The Effect of Acupressure Treatment on Standard Intelligence Test Scores and Reading Comprehension for Children with Learning Difficulties

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Introduction

Difficulties with learning academic tasks such as reading, spelling and mathematics have been recognised for over a century. Kussmaul (1887, cited in Kolb & Whishaw, 1990) is ascribed as the first person to specifically describe an inability to read, that persisted in the presence of intact sight and speech, as word blindness. The word *dyslexia* was coined by Berlin in 1887 (cited in Kolb & Whishaw, 1990). Within a decade Hinschelwood (1895) and Morgan (1896) observed students who were incapable of learning to read and hypothesised that this was based on a failure of development of the relevant brain areas which were believed to be absent or abnormal.

It was not until 1963 that Samuel Kirk (cited in Kolb & Whishaw, 1990), proposed the term “learning disabilities” as a general term to describe problems children had with academic learning. Since that time there’s been a proliferation of labels that attempt to dissociate the learning disabled from the retarded and brain damaged.

Learning disabilities in the context of the present study includes both dyslexia and Attention Deficit Disorder (ADD) with or without hyperactivity. Historically, dyslexia has been widely defined in terms of deficits in the areas of reading, spelling and language. However, more recent conceptualisations have included a definition that also encompasses a wide range of problems, including clumsiness and difficulty with rote learning (Fawcett, 1994). Fawcett and Nicolson have also challenged the prevailing hypothesis that dyslexia is merely a language based problem, suggesting that it might be a more generalised deficit in the acquisition of skills (Fawcett, 1994).

Incidence

Frequently, children diagnosed as learning disabled are also inattentive and deficient in linguistic skills, most often in reading (Aiken, 1996). Gaddes (cited in Kolb & Whishaw, 1990) looked at the proportion of children with learning disorders in various studies in both North America and Europe and found that the need for special training for learning disorders ranged between 10-15% of the school age population. In an address given by the Australian Federal Schools Minister, Dr David Kemp, in October 1996, Kemp stated that a study of 28,000 students in four surveys in Australia found 30% of year 9 students lacked basic literacy skills. This high incidence of learning disorders in school children indicates a need for effective treatment.

Causes

Rather than direct brain damage, the current model of Learning Difficulties is that abnormal physiological or biochemical processes may be responsible for malfunction in some part of the cerebral cortex. Abnormalities in electrophysiological recordings of specific high frequency EEG and AEP (averaged evoked potentials) have been associated with various types of learning disorders (Hughes, 1978 cited in Kolb & Whishaw, 1990). Recent studies with SSVEP (Steady state visual evoked potential) have shown that children diagnosed with Attention Deficit Disorder demonstrate similar abnormal SSVEP patterns when compared to normals while performing the same cognitive task. The brain dysfunction hypothesis suggests that the dysfunction may be a consequence of defective arousal mechanisms resulting in some form of inadequate cerebral activation (Kolb & Whishaw, 1990).

An alternative model of learning disorders is based on recent neurophysiological findings that suggest it is the timing and synchronisation of neural activity in separate brain areas that creates high order cognitive functions. Any loss or malfunction of the timing mechanism may cause disintegration of neural activity and hence dysfunction in cognitive tasks (Damasio, 1994; Nunez, 1995).

This model supports the approach that McCrossin et al (1994) developed in the late 1980s and early 1990s. From their perspective the integration of brain functions is the result of dynamic synchronisation in the timing of sets of neural events. Any loss of synchronisation represents a loss of integrated brain function resulting in dysfunction when performing specific tasks.

Measures of Cognitive Ability

Measures of intelligence are highly controversial because intelligence is a hypothetical construct and therefore impossible to define in terms of an 'essence' of intelligence (Cronbach, 1975; Eysenck, 1979; Murphy & Davidshofer, 1994). Nevertheless, a number of different standardised intelligence tests, such as the Wechsler Intelligence Scales (e.g. Wechsler Adult Intelligence Scale - Revised and the Wechsler Intelligence Scale for Children - Revised), have been developed that measure various aspects of cognitive function. Regardless of whether psychometric tests measure 'intelligence' or not, they do provide reliable assessment of performance on certain types of tasks. The use of intelligence tests in the current study is not to measure intelligence but rather to assess performance in a variety of cognitively demanding tasks.

Cattell (1963) defined intelligence as comprising of two distinct aspects: 'fluid' and 'crystallised' intelligence. Fluid intelligence is the capacity to perform abstract reasoning which involves 'native' intelligence and is thought to be unaffected by formal education. This includes the ability to solve puzzles, memorise a series of arbitrary items such as words or numbers, as well as the ability to change problem-solving strategies easily and flexibly. Crystallised intelligence, on the other hand, comprises of abilities that depend on knowledge and experience or the amount of stored factual knowledge, such as vocabulary and general informational knowledge (Murphy & Davidshofer, 1994).

In the current study, subjects' performance on the IT, which is a cognitive task measuring fluid intelligence, was compared before and after acupressure treatment designed to improve mental ability. The Digit Span subtest of the WISC-R was used as a measure of short term memory, retrieval and distractibility (Horn, 1985; Reynolds & Kaufman, 1985). Tests that are believed to measure Crystallised intelligence were not used as knowledge of facts is accumulated over a number of years and would not be expected to change substantially over the short time frame of the study.

Inspection Time

Savage (1970, cited in Deary & Stough, 1996) suggested that individual differences in intellectual ability may be attributable largely to the speed of intake of visual information processing. A currently used measure of the speed of visual information processing is Inspection Time (IT), an estimate of the stimulus presentation time (in milliseconds) which a subject requires to correctly respond 80% of the time (Deary, 1993; Deary & Stough, 1996). IT has been found to be highly correlated (-0.8 to -0.9) with performance IQ as measured by the Wechsler Adult Intelligence Scale - Revised (WAIS-R) (Nettelbeck & Lally, 1976; Lally & Nettelbeck, 1977). Although more recent studies suggest that the IT-IQ correlation may be closer to 0.5 (Nettelbeck, 1987).

Digit Span

The Digit Span (DS) subtest of the WISC-R is a measure of the auditory short term memory processing and freedom from distractibility, where a subject repeats a verbally presented sequence of random numbers. The span or number of digits that can be accurately reported varies with age, varying from 3 forwards and 0 backwards for a 4 year old to 6 forwards and 5 backwards of an average adult. Deficit digit span is when the subject recalls fewer digits than is average for their age (Horn, 1985; Reynolds & Kaufman, 1985; Wechsler, 1974).

Reading Comprehension

Reading comprehension is the ability to recall information about what was read shortly after reading it. Poor reading comprehension is expressed by the inability to recall much of the detail of what was read or to confuse or confabulate the information. Normal subjects can easily recall greater than 90% of the material read when tested within a few minutes of reading it. Individuals with poor comprehension can generally recall less than 50% and may recall almost nothing.

Acupressure Therapy for Learning Disorders

The present study used the Brain Integration Technique (BIT) acupressure protocol to improve mental abilities developed by McCrossin et al 1994) to investigate the effects of this acupressure treatment on performance of standardised tests of fluid intelligence, Digit Span and reading comprehension. The acupressure protocol employed has been empirically demonstrated to reproducibly improve various learning dysfunctions including deficit Digit Span ability and poor reading comprehension.

BIT has been developed empirically since 1989 (McCrossin et al, 1994) and has been applied to the improvement of specific learning problems on several thousand subjects with generally excellent results. Subjects (N=60) undergoing the BIT protocol that were pre and post-tested with the WISC-R have shown marked improvement on all of the subtests (Paphazy, 1990). In those cases where improvement was not observed or was marginal, either in general or on a specific subtest, neurological assessment demonstrated organic brain damage in almost all cases (Dr. Graeme Jackson, personal communication).

Acupressure Effects on Brain Function

Zhongfang et al. (1989), in animal studies, showed that the stimulation of specific acupoints using electro-acupuncture could activate or inhibit the electrical activity of specific neurons within the Amygdaloid Nucleus resulting in increasing and decreasing rates of neuronal discharge. They also found that stimulation of ‘sham’ points produced no detectable change in neuronal firing rates in the amygdala. Another recent study (Bucinskaite et al., 1994) found that electro-acupuncture increased levels of various neuropeptides in the rat brain, with significant increases in the hippocampus, the structure most directly involved in short-term memory.

Traditional acupuncture techniques are stated to be helpful for strengthening cerebral function and improving intelligence (Qian-Liang, 1989). In human subjects, Abad-Alegria et al. (1995) demonstrated that acupuncture stimulation of the acupoint ‘Heart 7’ produced long-lasting increases in activity that has been associated with cognitive activities. As in the study of Zhongfang et al. (1989), stimulation of non-acupuncture ‘sham’ points had no effect.

Method

The subjects in this study were twenty school age children with a history of learning difficulties randomly selected from the Melbourne Applied Physiology (MAP) Clinic were assessed and then reassessed 6 - 8 weeks later. The children ranged in age from 6 to 19 years (**M**=12.0, **SD**= 3.3). Parents were informed that the performance task scores before and after treatment would be used for research and they signed a consent form allowing their children to participate in this study.

Because people demonstrate a mosaic of learning dysfunctions with difficulties in some areas, yet average or above average performance in others, not all subjects were included in the data for all subtests. For instance, subjects that obtained the highest possible score on a particular pre-test were not used to compare with post test results as they could not possibly improve. The results of these same subjects on other subtest in areas in which they displayed lower than average scores on their pre-tests were used for comparison with their post test results.

Experiment Design and Data Analysis

A test-retest design was used to determine if there was a significant change in scores on all the tests employed. Half the group received the acupressure treatment and the other half received no treatment. The subjects were assessed using the DS sub-test of the WISC-R, the comprehension component of the Neale Analysis of Reading Ability-Revised and the IT computer administered test. One way repeated measures ANOVAs using pre and post testing for non treatment and treatment groups were used to analyse the data. Histograms of the data for all subtests were also visually examined for trends.

Acupressure Treatment Protocol

All subjects were treated according to Melbourne Applied Physiology's Brain Integration Technique (BIT) acupressure protocol (McCrossin et al, 1994). The protocol is a multi-step procedure whereby acupoints, both individually and in specific combinations, are stimulated and assessed for activation. Acupoints or acupoint combinations demonstrating unbalanced activity were then rebalanced using a series of standard Applied Physiology acupressure techniques (Utt, 1985, 1989, 1991) based on the principles of the Law of Five Elements of Chinese Acupuncture (Maciocia, 1992).

The initial BIT Acupressure treatment for learning dysfunctions involves assessment and acupressure treatment of acupoints and acupoint combinations that have been empirically demonstrated to re-integrate and re-synchronise brain function for improved cognitive ability, which on average requires approximately 10 hours of treatment time. While the basic protocol generally results in significantly improved overall information processing, more complex processes such as deficit DS and reading comprehension are two specific areas of dysfunction that often persist after these initial brain integration procedures are complete. Additional specific acupressure formats are then employed to address specific dysfunctions in DS and Reading comprehension until no further improvement is observed.

In this study no specific acupressure formats were employed to address poor performance in IT, even though acupressure formats to improve these functions are available. This was done purposefully to observe the effect of only the basic BIT brain integration protocol on these measures of fluid intelligence.

Inspection Time (IT) Task
The visual IT test used in this study was a simple two-choice discrimination task. According to Vickers et al. (1972), IT is a measure of the early stages of visual information processing, thus this measure to perception prior to the decision making process (Tsourtos et al., 1995). The object of this task is to determine the visual stimulus duration required by a subject in order to reach a given level of correct response in a simple discrimination task.

Digit Span (DS) Task
The DS subtest of the WISC-R involves two separate components, Digits Forwards and Digits Backwards using pairs of random digit sequences. The examiner reads aloud each sequence of random digits at the rate of one per second. After the last digit of the sequence has been read, the subject is to then recall the sequence in the order it was read for the Forward test and in the reverse order for Digits Backwards. For both tests subjects are first given the instructions and then practice sequence (e.g. 1, 2, 3) to make sure that they understand the procedure. After the practice procedure is completed correctly, the test begins.

Reading Comprehension
To assess the subjects' reading comprehension the age appropriate level of Reading Comprehension subtest of the Neale Analysis of Reading Ability-Revised (1966) was administered to each subject. The number of correct answers to the 8 questions about each reading passage was converted to a percentage reading comprehension score.

After the initial acupressure treatment to improve brain function, the subjects read a passage of equivalent difficulty to those in the Neale Test and their comprehension of the material read was verbally assessed. If reading comprehension was still less than 90%, the subject was immediately treated using specific acupressure formats to rebalance any acupoints or acupoint combinations that became activated or unbalanced by their attempt to recall the detail of what they had read. The subjects were then re-tested on the Neale subtest for reading comprehension and the result expressed as the percent of correct answers.

Results
Results for the IT and DS tasks are presented as raw scores, while the results for reading Comprehension are presented as a percentage of accurate responses. The number of subjects varies in the subtests because not all of the subjects were deficit in all of the tasks evaluated.

Inspection Time Task
A one way repeated measures ANOVA showed a highly significant difference between IT scores for before and after testing in the treatment group ($p=<0.001$), but no difference in the before and after testing for the non-treatment group. There was also a significant difference in IT scores between the treatment and non-treatment (control) groups ($p=<0.02$).

Figure 1a. *Inspection Time Scores for the Non Treatment Group at the Pre-test and Post-test of the Study.*

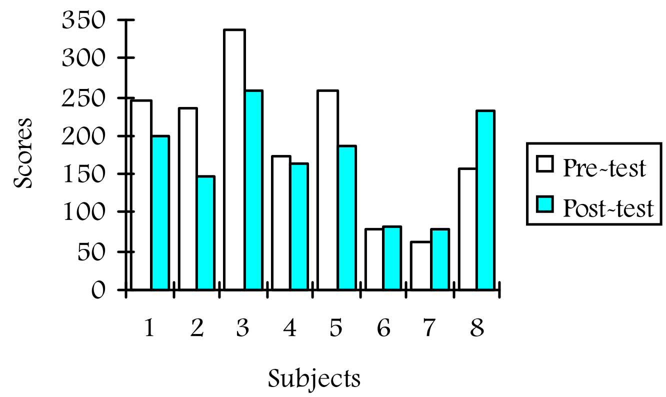
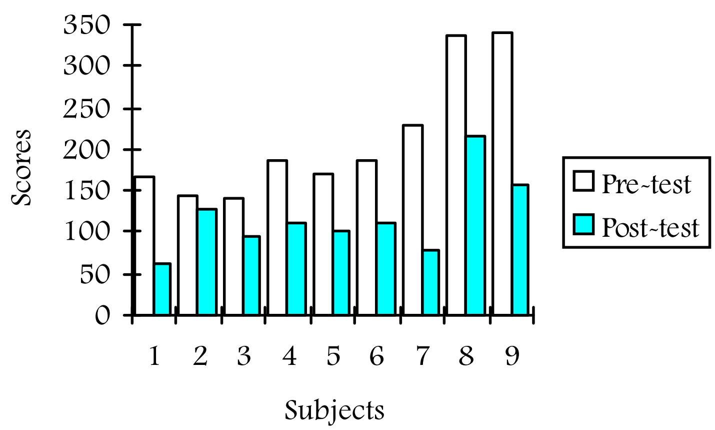


Figure 1b. *Inspection Time Scores for the Treatment Group at the Pre-test and Post-test times of the Study.*



Normal scores for control groups on the IT test range between 55 and 120 milliseconds (msec) (Tsourtos et al., 1995). In the treatment group all individuals improved with those who scored above 140 msec on the pre-test markedly improving their IT scores after treatment.

Digit Span Task

A one way repeated measures ANOVA revealed a highly significant difference between DS forwards scores for before and after testing in the treatment group ($p = <0.001$). The experimental group significantly improved DS forwards scores relative to the non treatment group (pre test **M** = 4.6±0.9, post test **M** = 6.1±0.8). There was also a highly significant difference between the treatment and non-treatment (control) groups in the DS backwards scores ($p < 0.001$) indicating that the experimental group significantly improved DS backwards scores relative to the non treatment group (pre test **M** = 3.0±0.8, post test **M** = 5.4±1.0).

Figure 2a. *Digit Span Scores for the Non Treatment Group at the Pre-test (B) and Post-test (E) of the Study.* * Zero backwards S as subject could not understand concept of reversing digits.
B = Before A = After

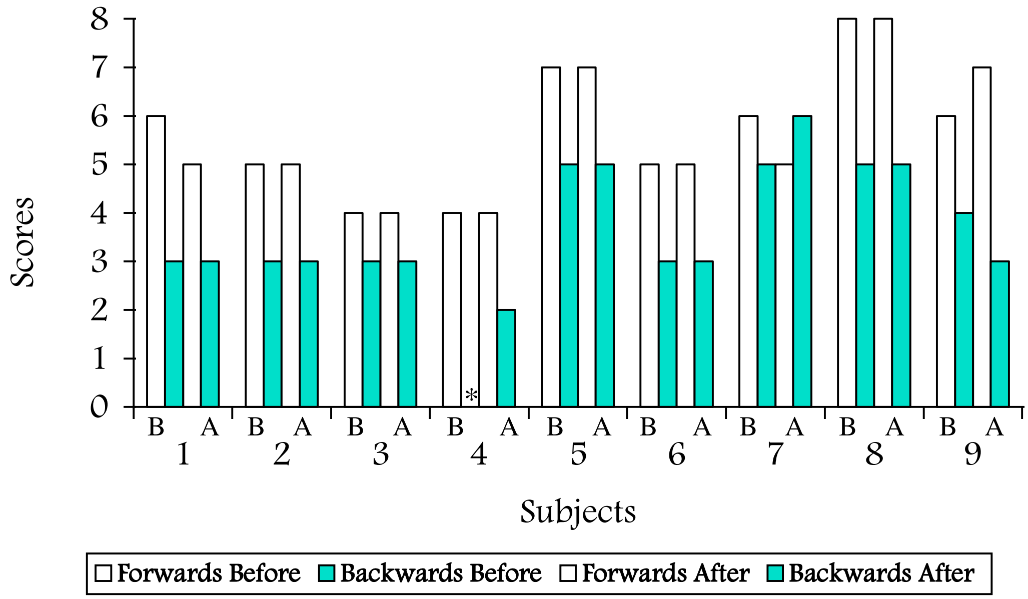
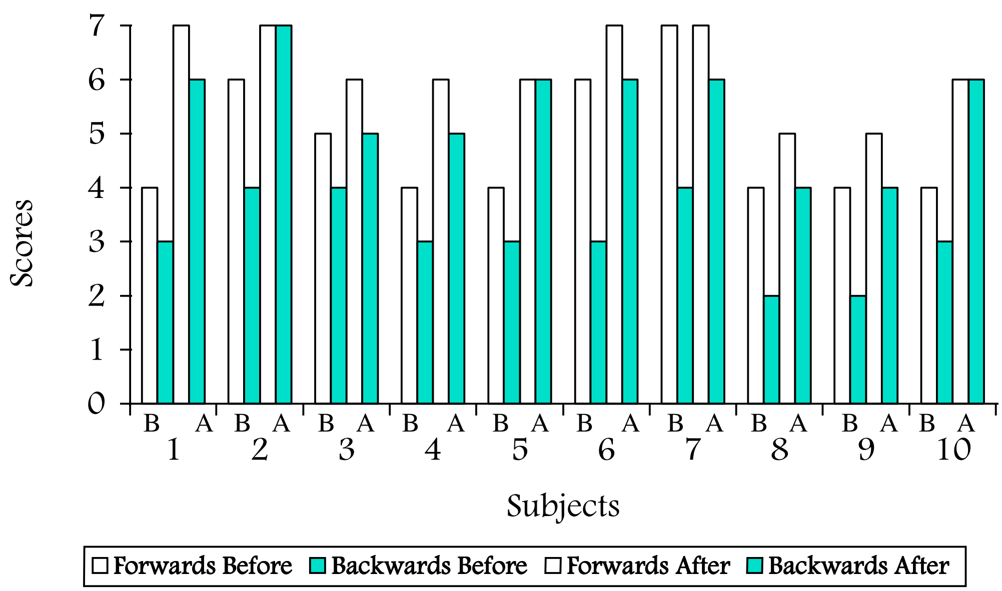


Figure 2b. *Digit Span Scores for the Treatment Group at the Pre-test (B) and Post-test (E) of the Study.* B = Before A = After



In the Non Treatment Group (Fig. 2a), all except one subject demonstrated deficit age-specific DS with a difference of 2 or greater between forward and backward DS and the scores remained virtually unchanged between pre- and post-testing. In the Treatment Group (Fig. 2b) subjects also demonstrated deficit age-specific DS, however, following treatment there was significant increases in both forward and backward DS scores for all subjects.

Reading Comprehension
A one way repeated measures ANOVA using pre and post testing for non treatment and treatment groups revealed a highly significant difference between the treatment and non-

treatment groups in the Reading Comprehension scores ($p < 0.001$) indicating that the experimental group significantly improved Reading Comprehension scores relative to the non treatment group (pre test **M** = 27.5%±20.8, post test **M** = 94.0%±6.3).

Figure 3a. *Reading Comprehension Scores for the Non Treatment Group at the Pre-test and Post-test of the Study.* * Six year old subject unable to read.

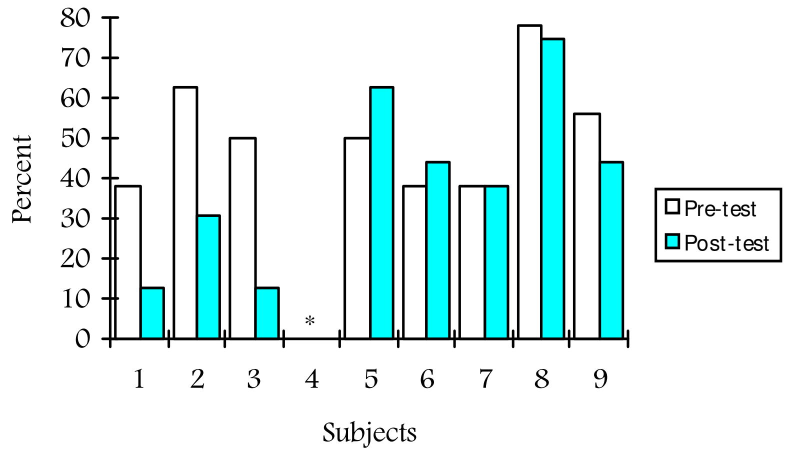
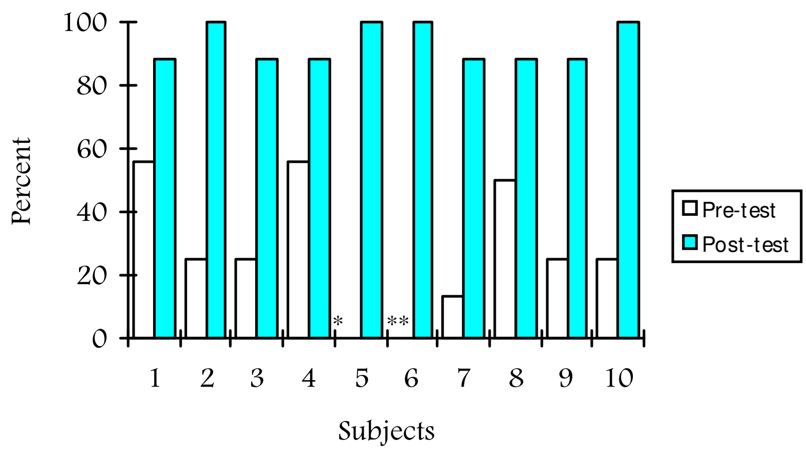


Figure 3b. *Reading Comprehension Scores for the Treatment Group at the Pre-test and Post-test of the Study.* * 16 year old subject unable to read.
** 11 year old subject able to read a few small words.



Reading comprehension for the Non Treatment group (Fig. 3a) varied considerably between the pre- and post-test with a number of subjects decreasing their percentage comprehension, others increasing slightly while others remained the same. One subject was unable to read and therefore received no score.

Reading comprehension for the treatment group (Fig. 3b) was considerably lower before treatment than the reading comprehension of the Non Treatment group. One subject (age=16 years) was unable to read and another (age=11) could only read a few small words. Following treatment, all subjects were now reading with a comprehension of greater than 80%. The two subjects who were unable to read before treatment were now reading with full comprehension at an elementary level.

Discussion

The present study has demonstrated that the BIT Acupressure Protocol produced significant improvement in performance on a standardised psychometric test considered to measure aspects of fluid intelligence. This change in information processing capacity translated into improved performance on the complex, cognitively demanding task of reading comprehension.

Acupressure Effects on tasks of Fluid Intelligence

The performance on these tests would suggest that the acupressure treatment improved the subjects' ability to perform two quite different types of information processing. The type of fluid intelligence measured with IT involves predominantly the speed of visual information processing, and hence is dependant on processing within largely a single sensory system that precedes complex decision making (Tsourtos et al., 1995).

Measures of fluid intelligence generally do not change significantly over time as evidenced by the pre- and post-test results for the Non Treatment group on all subtests for fluid intelligence. This is also supported by empirical observations and scientific validation of performance on psychological tests (Lezak, 1995). From this data it has been assumed that the person will, in the future, perform as they have in the past (or, allowing for growth, will hold their relative position among their peers) and therefore changes in performance on these subtests is considered unlikely. This appears to hold true even for children with learning disorders that have received extensive remediation (Paphazy, 1990). While some of the subtests of crystallised intelligence, such as comprehension and vocabulary, may improve to some degree after remediation, measures of fluid intelligence remain largely unchanged (Murphy & Davidshofer, 1994).

The subtest measuring fluid intelligence, IT, showed a trend toward improvement with significant improvement in most cases following the acupressure treatment. The present results demonstrate significant improvement in a reliable measure of fluid intelligence over a short time frame and is remarkable in this context.

Equally remarkable in this brief time frame are the observed changes in the complex cognitive task of reading comprehension and reading ability which rely upon a diverse number of perceptual and cognitive functions (McLoughlin & Lewis, 1994). Two of the subjects in the treatment group were unable to read prior to treatment. The 16-year-old subject had had weekly private tutoring for several years and had still not been able to read. Following the BIT protocol and with the same weekly tutoring, this subject was able to read at an elementary level and is continuing to show steady improvement. The 11-year-old subject could only recognise a few small words prior to treatment, following treatment was now able to read fluently at an elementary level and demonstrated the same continuing improvement even without special remediation.

Digits Forward

Taking into account that the normal range for Digits Forward for adults is 6±1, and that education appears to have a decided effect on this task, it is well *within normal limits* to have a span of 6 or better, a span of 5 may be *marginal* to normal limits, a span of 4 is definitely *borderline* and a 3 is *defective* (Lezak, 1995). But it should be noted that DS increases with age as it is dependant upon neurological maturation.

In the current study eight of the nine subjects in both groups had marginal to deficit DS function prior to treatment. Marginal in this context is having age appropriate forward

DS with a difference of two or more between the forward and backward scores. Deficit DS is defined as having a forward DS of two or more digits below the norm for their age.

Following the basic BIT protocol, subjects' that continued to demonstrate marginal or deficit DS had specific acupressure formats applied to improve this function. Application of this additional acupressure treatment significantly improved the DS of all subjects increasing their forward DS by 2 or 3 digits. Since digits forwards is more closely related to the efficiency of attention than to what is commonly thought of as memory (Horn, 1985; Lezak, 1995), this again supports the results of a previous study (McCrossin, 1995) suggesting that the acupressure treatment is capable of increasing attentional ability.

Digits Backward

The normal score difference between Digits Forward and Digits Backward tends to be one. A backwards score of 5 is considered to be *within normal limits*, 4 is *marginal*, 3 is *borderline defective* or *defective*, depending on the subject's educational background and age, and 2 is *defective* for persons up to the age of 60 (Lezak, 1995).

The Digits Backward task requires not only storing a few data bits briefly, but also rearranging them mentally. It is inherently a more difficult task in that it requires not only attention as in the case of the more passive Digits Forward task, but the use of working memory as well. Lezak (1995) states that it is therefore more of a memory test and involves mental "double-tracking" in that both the memory and the reversing operations must proceed simultaneously. It is suggested that the ability to reverse digits, or to spell a word or recite a letter sequence backwards, is "probably characteristic of normal cognitive function and language processes" (Bender, 1979 cited in Lezak, 1995) related to the brain's normal function of temporal ordering.

Lezak (1995) suggests the reversing operation depends upon internal visual scanning. I have found, and Lezak also states, that most normal adults, when asked to spell a word backwards will report when questioned afterwards that to perform the task they moved their eyes in response to a mental visual scanning approach to the task. Therefore, the concept of linking the capacity to reverse digits to visual scanning efficiency appears to be well founded.

Adequate forward and backward DS capacity appears to play a significant role in the academically important task of retaining certain types of information, the spelling of words and multiplication tables in particular. Children that have a deficit forward and backward DS consistently demonstrate difficulty with the memorisation of facts and rote learning. I have observed empirically with several thousand subjects that those children that demonstrate deficit backwards DS (a difference of 2 or more digits between their forward and backward score) consistently show difficulty retaining the spelling of words they have learned and multiplication tables. They may learn a number of words or their whole multiplication tables one week but are unable to recall them the following week.

When only forward DS improves, but the backward DS remains deficit, children often continue to display difficulty with retaining spelling words and multiplication tables. However, when both DS forwards and backwards have improved to within the normal range for their age, the subjects' ability to perform these tasks improves concomitantly.

Therefore, the increase in the digits forwards task from an average of 4.8 $\pm$1.1 to 6.2 $\pm$0.8 and the increase in digits backwards from an average of 3.1 $\pm$0.7 to 5.5 $\pm$0.9 suggests that the BIT acupressure treatment may support improvements in the subject's ability to learn to spell words and other tasks requiring attention and working memory. Empirical observations of several thousand children with spelling problems and other learning disorders at the MAP clinic support this concept. Similar improvements in spelling have been reported following another acupressure and movement protocol (Hannaford, 1995).

Since the digits backwards task places large demands upon working memory, the significant increases in the ability of all subjects to perform this task would suggest an increase in the capacity of their working memory. A number of studies (Awh et al., 1995; Damasio, 1994; Dubois et al., 1995; Milner & Petrides, 1984; Petrides, 1995; Roland, 1984) have shown that working memory predominantly requires prefrontal and dorsolateral frontal activity. The magnitude of increase in working memory evidenced by the massive improvements on the digits backward task would seem to necessitate an increase in the cortical activity supporting these working memory areas.

Efficacy of the BIT acupressure treatment

In a previous study (McCrossin, 1995) using SSVEP analysis on a decision making task, subjects with deficit DS initially demonstrated little frontal and pre frontal activity suggestive of limited access to working memory during the decision making task. Following the BIT acupressure treatment the same individuals then demonstrated markedly increased frontal and prefrontal activity which is consistent with an increased working memory capacity as evidenced by their improvement in performance on the digits backwards task from deficit to average or above average. Similar improvements in the performance of all subjects on this task in the current study provide strong evidence for the efficacy of this acupressure treatment in normalising this important brain dysfunction.

The results of this study demonstrate that the basic BIT acupressure protocol for integrating brain function does indeed improve the performance of children with learning disorders on a standardised psychometric test of fluid intelligence. Even more remarkable is that application of additional specific acupressure treatments following the basic brain integration protocol resulted in significant improvements on the cognitively complex tasks of DS and reading comprehension.

Similar significant improvements in DS and reading comprehension following application of the same acupressure protocol were observed in the earlier study (McCrossin, 1995). Associated with these improvements in DS and reading comprehension were dramatic changes in SSVEP patterns of cortical activity in all subjects from patterns typical of ADD children to patterns typical in normal subjects when performing both attentional and decision making tasks. This correlation of changes in the patterns of cortical activity with statistically significant improvements in cognitive functions following acupressure treatment supports the neural timing and synchronisation model of learning disorders.

Acupressure treatment of only several hours duration over several weeks would not be expected to alter four of the five factors suggested as possible causes of learning disorders: structural damage, abnormal cerebral lateralisation, maturational lag or environmental deprivation. Results of this study lend considerable support to the brain dysfunction hypothesis based on abnormal physiological or biochemical processes causing inadequate or poorly synchronised activation of cortical and subcortical areas.

A New Model of Learning Disorders

I propose a model of learning disorders that is based on the disruption or loss of timing and synchronisation between the neural activity in the diverse brain regions, both cortical and subcortical, that must be synchronised in order for successful integration to produce normal cognitive activity. Learning disorders would arise in this model from a lack of integration of functions that occur simultaneously in separate brain regions.

If the brain does integrate separate processes into meaningful combinations we call 'thought' or cognitive ability, then the main risk is mis-timing or loss of synchronisation between these processes. To quote Damasio (1994, p.95) "any malfunction of the timing mechanism would be likely to create spurious integration or *dis*integration".

For synchronous firing of neurons in many separate brain areas to create cognitive functions would require maintenance of focused activity at these different sites long enough for meaningful integration of disparate information and decisions to be made.

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