, teachers were not informed of the results on this test.

At the end of the year, when it was considered that the teachers really knew their students, they were requested to rank each member of their class, according to the students' general behaviour and academic performance throughout the year. This formed the basis of what would constitute expert opinion.

With reference to academic performance, teachers were asked: "On the basis of your knowledge of each child, please rank your class members in terms of overall academic performance (top student = no.1, through to the lowest ranked student)."

For general behaviour, the teachers were asked to complete a Likert-type ranking for each child in their class (Table 3). A maximum of 32 points was possible, which provided a basis for the ranking.

Table 3
Ranking Procedure for the Category *General*

Please give a rating for each of your students, according to the other aspects below, using the following code:

4 Always
3 Usually
2 Sometimes
1 Rarely
0 Never

1. Pays attention in class
2. Follows directions

3. Completes work diligently
4. Works co-operatively in groups
5. Regularly interrupts others
6. Is neat and tidy
7. Stays on-task
8. Complies with class rules

The students' academic performance rank, and general behaviour rank were further combined to produce a "combined academic and behaviour ranking". These will henceforth be referred to via the following abbreviations:

APR = Academic Performance Ranking
GBR = General Behaviour Ranking
CAB = Combined Academic and Behaviour Ranking

All measurements involving teacher rankings were undertaken on a within-class basis, as it could not be assumed that one teacher's ranking was comparable to another's, and especially across different schools. Thus, when comparing IQ with academic performance, the student's rank order in their class only, on both parameters, was incorporated into any analyses.

It is important to emphasise, therefore, that this study compared "objective" measures – IQ, Stroop Test, socio-economic status, type of school, – against more subjective measures, namely, the teacher's perception of the students' general behaviour, and academic performance. It was considered that this more subjective expert evidence could assist in explaining the results produced by the more objective measures.

RESULTS

All correlations were analysed using a Pearson product-moment two-tailed test, utilising SPSS.11 software. A pairwise analysis was undertaken for all correlations. The following Tables indicate scores and correlations.

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Table 4
Correlations between IQ vs. Stroop Test, and Academic Performance Rankings

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	IQ vs APR	Stroop vs APR
A	0.378	0.671*
B	0.226	-0.031
C	0.636**	0.687**
D	0.503*	0.415*
Mean ∑ A-D	0.436*	0.436*

* = significant to the .05 level, ** = significant to the .001 level.

Table 5
Correlations between IQ vs. Stroop Test, and General Behaviour Rankings

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	IQ vs GBR	Stroop vs GBR
A	0.098	0.670*
B	-0.138	0.001
C	0.491*	0.653**
D	0.287	0.388
Mean ∑ A-D	0.185	0.428*

* = significant to the .05 level, ** = significant to the .001 level.

Table 6
Correlations between IQ vs. Stroop Test, and Combined Academic & Behaviour Rankings

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	IQ vs CAB	Stroop vs CAB
A	0.352	0.864
B	0.094	-0.021
C	0.666	0.735
D	0.440	0.400
Mean ∑ A-D	0.388	0.495

* = significant to the .05 level, ** = significant to the .001 level.

Table 7
Other Results

	IQ	Stroop Test Times	APR vs GBR	IQ vs Stroop Rank
A	96	45 seconds	0.322	0.266
B	90	45 seconds	0.126	0.100
C	110	41 seconds	0.642**	0.456*
D	111	41 seconds	0.687**	0.254
Mean ∑ A-D	102	43 seconds	0.444*	0.269

* = significant to the .05 level, ** = significant to the .001 level.

The result of the comparison between IQ and the Stroop Test (dependent variables), when correlated with APR, GBR and CAB (independent variables) proved to be a significant finding. Both dependent variables correlated identically with APR. The Stroop test correlated more highly, and significantly, with both GBR and CAB. Results are summarised in Table 8.

Table 8
Correlation of Dependent and Independent Variables

	APR	GBR	CAB

IQ Rank	0.436*	0.185	0.388
Stroop Test Rank	0.436*	0.428*	0.495*

* = significant to the p >.05 level.

A more detailed comparison of the variables indicated that the Stroop Test produced stronger correlations with APR in 2 schools (not differentiated by school type), stronger correlations with GBR in all 4 schools, and stronger correlations with CAB in 3 schools. In other words, across the range of 12 comparisons that could be made (4 schools for each of APR, GBR, and CAB), the Stroop correlated more strongly than IQ on 9 occasions.

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Regarding the relationship of both IQ and Stroop Test Ranking to SES, the correlation between SES and IQ proved to be strong ($r = 0.610$, $p>0.001$), whereas the correlation between SES and the Stroop Test proved to be insignificant ($r = -0.131$).

No significant differences were found between IQ and Stroop by type of school, nor were any significant differences found with regard to gender.

As indicated in Table 7, a small correlation of 0.269 was found between IQ Rank and Stroop Rank. If looked at in terms of raw scores, the correlation between IQ and Stroop Scores proved to be 0.327, also not significant.

DISCUSSION

These results suggest that the Stroop Test may be a powerful predictive instrument with regard to students' academic performance and general behaviour rankings. It correlated highly with IQ score as an indicator of academic performance rankings, and distinctly outperformed IQ with regard to general behaviour rankings.

A significant characteristic of the Stroop Test seems to be its relative immunity to socio-economic bias. While a very strong correlation emerged between IQ and SES, this was not to be found in the case of the Stroop Test. Likewise, neither the type of school nor gender showed any significant connection to the Stroop effect.

The correlation between the Stroop Test and general behaviour ranking warrants closer consideration. It must be remembered that the Stroop Test is predominantly a test of attentional function, or conversely, ease of distraction. When examining the 8 criteria supplied for teachers in assessing general behaviour, it becomes apparent that attentional factors could well play a strong part in at least five of the eight criteria.

Criteria one stated "pays attention in class", and is the most self-evidently connected with attentional function. Criteria two stated "follows directions, and it is quite conceivable that a lack of attention to the teacher's directions would be a primary cause of students not following them, as has been shown to be true in other research (Good & Brophy, 1994; Wragg, 1995).[18] Criteria three stated "completes work diligently". Here again, it is somewhat self-evident that diligence, and the tenacity to see a task through to its completion requires a corresponding ability to remain focused and give one's attention to it. Criteria six stated "is neat and tidy". While not being as self-evident, a little consideration would indicate how the ability to produce neat

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and tidy work requires a certain degree of patience and perseverance that attends to detail. An inability to gives one's attention to a task, or be easily distracted from it, may well hinder a student's ability to produce neat and tidy work. Criteria seven stated "stays on task". Here again, it is self-evident how this could be affected by attentional dysfunction.

The three other experimental criteria were: "works co-operatively in groups", "regularly interrupts others", and "complies with class rules". While it is conceivable that attentional dysfunction may well play a part in how a student is ranked in terms of these criteria, they are perhaps not as self-evident or easily arguable as the others.

Examined individually, each of the five criteria discussed produced positive but weak correlations with the Stroop Test, as indicated below:

1. Stroop Test vs. Pays Attention in Class ($r = 0.220$, $p<0.05$)
2. Stroop Test vs Follows Directions ($r = 0.238$, $p<0.05$)
3. Stroop Test vs Completes Work diligently ($r = 0.302$, $p.<0.001$)
4. Stroop Test vs Is Neat and Tidy ($r = 0.248$, $p<0.05$)
5. Stroop Test vs Stays on ask ($r = 0.268$, $p<0.05$)

The other 3 factors did not yield significant correlations.

Returning to the work of Lohr, it was suggested that there exists a connection between attentional dysfunction and affective disorders. Assuming that both attentional and affective factors are locked into general behaviour, this may also go some way to explaining the strength of the Stroop test vs. GBR correlation. The argument would run along the lines:

P1… If affective disorders, then attentional dysfunction.
P2… If attentional dysfunction, then fall in general behaviour ranking.
C… If affective disorders, then fall in general behaviour ranking.

This would square with research which suggests that there exists a strong connection between a student's affective life, and how well s/he behaves in class (Balson, 1992; Porter, 2000).[19] Given Lohr's thesis, while the Stroop Test may be identifying predominantly attentional factors, it may well be identifying affective factors as well.

Such considerations may serve to connect the Stroop Test with current discussions on "emotional intelligence", and even help to further clarify this concept.

CONCLUSION

To conclude this paper, we would like to engage in a little theoretical speculation. Returning to the review of related literature, it may be worth reconsidering some possibilities with regard to the role of the anterior cingulate in both attentional and affective disorders. Recall that the anterior cingulate lies between the left and right halves of the frontal portion of the brain, and is thought to be the region of the brain that is responsible for selecting an appropriate response, when given two conflicting conditions. This becomes significant, given that word and colour recognition are

associated with left and right brain function. The ability to process information from both the left and right hemispheres, and to integrate information across the hemispheres, may go a long way to explaining the Stroop Test's ability to predict academic performance as well as IQ.

Recall also that the anterior cingulate is thought to be involved in a wide range of emotional responses, residing just above the limbic system, deep in the cortex – the limbic system being the driver for more impulsive and emotional behaviours, in contrast with the cortex, which drives more rational/cognitive behaviours. This may go a long way to explaining the Stroop Test's ability to predict general behaviour, given its plausible association with attentional function.

The anterior cingulate, therefore, may well be a very important region of the brain, and the Stroop Test may well be directly targeting it. As researchers at the University of Michigan indicate, it may well be acting as a kind of conduit between both left and right brain, and limbic and cerebral functions [20].

The anterior cingulate may well be a crucial point of intersection between the left and right, and limbic and cerebral regions of the brain. As such, it may play a major role in integrating an individual's thought processes, and creating the balance between one's cognitive and affective life. Little did Stroop know that he had possibility identified a test that just happens to target this vital point of integration, where the four crossroads meet!

If replication studies can confirm the Stroop Test's ability in predicting academic performance as well as IQ, then educators will need to seriously consider the role of the anterior cingulate cortex in mediating performance. Accordingly, new theories may need to be considered for explaining both intelligence and general behaviour. Spin-offs for better understanding associated areas such as ADHD, dyslexia, and bullying, may be enormous.

LINKS WITH CLASSROOM PRACTICE

Most experienced teachers will immediately acknowledge the impact that attentional disorders and mood fluctuations have on students' academic performance and general behaviour in the classroom, as well as the need to come to a better understanding of these factors. At the same time, there is an increasing realization of the importance of affectivity in learning. The current discussion regarding multiple intelligences and emotional intelligence is indicative of this, and how our understanding of learning is rapidly broadening well beyond the cognitive domain.

It would appear that students' academic performance, their general behaviour in the classroom, attentional dysfunctions, and various other affective factors form an important but complex cluster of variables that are crucial in the learning process. As with any cluster of variables, it is sometimes difficult to discern the exact nature of the relationships between each of the variables. Tests that demonstrate strong correlations across a range of variables in a cluster, however, are often very helpful in coming to a better understanding of how the cluster as a whole works. Allied with a good theory and physiological understanding of how the brain operates, such tests may help in

generating vital clues that could help build a much clearer picture of the learning process.

The strength of correlations found in this research between the Stroop Test and academic performance and general behaviour suggests that the test is worth more consideration as a diagnostic instrument in Educational Psychology.

The simplicity of the test, its apparent immunity from socio-economic bias, and its plausible linking of cognitive and affective factors offer tremendous potential advantages over conventional measurements of IQ. It is significant that while a standard IQ test will correlate well with academic performance, it appears to not be a good indicator of other behavioural aspects that are important to learning. Given this research, the Stroop Test would appear to match IQ as an indicator of academic performance, but would appear to outperform it as an indicator of students' general behaviour in the classroom. The research would suggest that teachers could do far worse than to add the Stroop Test to their arsenal of diagnostic instruments, aimed at identifying possible attentional and affective problems for students.

Another exciting dimension to emerge from this study concerns the potentially vital function that the anterior cingulate serves in learning. While educational theory and research has certainly delved into aspects such as left and right brain processing, and more recently the relations between the limbic and cerebral systems, connecting each of these offers the potential to advance our understanding yet another step forward. If the Stroop Test directly targets the anterior cingulate, and if the anterior cingulate is truly a conduit between both left and right brain, and limbic and cerebral functions, then the test may prove very useful in the development of a more unified theory. Such a theory may eventually be able to demonstrate how a balance of left and right brain processing and cognitive and affective factors can work together in producing tremendous learning. In essence, the Stroop Test is worthy of consideration by anyone interested in the whole brain theory of learning.

ENDNOTES

[1] The original article which reported the test was Stroop, J.R. (1935). Studies of Interference in Serial Verbal Reactions. *Journal of Experimental Psychology,* Volume 18, p.643-662.

[2] An excellent review of the research can be found in Bower, B. (1992). Brother Stroop's Enduring Effect: a mental task devised nearly 60 years ago still intrigues psychologists. *Science News.* Volume 141, p.312-314. Also MacLeod, M. (1991). Half a Century of Research on the Stroop Effect: an integrative approach. *Psychological Bulletin.* Volume 102, Number 2, p.163-203.

[3] http://www.adhd.org.nz/stroop1.html

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