

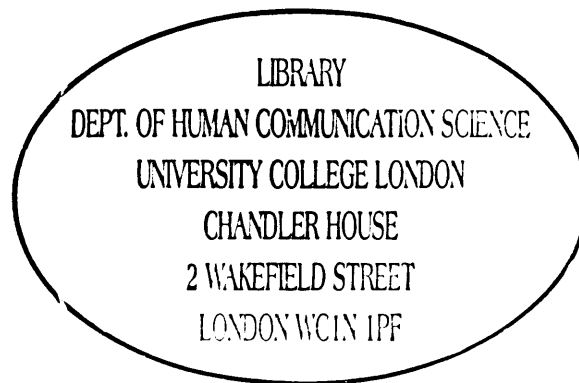
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**DYSLEXIA IN HIGHER EDUCATION – EXISTENCE AND  
IMPLICATIONS OF THE DOUBLE DEFICIT HYPOTHESIS**

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**Submitted in partial fulfilment of the MSc in Speech and Language  
Sciences**

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## ABSTRACT

The double deficit hypothesis of dyslexia proposes naming speed as a second independent core deficit in dyslexia alongside phonological awareness. This study aimed to explore the double deficit in 237 students in higher education. Three literacy skills were examined (reading, spelling and timed non-word reading) to determine the independence of phonological awareness and rapid naming, and to compare literacy abilities among subgroups of students with dyslexia. Four subgroups were compared: a phonological awareness deficit subgroup, a naming speed deficit subgroup, a double deficit subgroup (with both phonological awareness and naming speed deficits), and a subgroup of the remaining dyslexic students who could not be classified according to the study criteria used. Results indicated separable effects of each variable; reading appeared more dependent on phonological awareness while timed non-word reading was more closely associated with rapid naming. However dyslexia deficit subgroup comparisons failed to validate naming speed as a diagnostic tool. Nevertheless, naming speed deficits retained their importance in identifying the most disadvantaged readers. It is therefore concluded that the *interaction* of phonological awareness and naming speed deficits hinders the literacy skills of individuals with a double deficit.

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## **1.0 INTRODUCTION**

It is widely acknowledged that phonological awareness skills are a major contributor to reading acquisition (Sunseth & Bowers, 2002). Many readers excel in these skills and easily manipulate sounds, whereas readers with below-average skills experience difficulties (Savage, Frederickson, Goodwin, Patni, Smith & Tuersley, 2005). It is from these specific difficulties with phonological awareness, e.g. delays in sensitivity to rhyme, alliteration and phonemic segmentation, that the phonological deficit hypothesis of dyslexia was formed (Vukovic, Wilson & Nash, 2004; Wilson & Lesaux, 2001). According to this theory developed over 20 years ago, deficits in phonological processing form the core deficit in the majority of cases of dyslexia (Bradley & Bryant, 1983; Stanovich, 1992). Difficulties converting grapheme strings into phonemes when reading, i.e. using letter to sound correspondences, have been documented as the primary symptom in most cases of reading disability (Compton, DeFries & Olson, 2001; Pennington, Van Orden, Smith, Green & Haith, 1990).

The evidence base for the phonological deficit hypothesis of dyslexia extends into the adult population with deficits persisting into and beyond adolescence (Cirino, Israelian, Morris & Morris, 2005; Lovett, Steinbach & Frijters, 2000; Pennington et al., 1990). In a study of phonological processing deficits in college students with dyslexia who had age-appropriate reading skills, Wilson and Lesaux (2001) found that deficits continued in all areas investigated: phonological awareness, phonological recoding in lexical access and phonological recoding in working memory. With so much research highlighting the presence of a phonological deficit, the diagnosis of and intervention programmes for dyslexia focus primarily on these areas (Wolf & Bowers, 2000). Yet it has been argued recently that phonological deficits alone do not account for dyslexia in every individual (Wolf & Bowers, 1999, 2000).

## **1.1 Naming speed**

The neurologist Geschwind was the first to link the processes involved in naming with the development of reading (cited by Wolf, 1997). In 1965 Geschwind predicted that a child's colour naming ability would be the best indicator of his/ her readiness for reading. The rationale was that colour naming involves cognitive, linguistic and perceptual processes to retrieve a verbal label for a visual symbol, without the need to know letters (Wolf, 1997). Denckla (1972) and Rudel (Denckla & Rudel, 1976a, 1976b) investigated this theory and found that speed of colour naming, rather than accuracy, distinguished between dyslexic and other readers, with the former performing significantly slower than the latter. Following this finding they developed rapid automatised naming (RAN) tasks where 50 stimuli are named as quickly as possible (five letters, digits, colours or pictured objects randomly repeated ten times). They reported that naming speed discriminated dyslexic children from both average readers and children with other learning difficulties (Denckla & Rudel, 1976b).

Following Denckla and Rudel's research, Lovett (1984) was the first to identify a subgroup of children with reading difficulties, who had a rate deficit but average phonological skills, and a subgroup with both rate and phonological (or accuracy) deficits. Lovett (1984) postulated that the distinction between accuracy and rate deficits could be used diagnostically to identify particular impairments of dyslexia, but that subsequent classification would be needed to better understand a child's language abilities.

Wolf and Bowers (1999) claim that naming speed deficits are specific to those with dyslexia, i.e. they are not demonstrated by individuals with other learning difficulties, and characterise reading disabilities from pre-reading phases to adulthood. Other researchers have also found naming speed deficits in children, adolescents and young adults (e.g. Bowers & Swanson, 1991; Kinsbourne, Rufo, Gamzu, Palmer & Berliner, 1991; Korhonen, 1991b). Korhonen's 1995 study demonstrated that naming speed deficits persist into early adulthood, as difficulties diagnosed at nine years of age had

not resolved by 18 years. They did not appear as severe, but were nevertheless present.

## **1.2 What do naming speed deficits represent?**

Many dyslexic readers do not have word finding difficulties but perform significantly more slowly on naming speed tasks than their average-reading peers (Wolf, Bowers & Biddle, 2000). RAN tasks, such as those of Denckla and Rudel mentioned previously, are often used to assess naming speed, i.e. to measure how quickly a verbal label is produced for high-frequency stimuli. While the literature is clear on how to measure naming speed, it is more ambiguous about which specific elements of RAN are important for reading development, and therefore what naming speed represents (Vukovic & Siegel, 2006). This renders the identification of naming speed deficits in dyslexic readers problematic, as efficient intervention requires stable foundations (Vukovic et al., 2004). The diagnostic specificity of RAN tasks is hindered by the lack of consensus for an operational definition of what naming speed represents (Vukovic & Siegel, 2006).

Although the literature lacks an agreed comprehensive definition of RAN's contribution to literacy, it is generally acknowledged that naming speed deficits incur a failure to recognise words quickly (Bowers & Wolf, 1993; Sunseth & Bowers, 2002), which impacts upon reading rate (Savage & Frederickson, 2005). While those with phonological awareness deficits are more impaired than those with naming speed deficits on word identification and analysis, the reverse is true when there is a need to identify words both accurately and rapidly (Compton et al., 2001; Torgesen, Wagner, Rashotte, Burgess & Hecht, 1997). Slow RAN may represent the rate at which letters are identified in words. Slower speeds would prevent the reader from becoming sensitive to commonly occurring letter patterns (Bowers, Golden, Kennedy & Young, 1994). This would, in turn, affect the quality of orthographic representations and increase the number of exposures needed to correctly identify words (Wolf et al., 2000).

Rapid naming requires the ability to coordinate visual and phonological codes quickly and precisely (McBride-Chang & Manis, 1996), providing a simpler example of the reading process (Wolf et al., 2000). Both Lovett (1984), and Bowers and Swanson (1991) refer to LaBerge and Samuels' model of reading from 1974, which stipulated two criteria for reading skill to develop: accuracy and automaticity. Readers are obliged to analyse much information simultaneously, e.g. letter features, individual letters, letter clusters, words and meaning (Lovett, 1984). This assumes a high level of automaticity for many reading processes, which then allows the reader to focus on comprehension of the text (Bowers & Swanson, 1991; Lovett, 1984). Slow word decoding, regardless of accuracy, may therefore diminish reading comprehension (Cirino et al., 2005). Automaticity of skills related to naming speed may be crucial for comprehension and reading rate in adults, especially in higher education settings, as students are expected to read and understand a large volume of material (Cirino et al., 2005).

### **1.3 The double deficit hypothesis**

The double deficit hypothesis is an alternative theory of dyslexia where naming speed is implicated as a second independent core deficit alongside phonological awareness (Wolf & Bowers, 1999, 2000). Three subgroups of dyslexia are therefore assumed: a phonological awareness deficit subgroup, characterised by a phonological awareness deficit and average naming speed ability; a naming speed deficit subgroup, characterised by a naming speed deficit and average phonological awareness skills; and a double deficit subgroup, characterised by both phonological awareness and naming speed deficits. This theory was developed from the acknowledgement that a group of dyslexic children existed who had poor comprehension but adequate phonological decoding skills. Phonological intervention programmes were ineffective for these readers (Vukovic & Siegel, 2006) and they were referred to as the treatment resisters (Blachman, 1994).

In a study on children between kindergarten and grade four, Wolf and Bowers (1999) hypothesised that the double deficit subgroup would show the most severe deficit, while the phonological awareness subgroup would

experience a moderate reading impairment, and the naming speed subgroup would be least impaired. Their findings supported these hypotheses with pupils in the double deficit subgroup performing at approximately two and a half to three years below the expected level on six aspects of reading. The coexistence of phonological awareness and naming speed deficits in the double deficit subgroup limits the number of compensatory routes available, leaving such an individual with a severe disadvantage in reading and spelling compared to somebody with only a single deficit (Wolf & Bowers, 2000).

It is recognised that phonological awareness and naming speed are not the only deficits that can disturb reading development (Wolf et al., 2000). Other underlying deficits may be present, such as visual and cerebellar impairments (see Ramus, Rosen, Dakin, Day, Castellote, White & Frith, 2003 for a review). Wolf and Bowers (1999) admit that the double deficit hypothesis cannot provide a complete explanation for dyslexia, however it can be used as a tool to further research and understanding of the heterogeneous nature of dyslexic readers. It also has implications for intervention efforts, as most are currently directed at phonological skills, which, they attest, are only one element of the equation (Vukovic & Siegel, 2006).

#### **1.4 The independent contribution of naming speed**

Several studies provide evidence that naming speed is an independent contributor to the reading process, thereby supporting the double deficit hypothesis proposed by Wolf and Bowers (1999, 2000). Blachman (1984) found that the performance of first grade children on rapid naming tasks was associated with their reading achievement at grade one. Felton and Brown (1990) discovered that rapid naming contributed independent variance to first grade word reading ability in their study of 81 children at risk of a reading impairment. Bowers and Swanson (1991) identified naming speed as contributing unique variance to second grade reading ability in a study of 43 children; however as Vukovic and Siegel (2006) noted, this study defined reading ability by latency rather than accuracy measures. Manis, Seidenberg and Doi (1999) found that once vocabulary was controlled, grade one RAN

measures contributed unique variance to grade two reading skills in children of differing reading ability. Neuhaus and Swank (2002) identified rapid letter naming as a significant predictor of word reading ability in 221 first grade pupils in average classrooms. McBride-Chang and Manis (1996) found that both naming speed and phonological measures were significantly associated with reading ability for below-average readers, whereas phonological measures only were related with reading ability for above-average readers. Similarly Savage et al. (2005) found that both naming speed and phonological measures predicted the literacy skills of poor readers, but phonological processing only predicted skilled readers' literacy ability. For skilled readers, naming speed may not contribute unique variance to word reading (McBride-Chang & Manis, 1996).

Some authors have proposed that naming speed loses its power to predict reading ability over time (see Vukovic & Siegel, 2006 for a review). They refer to Torgesen et al.'s finding (1997) that naming speed contributed independently to word recognition in the second grade, but lost all predictive ability by the fourth grade. The conclusion was that naming speed plays a more important role in the earlier rather than the later stages of reading acquisition. In contrast, Meyer, Wood, Hart and Felton (1998, also cited by Vukovic & Siegel, 2006) identified naming speed measures in the third grade as having predictive ability for single word reading of below-average readers in the fifth and eighth grades. Naming speed was not predictive for average readers.

### **1.5 Evidence from other languages**

Significant naming speed deficits have been identified in children whose mother tongue is German, Dutch, Finnish and Spanish (Wolf, 1997). These languages have a regular orthography, unlike English, thus placing fewer phonological demands on the reader. For example, the letter *c* in English is pronounced differently in words depending on the following vowel, e.g. a soft *c* in *cement* but a hard *c* in *car*, thus requiring the reader to assimilate this phonological knowledge quickly. The letter itself however is always pronounced softly (*sea*). Without the need for phonological analysis and

synthesis, naming speed deficits appear to give a more reliable indication of children at risk of developing a reading disability (Wolf & Bowers 1999). Children with both naming speed deficits and double deficits have been found to have difficulties in developing their reading ability in German (see Wolf & Bowers, 1999). These cross-linguistic findings eliminate the irregular nature of English orthography as a cause of naming speed findings in English speaking subjects (Wolf et al., 2000).

### **1.6 Identification of a naming speed only deficit**

Few studies have investigated naming speed and the double deficit hypothesis in adult populations (Vukovic & Siegel, 2006; Vukovic et al., 2004). The majority of supporting evidence therefore stems from child-based studies. Current research demonstrates that some individuals with dyslexia have naming speed deficits, but it remains unclear whether these are a specific characteristic of dyslexia, as several investigators have found few individuals with average phonological skills and a naming speed deficit (Vukovic & Siegel, 2006). Badian (1997) found double deficits in both people who were poor readers with no obvious cause, and individuals with dyslexia aged six to ten years, but found singular naming speed deficits in the first group only. Vukovic and Siegel (2006) claimed that individual reader differences inherent in children between the ages of six and ten make it difficult to analyse the findings accurately with reference to the double deficit hypothesis; results may simply represent individual differences.

Morris, Stuebing, Fletcher, Shaywitz, Lyon, Shankweiler, Katz, Francis and Shaywitz's study (1998) of 232 children found that pupils with a singular naming speed deficit had average reading abilities. Poor reading was only found in pupils who had phonological awareness deficits alongside naming speed deficits, i.e. double deficits, which implies that below-average literacy ability is caused by the phonological, rather than the naming speed, impairment (Vukovic & Siegel, 2006). Pennington, Cardoso-Martins, Green and Lefly (2001) studied 168 subjects including children and adolescents with dyslexia alongside chronological- and reading-age controls. They found nine individuals without a phonological awareness deficit, of which only two had

naming speed deficits. They concluded that naming speed was not associated with dyslexia and occurred only in those with the most severe deficits. Schatschneider, Carlson, Francis, Foorman and Fletcher (2002) conducted a longitudinal study of 945 children from kindergarten to second grade. They discovered that the double deficit subgroup had more impaired phonological skills than the phonological awareness deficit only subgroup, and that the more severe the phonological awareness deficits, the greater were the reading impairments. As naming speed and phonological processes were correlated, they concluded that the more severe impairments found in those with a double deficit were due to the phonological awareness deficit, rather than a combination of this with a naming speed deficit.

Various authors have highlighted the difficulties in addressing issues surrounding the double deficit hypothesis. Cirino et al. (2005) assert that the skills assessed and criteria adopted for a diagnosis of reading disability frequently vary. In many settings a diagnosis is largely based on untimed measures of reading. As phonological awareness skills are also untimed, a bias may be established towards a stronger relationship between phonological awareness and reading, rather than naming speed and reading. Compton et al. (2001) emphasise that reading ability lies on a continuum. Arbitrary cut-offs therefore create groups that differ in their level of specific impairment. This statistical 'slicing' restricts the ability to draw definitive conclusions from findings (Schatschneider et al., 2002).

### **1.7 Should naming speed be categorised as a phonological process?**

The evidence for the double deficit hypothesis is conflicting, with some researchers finding that naming speed makes a unique contribution to reading ability, while others can only identify naming speed deficits in conjunction with a phonological impairment. The classification of naming speed as an entity separate from phonological processing is therefore controversial. Schatschneider et al. (2002) categorised naming speed primarily as a phonological process, as naming speed and phonological measures were positively correlated. They maintained that naming speed was predictive of early reading predominantly because it allows the speed of



access to phonologically based codes to be measured. Similarly, Wagner, Torgesen and Rashotte (1994) subsumed naming speed as a phonological process because it requires phonological codes to be retrieved from memory. Chiappe, Stringer, Siegel and Stanovich (2002) argued that naming speed deficits could represent phonological impairments, instead of a second independent core deficit of dyslexia, as 75% of variance accounted for by naming speed measures was shared with phonological processing. Savage et al. (2005) also claimed a lack of evidence validating RAN as a fluency measure, as it was strongly correlated with phonological skills (spoonerisms and nonsense word reading).

In contrast, Wolf and Bowers (1999) claimed that correlations between phonological awareness tasks and naming speed are typically weak, thus asserting their relative independence. Sunseth and Bowers (2002) argued that naming speed seems more strongly correlated with orthographic knowledge than with phonological measures, thereby contributing independent variance to orthographic tasks. Wolf et al. (2000) stated that the complexity of naming speed exceeds a phonological process. In summary,

“..naming speed is conceptualised as a complex ensemble of attentional, perceptual, conceptual, memory, phonological, semantic, and motoric subprocesses that places heavy emphasis on precise timing requirements within each component and across all components” (p.395).

Naming speed therefore includes a phonological component, but this is an inadequate basis for categorising it as a phonological variable (Wolf & Bowers, 1999; Wolf et al., 2000).

### **1.8 Intervention: Implications and evidence**

If naming speed is a unique predictor of reading ability, important consequences ensue for the identification and subsequent treatment of at-risk readers (McBride-Chang & Manis, 1996). Individuals would either be wrongly classified as having phonological awareness deficits and offered inappropriate intervention, or they may not be diagnosed at all as their impairment may be masked by average phonological skills (Wolf & Bowers,

2000). Two of the three hypothesised subgroups would consequently receive insufficient intervention (Wolf et al., 2000). Investigating these assumptions in findings of intervention studies may prove useful in validating the double deficit hypothesis (Vukovic & Siegel, 2006).

The RAVE-O (Retrieval, Automaticity, Vocabulary, Elaboration, Orthography) programme (Wolf, Miller & Donnelly, 2000) aims to develop automaticity in those with naming speed and double deficits, and should be used in conjunction with a phonological programme to link phonological analysis with fluency in reading (Wolf & Bowers, 1999). Deeney, Wolf and O'Rourke (2001, cited in Vukovic & Siegel, 2006) studied the effect of the RAVE-O (combined with a phonological programme) on one individual in the second grade, who they claimed had a naming speed only deficit. After 70 hours of intervention, gains were made in both naming speed and phonological awareness. However, Vukovic and Siegel (2006) reported that on closer inspection, the child was found to have a phonological processing as well as a naming speed deficit. Also, as the programme did not specifically target naming speed processes, it is impossible to ascertain which parts of the intervention, if any, caused the improved naming speed ability. Perhaps the gains were due to the phonological element of the programme or to some external influence (Vukovic & Siegel, 2006).

Lovett et al. (2000) investigated the effects of intervention (phonological, metacognitive and control intervention groups) on 166 children with dyslexia (aged seven to 13 years) separated into the three hypothesised reading subgroups. They found that all three types of impaired reader made progress in their reading and phonological skills. However, Vukovic and Siegel (2006) again noted how the naming speed subgroup were not without some decoding deficits, meaning that they would have been better classified as having double deficits. Those with double deficits therefore do benefit from phonological interventions.

As the few intervention studies that have been conducted have failed to locate readers with naming speed only deficits, and the literature lacks an

agreed operational definition of what naming speed represents, it is difficult to determine how best to plan intervention for those with naming speed deficits, either with or without concurrent phonological awareness deficits (Vukovic & Siegel, 2006). Potential progress resulting from intervention focusing on the underlying processes involved in naming speed has yet to be proven.

### **1.9 Summary**

The double deficit hypothesis implicates phonological awareness and naming speed as two independent core sources of reading dysfunction (Wolf & Bowers, 1999, 2000). The exact contribution of naming speed to the reading process remains unspecified, but there exists a general consensus that fluency and automaticity of reading are deficient in those with naming speed impairments. The evidence supporting the double deficit hypothesis is controversial with some researchers advocating naming speed's unique contribution to reading, while others categorise rapid naming as a phonological process. Intervention studies have also drawn limited conclusions.

### **1.10 Present study**

The majority of research on the double deficit hypothesis stems from child samples with few investigations having been conducted on adult populations. The limited research that has studied adults involved only small numbers of participants. This study therefore aimed to investigate the double deficit hypothesis in a large group of students in higher education to evaluate the effects of phonological awareness and rapid naming skills on literacy performance. The hypotheses investigated were:

1. Both rapid naming and phonological awareness skills affect decoding and encoding ability.
2. The impact of dyslexia on literacy skills will depend on the nature of the underlying deficit. Three possible deficits are explored: a phonological awareness deficit, a naming speed deficit and a double deficit (deficits in both phonological awareness and naming speed).

3. Students with a double deficit will be more severely affected than students with a single deficit. A qualitative difference will be evident in the performance of double deficit students in both decoding and encoding.

## **2.0 METHODOLOGY**

### **2.1 Participants**

The clinical (dyslexic) group comprised 132 participants and the control group had 105 participants. All participants were students in higher education and spoke English as their first language.

#### **2.1.1 Criteria for selection of the clinical group**

The clinical population had been diagnosed as dyslexic through the Dyslexia Assessment and Support Centre of University College London. The diagnostic criteria at the Centre, which are based on the Department for Education and Skills Guidelines (2005) for the assessment of dyslexia in higher education, are as follows:

- i) a history of difficulty with the acquisition and development of literacy skills
- ii) a persisting difficulty with some aspects of literacy skills
- iii) evidence of a cognitive deficit, usually in phonological processing.

All students selected for inclusion met the three criteria listed above and were London University students.

#### **2.1.2 Criteria for selection of the control group**

The control group were selected on the basis that they had experienced no difficulties in the acquisition and development of literacy skills. They were recruited from various Russell Group universities in the United Kingdom, under the condition that they had not participated in any previous studies investigating dyslexia by the Department of Human Communication Science at University College London.

#### **2.1.3 Clinical group characteristics**

Clinical group ages ranged from 18 to 44 years with a mean of 24.48 years. The majority of participants were female (83 compared to 49 males) and were studying for their first degree (88 as opposed to 44 studying for a further degree).

#### 2.1.4 Control group characteristics

Control group ages ranged from 19 to 30 years with a mean of 22.21 years. The majority of participants were again female (77 as opposed to 28 males) and were studying for their first degree (73 compared to 32 studying for a second degree).

Table 1 summarises the participant characteristics.

**Table 1 Participant characteristics for the clinical and control groups**

	Age (years)		Gender (number)		Degree (number)	
	Mean	Range	Male	Female	First	Second
Clinical (n = 132)	24.48	18-44	49	83	88	44
Control (n = 105)	22.21	19-30	28	77	73	32

#### 2.2 Group matching

The clinical and control groups were matched on several measures. First, their mean age was similar (clinical group 24.48 years, control group 22.21 years). Secondly, there were proportionately more females than males in each group (clinical group ratio 1:1.69, control group ratio 1:2.75). Thirdly, the majority of participants were studying for their first degree (clinical group ratio 1:2, control group ratio 1:2.28). Lastly, participants had met high entry criteria to gain a place at university.

The initial aim of the study was to also match participants on verbal ability. To measure this skill, the Similarities test of the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) was used. Participants heard two words and were asked to state how these were alike in terms of meaning. An example was provided before the test began (e.g. red and blue are both colours). Testing was discontinued after four consecutive scores of zero and T scores were calculated according to age bands.

The results of this test prevented participants from being matched on verbal skill, as the clinical group performed significantly better than the control group (clinical mean 61.08, control mean 57.03;  $t=4.2$ ,  $p<0.001$ ). Whilst discrediting group matching on verbal ability, this surprising result lends weight to any significant differences found in this study (see Results section). As the clinical population has a higher verbal IQ than the control participants, any test where the clinical participants perform at a significantly lower level eliminates underlying verbal ability as a possible cause of their poorer performance.

### **2.3 Procedure**

Each participant was required to sign a consent form before testing. Appendix A contains copies of the consent forms used for the clinical and control participants. All tests were administered individually in a quiet setting. The clinical data was collected as part of the diagnostic assessment procedure by the University College London Dyslexia Coordinator. Five students from University College London, including the author of this study, collected the control data. The control group tests were presented in one session of between 20 and 30 minutes.

### **2.4 Consistency**

Measures were taken to ensure consistency in testing. First, all students collecting control data were trained in test administration by the University College London Dyslexia Coordinator. Secondly, inter-rater reliability was checked by the University College London Dyslexia Coordinator. It was found that the control participants' performance was consistently scored by all test administrators.

### **2.5 Measures**

The tests administered investigated spelling, reading, phonological awareness, phonemic decoding and rapid naming using the following tools:

#### **2.5.1 Spelling**

The blue spelling form of the Wide Range Achievement Test 3 (Wilkinson, 1993) was administered. Testing began at item ten (*circle*). Each word was

presented verbally in isolation, then in a sentence, then again in isolation, in increasing order of difficulty. Participants were asked to write the target word. The test was discontinued after ten consecutive words had been misspelled. Standard scores were calculated according to age bands.

### 2.5.2 Reading

The blue form of the Wide Range Achievement Test 3 (Wilkinson, 1993) was administered. Participants were asked to read aloud the words across the page, in increasing order of difficulty. The test administrator marked errors and discontinued the test following ten consecutive errors. Standard scores were calculated according to age bands.

### 2.5.3 Phonological awareness

Jamieson's unpublished spoonerism test was administered (Appendix B contains a copy of the test). Ten pairs of words were presented verbally to the participant, whose task was to transpose the initial phonemes. Participants were given one example and three practice items with an explanation of any errors. The test was timed from the first to last item and divided by ten to gain an average time per spoonerism (including delivery). An accuracy score was also recorded. Correct items required *both* halves of the spoonerism to be correct. The selected pairs of words were chosen because they included no initial clusters; seven items could lead to confusion between initial letters and initial sounds thereby allowing orthographic interference to be considered, e.g. *bedroom carpet*, *shopping centre*, *ginger cake*, *head gardener*, *Vatican City*, *think tank* and *channel five*; they would be unlikely to become dated, as the word pairs were associated rather than simply being names of famous people (which other spoonerism tests have used); and the vocabulary consisted of words which students would know. The test was discontinued only when participants demonstrated frustration or distress.

### 2.5.4 Phonemic decoding

Form B of the Phonemic Decoding Efficiency subtest of the Test of Word Reading Efficiency (Torgesen, Wagner & Rashotte, 1999) was administered.



This measures the number of non-words of increasing length and difficulty correctly read in 45 seconds. Participants were first given a practice list of eight items to read aloud as quickly as possible. Errors were marked (including non-words participants were unable to attempt) and participants were stopped at 45 seconds regardless of the number of items remaining. Standard scores were calculated according to age bands.

#### 2.5.5 Rapid naming

Both the Rapid Digit Naming and Rapid Letter Naming subtests of the Comprehensive Test of Phonological Processing (Wagner, Torgesen & Rashotte, 1999) were administered. Each test required the participant to read a series of six items (either digits 2, 3, 4, 5, 7, 8, or letters *a, c, k, n, s, t*) from left to right and line to line (a 9 x 4 random order arrangement was used) as quickly as possible. The process was repeated with a second set of the same items arranged in a different order and standard scores were calculated based on the time taken to read all 72 stimuli. Participants were asked to read aloud each stimulus on a practice form before the test to dismiss any visual difficulties.

### 3.0 RESULTS

#### 3.1 Descriptive statistics

Test means and standard deviations for both the clinical and control groups are shown in Table 2 with significance levels. The control group performed significantly better than the clinical group in all trials ( $p < .001$ ). They achieved higher scores and required less time per spoonerism in the phonological awareness test (control group mean 6.27 seconds, clinical group mean 8.47 seconds). The standard deviations of the control group were less than those of the clinical group for measures of spelling, reading, and phonological awareness (including spoonerism accuracy and time), but were greater than those of the clinical group for measures of phonemic decoding and rapid naming (both digits and letters). Variance between the groups was therefore inconsistent.

**Table 2 Test means and standard deviations for the clinical and control groups including significance levels**

	Clinical Group		Control Group		Significance	
	Mean	S.D	Mean	S.D	t	p
WRAT 3 Spelling (standard score)	98.03	11.3	113.31	7.37	-12.54	.000
WRAT 3 Reading (standard score)	99.47	10.55	112.51	6.3	-11.81	.000
Spoonerisms Accuracy	4.68	2.97	7.99	1.8	-10.58	.000
Average Time per Spoonerism (seconds)	8.47	5.44	6.27	3.02	3.95	.000
TOWRE Phonemic Decoding (standard score)	83.25	11.5	106.93	11.96	-15.4	.000
CTOPP Rapid Digit Naming (standard score)	7.43	2.94	11.6	2.97	-10.78	.000
CTOPP Rapid Letter Naming (standard score)	6.12	2.7	11.19	3.73	-11.7	.000

### **3.2 Rapid naming**

In order to analyse the data with reference to the hypotheses posed at the end of the introduction, it was necessary to ascertain if the difference in scores between the two measures of rapid naming was significant for each participant. An insignificant result would have enabled an average rapid naming score to be calculated, thus simplifying further investigations. However, a paired samples t test identified a significant difference between the digit and letter naming scores ( $t=7.82$ ,  $p<.001$ ). This study therefore retained and utilised the two measures of rapid naming separately in analysis.

The remainder of the results are reported in relation to the hypotheses posed.

### **3.3 Hypothesis 1: Both rapid naming and phonological awareness skills affect decoding and encoding ability.**

For this hypothesis, it was necessary to explore the independence of rapid naming and phonological awareness, and their separate contributions towards literacy skills. Two analyses were performed with all 237 participants.

#### **3.3.1 Correlation**

Pearson's correlation coefficient was used to determine the strength of association between each rapid naming measure and spoonerism accuracy. Table 3 shows the results. There was a highly significant positive correlation between each rapid naming measure and spoonerism accuracy (digit naming and spoonerism accuracy  $.336$ ,  $p<.001$ ; letter naming and spoonerism accuracy  $.397$ ,  $p<.001$ ). Although significant, the correlations were modest, thus asserting a level of independence between the variables.

**Table 3 Correlations between rapid naming and phonological awareness measures**

		CTOPP Digit Naming	CTOPP Letter Naming
Spoonerism Accuracy	Pearson Correlation	.336	.397
	Significance (two-tailed)	<.001	<.001

### 3.3.2 Multiple regression

Multiple regression analyses were used to establish the level of independent and overlapping effects of rapid naming and phonological awareness on literacy skills, i.e. to what extent is literacy affected by each variable separately and by the variables jointly? Analyses were conducted first for digit naming and spoonerism accuracy, and secondly for letter naming and spoonerism accuracy. Results are shown in Tables 4 and 5.

Rapid letter naming was more closely associated with all literacy skills than rapid digit naming. This also resulted in a higher shared variance (interaction) between rapid letter naming and spoonerism accuracy, as opposed to rapid digit naming and spoonerism accuracy, for each literacy area.

Spoonerism accuracy, i.e. phonological awareness, was more closely related to reading ability ( $t=10.53$ , part correlation  $.513^2/ 26\%$ ,  $p<.001$  when paired with digit naming;  $t=9.91$ , part correlation  $.481^2/ 23\%$ ,  $p<.001$  when paired with letter naming) whereas rapid naming (both digit and letter) was more closely related to timed non-word reading, i.e. phonemic decoding (digit naming  $t=13.56$ , part correlation  $.514^2/ 26\%$ ,  $p<.001$ ; letter naming  $t=14.97$ , part correlation  $.542^2/ 29\%$ ,  $p<.001$ ).

Both rapid letter naming and spoonerism accuracy were equally associated with spelling ability (letter naming  $t=8.2$ , part correlation  $.382^2/ 15\%$ ,  $p<.001$ ; spoonerism accuracy  $t=8.33$ , part correlation  $.388^2/ 15\%$ ,  $p<.001$ ).

However, when rapid digit naming was entered as the second variable instead of rapid letter naming, the association shifted in the favour of

spoonerism accuracy (digit naming  $t=7.5$ , part correlation  $.356^2/ 13\%$ ,  $p<.001$ ; spoonerism accuracy  $t=9.15$ , part correlation  $.434^2/ 19\%$ ,  $p<.001$ ).

Phonological awareness skills therefore seem more important in untimed conditions focusing on accuracy, whereas rapid naming skills appear more related to abilities where both speed and accuracy are important.

**Table 4 Variance (%) in literacy skills attributable to individual differences in rapid digit naming and spoonerism accuracy, and their interaction**

	CTOPP Digit Naming	Spoonerism Accuracy	Interaction	Total
WRAT 3 Reading	5	26	13	44
WRAT 3 Spelling	13	19	15	47
TOWRE Phonemic Decoding	26	18	22	66

Both variables were independently significant at  $p < .001$

**Table 5 Variance (%) in literacy skills attributable to individual differences in rapid letter naming and spoonerism accuracy, and their interaction**

	CTOPP Letter Naming	Spoonerism Accuracy	Interaction	Total
WRAT 3 Reading	6	23	16	45
WRAT 3 Spelling	15	15	19	49
TOWRE Phonemic Decoding	29	13	27	69

Both variables were independently significant at  $p < .001$

### 3.3.3 Summary

In summary, rapid naming and spoonerism accuracy have some independence from each other whilst being significantly related. Each variable exerts both independent and overlapping effects on literacy ability. The size of effect differs depending on literacy skill.

**3.4 Hypothesis 2: The impact of dyslexia on literacy skills will depend on the nature of the underlying deficit. Three possible deficits are explored: a phonological awareness deficit, a naming speed deficit and a double deficit (deficits in both phonological awareness and naming speed).**

This hypothesis required the clinical population to be divided into four groups in order to compare the differing effects on literacy skills. The first group exhibited a phonological awareness deficit (PAD), the second a naming speed deficit (NSD), the third a double deficit (DD), and the fourth group consisted of the remaining dyslexic participants (RD). Participants in the RD group had been diagnosed with dyslexia but did not meet the strict criteria used in this study to form the PAD, NSD and DD groups as detailed below. The control population was not included in this part of the analysis.

#### 3.4.1 PAD group

The spoonerism test used to measure phonological awareness was not standardised. Determining the cut-off for a PAD was therefore a subjective matter for the author of this study. As all control participants, apart from one, scored four or above for spoonerism accuracy, it was decided that those who scored three or below, and those whose test was discontinued, would be considered to have a PAD.

#### 3.4.2 NSD group

The rapid naming tests used are part of the Comprehensive Test of Phonological Processing (Wagner et al., 1999), which is standardised. Participants were considered to have a NSD if they scored at or below the 16<sup>th</sup> percentile rank (one standard deviation below the mean) in *both* rapid naming measures. Note that this is a low score *within* a group with impaired literacy skills. This equated to a scaled score of seven or below (mean=10) for both digit and letter naming.

### 3.4.3 DD and RD groups

Participants were considered to have a DD if they met both criteria detailed above. Those within the RD group scored above the cut-off for both the spoonerism and rapid naming tests.

### 3.4.4 Descriptives

Using the above criteria, the PAD group comprised 26 participants (20%), the NSD group 46 participants (35%), the DD group 23 participants (17%) and the RD group 37 participants (28%).

### 3.4.5 Analysis of variance

A one-way analysis of variance was used to compare the group means for the reading, spelling and phonemic decoding tests, and therefore to highlight the impact of underlying deficits on literacy skills. In conjunction, Bonferroni was used as the post hoc test. Given the large sample size (132 participants), concerns regarding equality of variance were reduced.

### 3.4.6 WRAT 3 Reading

Group means and standard deviations for reading are shown in Table 6. Significance levels for a comparison of reading group means are shown in Table 7. The impact of dyslexia on reading ability does depend on the underlying deficit ( $F=15.95$ ,  $df=3,128$ ,  $p<.001$ ). The NSD group (mean 103.85) performed significantly better than the PAD group (mean 97.73,  $p<.05$ ) and the DD group (mean 88.52,  $p<.001$ ). The PAD group scored significantly higher than the DD group ( $p<.005$ ). Surprisingly the NSD group outperformed the RD group (mean 102.05), although the difference was insignificant. The DD group was the *only* group to perform significantly lower than the RD group ( $p<.001$ ). These results provide some support for the findings of the multiple regression analyses for Hypothesis 1. Those with a PAD experienced more difficulties with reading than those with a NSD, yet neither performance of the single deficit groups differed significantly from the RD group. The DD group was the lowest performing group.

**Table 6 WRAT 3 Reading – Group means and standard deviations**

	Number of Participants	Mean	S.D.
PAD	26	97.73	10.55
NSD	46	103.85	9.05
DD	23	88.52	8.52
RD	37	102.05	8.4

**Table 7 WRAT 3 Reading – Significance of group mean comparisons**

		Significance (p)
PAD	NSD	.042
	DD	.003
	RD	.394
NSD	PAD	-
	DD	.000
	RD	1.000
DD	PAD	-
	NSD	-
	RD	.000

Plots of the reading group means and their corresponding 95% confidence intervals can be found in Appendix C.

### 3.4.7 WRAT 3 Spelling

Group means and standard deviations for spelling are shown in Table 8. Significance levels for a comparison of spelling group means are shown in Table 9. The impact of dyslexia on spelling does depend on the nature of the underlying deficit ( $F=8.13$ ,  $df=3,128$ ,  $p<.001$ ). The DD group (mean 89.26) performed significantly below both the NSD group (mean 101.04,  $p<.001$ ) and the RD group (mean 101.22,  $p<.001$ ). No other results were significant, although the PAD group (mean 95.92) scored below the NSD and RD groups (5.12 and 5.3 points lower respectively), and above the DD group (6.66



points higher). The NSD group performed similarly to the RD group (.18 difference in means), which suggests that an underlying NSD has few implications for spelling ability.

**Table 8 WRAT 3 Spelling – Group means and standard deviations**

	Number of Participants	Mean	S.D.
PAD	26	95.92	13.92
NSD	46	101.04	8.78
DD	23	89.26	10.84
RD	37	101.22	9.37

**Table 9 WRAT 3 Spelling – Significance of group mean comparisons**

		Significance (p)
PAD	NSD	.291
	DD	.169
	RD	.303
NSD	PAD	-
	DD	.000
	RD	1.000
DD	PAD	-
	NSD	-
	RD	.000

Plots of the spelling group means and their corresponding 95% confidence intervals can be found in Appendix D.

### 3.4.8 TOWRE Phonemic decoding (timed non-word reading)

Group means and standard deviations for phonemic decoding are shown in Table 10. Significance levels for a comparison of phonemic decoding group means are shown in Table 11. The impact of dyslexia on phonemic decoding does depend on the underlying deficit ( $F=18.92$ ,  $df=3,128$ ,  $p<.001$ ). The DD group (mean 70.91) scored significantly below all other groups (PAD mean

84.04, NSD mean 83.35, RD mean 90.24,  $p < .001$ ). The only other significant difference existed between the NSD and RD groups with the former scoring 6.89 points below the latter. The PAD group performed better than the NSD group, as expected considering that naming speed was found to be more strongly associated with timed measures in the multiple regression analyses, yet this difference failed to reach significance (.69 points difference only). Neither was the poorer performance of the PAD group significant when compared to the RD group.

**Table 10 TOWRE Phonemic Decoding – Group means and standard deviations**

	Number of Participants	Mean	S.D.
PAD	26	84.04	11.05
NSD	46	83.35	8.51
DD	23	70.91	10.97
RD	37	90.24	9.21

**Table 11 TOWRE Phonemic Decoding – Significance of group mean comparisons**

		Significance (p)
PAD	NSD	1.000
	DD	.000
	RD	.081
NSD	PAD	-
	DD	.000
	RD	.010
DD	PAD	-
	NSD	-
	RD	.000

Plots of the phonemic decoding group means and their corresponding 95% confidence intervals can be found in Appendix E.

### 3.4.9 Summary

In support of the findings for Hypothesis 1, performance in phonemic decoding (timed non-word reading) was significantly affected by a NSD. Reading and spelling ability among those with a NSD remained at a similar level to those in the RD group. Again supporting the analysis for Hypothesis 1, the impact of a PAD was significantly greater than that of a NSD for reading skill. Finally, the DD group was the poorest performing group for each literacy skill. The lower score of this group was significant, apart from when compared to the spelling ability of the PAD group.

**3.5 Hypothesis 3: Students with a double deficit will be more severely affected than students with a single deficit. A qualitative difference will be evident in the performance of double deficit students in both decoding and encoding.**

The above analysis confirmed that the literacy skills of students with a DD were more severely affected than those of students with a single deficit. A further examination of some single cases may provide evidence of qualitative differences in the performance of the DD students. Six cases were chosen (two from each of the PAD, NSD and DD groups) avoiding extreme scores. Table 12 details the scores for rapid naming, phonological awareness and literacy measures for the six participants.

**Table 12 Rapid naming, phonological awareness and literacy scores for the chosen single cases**

	Participants					
	PAD Group		NSD Group		DD Group	
	1	2	3	4	5	6
CTOPP Digit Naming	12	7	3	4	5	7
CTOPP Letter Naming	10	8	4	4	3	5
Spoonerism Accuracy	1	2	4	7	2	1
Spoonerism Time	14.7	16	11.2	5.2	12.5	discontd.
WRAT 3 Reading	93	84	119	108	88	88
TOWRE Phonemic Decoding	86	81	90	71	67	81
WRAT 3 Spelling	103	76	108	82	91	97

Scores are not the focus of this section, yet it must be noted that the DD participants did not always demonstrate the poorest literacy skills.

### 3.5.1 WRAT 3 Reading

The PAD participants had difficulties decoding unfamiliar words, demonstrating a lack of awareness of the detail within letter sequences, e.g. participant 1 read *pseudonym* as *sidoin*, and participant 2 read *usurp* as *ursrup*. The NSD participants performed very differently from each other. Participant 3 made only three errors in 42 words, while participant 4 read very slowly and hesitantly, self-correcting two errors. These errors again indicated that effective decoding strategies for unfamiliar words had not been developed, e.g. participant 4 read *covetousness* as *coventurousness*. The DD participants read the words in the first half of the test correctly without hesitation, but struggled considerably with the less familiar words contained in the second half. Errors again demonstrated a reduced knowledge of the detail within letter sequences, e.g. participant 5 read *irascible* as *iresizable*, and participant 6 read *discretinary* for *discretionary*.

### 3.5.2 TOWRE Phonemic decoding

The PAD participants read the non-words at a fast pace. However, speed compromised accuracy. Participant 1 made 23 errors (mainly for single syllable non-words) and participant 2 made 26 errors. These results emphasise an inefficient decoding ability for unfamiliar letter strings. The NSD participants adopted a much slower reading rate and made far fewer errors. Participant 3 made five errors, three of which were for single syllable non-words, e.g. *bees* for *bice*, while participant 4 made eight errors, e.g. *marked* for *mact*. Both DD participants made nine errors for single syllable non-words, proving the ineffectiveness of techniques used to decode unfamiliar letter chains.

### 3.5.3 WRAT 3 Spelling

Both PAD participants demonstrated unfamiliarity with spelling conventions, e.g. participant 1 wrote *posession* for *possession*, and participant 2 spelt *believe* as *belive*. However they also made non-phonetic spelling errors, i.e. errors where the sound structure of the word is not reflected, e.g. participant 1 spelt *pusillanimous* as *purseramerless*, and participant 2 wrote *enthusisam* for *enthusiasm*. The NSD participants both showed a reduced awareness of spelling conventions, e.g. participant 3 spelt *success* as *sucsess*, and participant 4 wrote *caricter* for *character*. Only participant 3 made non-phonetic spelling errors, e.g. *pluesinamomous* for *pusillanimous*. Errors made by participant 4 tended to reflect the sound structure of the target word, e.g. *corekt* for *correct*, *resnable* for *reasonable*. The DD participants also revealed an unstable knowledge of spelling conventions alongside non-phonetic errors, e.g. *exsecitive* for *executive*, and *oppontunity* for *opportunity* (participant 5); *breif* for *brief*, and *acquist* for *acquiesce* (participant 6).

### 3.5.4 Summary

The DD students, whilst demonstrating similar patterns to the single deficit participants, e.g. unsuccessful decoding strategies for unfamiliar letter strings, also showed a qualitative difference from the single deficit groups for both reading and phonemic decoding. The main factors contributing to this difference were response times and number of errors. The DD participants

were less hesitant when reading familiar words and performed between the two extremes of the PAD and NSD participants for phonemic decoding. Both the DD and PAD participants performed similarly at spelling. One NSD participant made no non-phonetic spelling errors.

## **4.0 DISCUSSION**

### **4.1 Purpose of study**

This study aimed to investigate the double deficit hypothesis in the higher education population. It sought to determine both the quantitative and qualitative effects of the two hypothesised independent sources of reading dysfunction, phonological awareness and naming speed (Wolf & Bowers, 1999, 2000), on literacy skills.

### **4.2 Hypothesis 1: Both rapid naming and phonological awareness skills affect decoding and encoding ability.**

Analyses for this hypothesis investigated the independent effects of each variable on literacy.

#### **4.2.1 Correlation**

The significant positive correlation between rapid naming and spoonerism accuracy identifies their relationship. As one variable increases, so does the other, meaning that phonological awareness and naming speed are closely associated. However it would seem odd if these variables were not significantly related, as both skills require similar abilities. The literature claims that phonological awareness is required to manipulate sounds, transposing letters with sounds in reading and vice versa for spelling (Compton et al., 2001; Pennington et al., 1990), yet this view of phonological awareness is far too simplified. Many subsets of skill are involved, requiring various abilities simultaneously, e.g. successful completion of a spoonerism task requires an efficient auditory working memory, orthographic and phonological representations of the words presented, manipulation of phonemes, motor programming of the 'new words' and articulation.

Some also simplify naming speed ability as a determinant of how quickly words are recognised (Bowers & Wolf, 1993; Sunseth & Bowers, 2002) and therefore read (Savage & Frederickson, 2005), while others refer to the complex nature of this skill (Wolf, Bowers & Biddle, 2000), e.g. rapid naming tasks require access to phonological representations, motor programming,

articulation and the ability to associate letters with sounds. Both phonological awareness and naming speed therefore draw on some common abilities, rendering an insignificant association between them unlikely. LaBerge and Samuels (1974, cited by Bowers & Swanson, 1991; Lovett, 1984) identified both accuracy and automaticity as criteria for reading skill to develop. As both skills are deemed necessary, a close relationship between them seems inevitable.

Although phonological awareness and naming speed were positively correlated, this appears an insufficient reason to categorise naming speed as a phonological process, as did Schatschneider et al. (2002). Whilst the correlations found were significant, they were not strong, as found by Savage et al. (2005); and were modest rather than weak, as proposed by Wolf and Bowers (1999). Each skill requires different, as well as common abilities, as mentioned previously. This study would therefore suggest that each variable exerts both separate and similar effects, providing some support for the double deficit hypothesis.

#### 4.2.2 Multiple regression

Rapid naming and phonological awareness were proven to have separate effects on literacy skills. Spoonerism accuracy was more closely related to reading skill, and rapid naming to timed non-word reading (TOWRE phonemic decoding). The results were therefore in accordance with previous studies (Compton et al., 2001; Torgesen et al., 1997), as a phonological awareness deficit compromised accuracy and a naming speed deficit only seemed to affect performance when both accuracy *and* speed were required. The importance of these results is emphasised by a comparison of individual and shared variances (interactions). The variance attributable to spoonerism accuracy for reading and rapid naming for timed non-word reading was always greater than the shared variance (the cumulative effect of both variables as opposed to their independent effects). The double deficit hypothesis gains evidence for both reading and non-word reading. However these associations could result from artefacts in testing, i.e. the spoonerism



and reading tests were both untimed, while the rapid naming and non-word reading tests were timed.

The effect of each variable on spelling ability was less clear and depended on the rapid naming measure used (whether digit or letter naming). Letter naming and spoonerism accuracy were both equally associated with spelling, whereas digit naming had a less marked effect. Spelling ability therefore seems more dependent on phonological awareness skills. The double deficit hypothesis gains further support only when rapid digit naming is used as the naming speed measure, as this combination results in uneven effects of each variable and therefore separable sources of literacy difficulty.

The literacy task with the highest shared variance, from both rapid naming and phonological awareness, was the timed non-word reading test (phonemic decoding). Students with a double deficit are therefore likely to struggle most when reading under timed conditions, as opposed to reading at an easy pace or spelling. As the shared variance was always under 30%, under half of the 75% found by Chiappe et al. (2002), it is difficult to support their finding that naming speed deficits may represent phonological impairments rather than a second independent core deficit of dyslexia. Also, Chiappe et al.'s study (2002) only involved 30 adults classified as poor readers based on a reading performance at or below the 25<sup>th</sup> percentile on the WRAT 3 reading test (Wilkinson, 1993), with 32 chronological-age controls and 31 reading-level controls. No mention is made of a diagnosis of dyslexia. It is therefore uncertain whether any individuals with dyslexia were included, allowing only limited conclusions to be drawn.

Although phonemic decoding involved reading non-words, no conclusions can be drawn about the effect of various deficits on reading new vocabulary (unknown words are effectively non-words) as comparable tests were not conducted. For future studies it would be useful to compare both timed and untimed measures of reading real and non-words. The findings of this study confirm that those with a naming speed deficit perform worse than those with a phonological awareness deficit in timed conditions. Such individuals in

higher education are likely to have difficulties processing the required amount of material and effectively demonstrating their knowledge in examinations (Cirino et al., 2005).

The multiple regression analyses were conducted on all data, without separating the participants into clinical and control groups. As separate effects on literacy were found in relation to the phonological awareness and naming speed tasks, the validity of the claim that naming speed may not contribute unique variance to reading for skilled readers (McBride-Chang & Manis, 1996; Savage et al., 2005) is questionable. Further research conducting tests on each group separately would clarify this point and would allow an exploration of the possibility that the two groups demonstrate different effects.

#### 4.2.3 Rapid naming

Rapid letter naming was more closely related to all literacy skills than rapid digit naming, possibly because it involves the components of reading and spelling, i.e. letters. The conflict between letter names and their alternating sounds in words demonstrates the association between letter naming and literacy. Confusion can abound, and the claim that naming speed is more strongly correlated with orthographic knowledge than with phonological measures (Sunseth & Bowers, 2002) is worthy of consideration.

**4.3 Hypothesis 2: The impact of dyslexia on literacy skills will depend on the nature of the underlying deficit. Three possible deficits are explored: a phonological awareness deficit (PAD), a naming speed deficit (NSD) and a double deficit (DD; deficits in both phonological awareness and naming speed).**

This hypothesis required the clinical population to be divided into groups and their literacy skills compared. Some studies have failed to find dyslexic subjects with a singular NSD (e.g. Badian, 1997; Morris et al., 1998), however the NSD group in this study was the largest (n=46) forming 35% of the total number of participants with dyslexia. Recall that the author of this study set the criterion for group membership very conservatively, using the

rapid naming standardisation to form the NSD group, and classifying those scoring three or below (or having their test discontinued) on the unpublished spoonerism test as having a PAD, as some control participants had scored four. Yet even if the PAD cut-off had been relaxed to include those scoring four (thereby resulting in more participants being classified as having a PAD or a DD), the NSD group would have remained the largest with 40 participants (eight more than the second largest group) comprising 30% of the clinical population. NSDs were therefore frequently found in this study without accompanying PADs. Possible reasons for this include the strict group criteria (relaxed cut-offs would have reduced the NSD group and increased the PAD and DD groups); the compensatory skills mastered by the students for their PADs (all participants were high academic achievers); and successful intervention received by the students resulting in less disabling PADs.

#### 4.3.1 Analysis of variance

The analysis of variance tests supported Hypothesis 2. The impact of dyslexia on reading, spelling and phonemic decoding depended on the nature of the underlying deficit.

#### 4.3.2 WRAT 3 Reading

The DD group was the most severely affected, scoring significantly below all other groups. The PAD group performed significantly below the NSD group, but neither single deficit group performed significantly differently to the remaining dyslexic students (RD group), i.e. to those diagnosed with dyslexia but who had not met the strict study criteria set for the other groups. In fact, the NSD group scored slightly better than the RD group, which leads one to question why the DD group scored significantly lower than all other groups. With neither single deficit proving much of a problem for reading skill (although the PAD group was the second worst performing group), it seems illogical that the DD group (with both single deficits) should perform so poorly. The only conclusion possible is that the interaction of both single deficits is responsible for the weaker performance. DD readers are more severely affected by the combination of difficulties and therefore have fewer

compensatory routes available to successfully perform the task (Wolf & Bowers, 2000).

A further study might examine any patterns in the performance of the RD group, i.e. do mild DDs affect literacy more severely than mild single deficits? It may also be beneficial to compare the phonological awareness and naming speed skills of each of the deficit groups. This would reveal any significant differences between their abilities, which may explain the DD group's performance, i.e. if the DD group had worse phonological awareness skills than the PAD group or worse naming speed skills than the NSD group. However, such an analysis will only provide averages, whereas in reality individuals lie on a continuum of ability.

It may seem surprising that neither single deficit group performed significantly differently to the RD group, but recall that this group consists of individuals diagnosed with dyslexia. They did not meet the strict study criteria for entrance to either the PAD or NSD groups, but nevertheless have dyslexia. A number of reasons may exist for these insignificant differences. First, the study criteria used may have been too strict, excluding individuals with less severe PADs and NSDs from the groups and causing statistical 'slicing' (Schatschneider et al., 2002). This would have resulted in members of the RD group experiencing similar difficulties to the other groups but to a lesser extent. Secondly, all participants were higher education students, who had achieved a high academic level to enter university. They may therefore have found ways to compensate for their specific difficulties, masking deficits. Lastly, the double deficit hypothesis is not an exhaustive explanation for dyslexia (Wolf & Bowers, 1999; Wolf et al., 2000). The RD group may have a third, as yet unknown deficit, which is causing literacy difficulties.

#### 4.3.3 WRAT 3 Spelling

The DD group was again the most severely affected and the only group to perform significantly below the RD group. The NSD and RD groups scored so similarly that they could have been amalgamated into one group. The PAD group did not perform significantly differently to any other group. The

insignificant differences between the PAD, NSD and RD groups again call into question the poor performance of the DD group and point to the conclusion that their weaker performance is caused by the interaction of both single deficits.

#### 4.3.4 TOWRE Phonemic decoding (timed non-word reading)

The DD group again demonstrated the worst performance. The difference in performance between the NSD and PAD groups was insignificant, yet the NSD group was the only single deficit group to perform significantly below the RD group. The performance of the NSD group could therefore account for the low DD score. However the interaction of deficits may still play a role, as the DD group scored significantly below, rather than similarly to, the NSD group.

#### 4.3.5 NSD relevance

Given the above analysis, one may question the value of measuring naming speed. The NSD group scored similarly to the RD group for reading and spelling (perhaps the RD group experienced NSDs of a less severe nature than the NSD group), and similarly to the PAD group for timed non-word reading. In fact, the only significant difference between the NSD and PAD performance was for reading, where the PAD group were at a greater disadvantage. Naming speed therefore failed to reveal many 'individual' results in the higher education population, offering some support for the claim that it loses its predictive power over time (see Vukovic & Siegel, 2006). Its main contribution appeared to be to tasks undertaken in timed conditions, yet naming speed involves much more than actual speed. Purer tests of speed could provide useful information about timed scenarios, e.g. copying symbols or measures that avoid the need for other skills, such as articulation and accessing phonological representations. 'Pure' tasks, while difficult to design, allow the precise level of breakdown to be located and would therefore add much to naming speed research.

Perhaps the most important finding of these analyses is that something appears to be happening in the interaction between single deficits, causing

DD readers to experience the most severe literacy difficulties. Whilst questioning the validity of naming speed as a diagnostic tool, this study lends little support to the findings of Schatschneider et al. (2002), that the more severe impairments in DDs are due to PADs, rather than a combination of these with NSDs. Further investigation into naming speed and what it represents is needed, particularly as the existing literature lacks consensus for a definition (Vukovic & Siegel, 2006). Studies could also examine the cognitive abilities of those with NSDs to identify compensatory skills in use, as those with NSDs scored relatively well in this study, moving beyond the 'least impaired' status hypothesised (Wolf & Bowers, 1999). However, despite naming speed being little understood, it can identify the most disadvantaged readers.

**4.4 Hypothesis 3: Students with a double deficit will be more severely affected than students with a single deficit. A qualitative difference will be evident in the performance of double deficit students in both decoding and encoding.**

The previous analysis revealed that DD students were the most severely affected, as predicted by Wolf and Bowers (1999). However, large studies such as this only ever provide averages. It was therefore decided to examine some individual cases to gain qualitative data. Although statistics were not the focus of this section, they do demonstrate that average scores can mask the performance of individual participants. Of the six participants chosen (two each classified as having a PAD, NSD and DD), only once was the worst literacy score attained by a DD participant. Whilst this could be a result of statistical 'slicing' from arbitrary cut-offs (Schatschneider et al., 2002), it also serves as a reminder that literacy skills lie on a continuum (Compton et al., 2001). Generalisations may be inaccurate, due to the heterogeneous nature of the manifestations of dyslexia.

The DD participants experienced the same sorts of difficulties and demonstrated similar errors to the PAD and NSD participants, e.g. a limited knowledge of the detail within letter sequences resulting in difficulties decoding unfamiliar words, a reduced awareness of spelling conventions and

the presence of non-phonetic spelling errors. However the groups did differ on reading ability in terms of speed of response (the DD participants read familiar words without hesitation, but struggled noticeably with less familiar words), and number of errors (the DD participants made fewer errors than the PAD participants but more than the NSD participants; research into the interaction of deficits is required before a valid explanation can be offered for this unexpected finding). Spelling ability remained similar across the groups.

Considering the DD group was by far the most disadvantaged in the analysis for Hypothesis 2, these qualitative findings are rather surprising as they fail to pinpoint DD students as the lowest achievers. The DD participants even made fewer errors than the single PAD students. Perhaps choosing different individual cases would have provided different results, with participants lying at various stages along the literacy continuum. Further research into individuals with dyslexia may supply important information about the extent of the various difficulties experienced. Nevertheless, this study's qualitative analysis adds a note of caution to the interpretation of statistical tests, and reminds of the need to consider each person as an individual with differing strengths and areas of need.

#### **4.5 Improvements and further research**

This study would be improved by equating the PAD and NSD group cut-offs to the same percentile rank, i.e. the same level of deficit. NSDs were classified from performances at or below the 16<sup>th</sup> percentile rank, which appears more generous than the cut-off used for the unstandardised phonological awareness test. This may mean that more students should have been classified as having PADs and DDs.

Other improvements and areas for further research have been noted throughout the Discussion section and include the exclusion of confounding variables (i.e. comparing timed and untimed tests of real and non-word reading), running statistical tests on clinical and control participants separately to compare group effects, comparing the phonological awareness and naming speed skills of the PAD, NSD, DD and RD groups and

investigating the cognitive abilities of students with NSDs to identify compensatory routes available.

Of particular importance for research on dyslexia is the need to ascertain what rapid naming involves and what this represents for literacy ability.

#### **4.6 Summary and conclusion**

This study examined the double deficit hypothesis in a large sample of higher education students and reflected the controversy surrounding Wolf and Bowers' (1999, 2000) proposal of naming speed as a second independent core deficit of dyslexia. Naming speed and phonological awareness were found to have significant, yet modest, correlations suggesting a level of independence from each other alongside some shared characteristics. Multiple regression analyses further supported the independence between naming speed and phonological awareness, revealing separate effects of each variable on literacy skills.

However, conflicting evidence was found in the analysis of variance when the performance of deficit groups was compared. Whilst some expected differences were confirmed, e.g. that those with PADs are more disadvantaged in reading than those with NSDs and that NSDs significantly affect the ability to complete tasks under timed conditions, further detailed analysis of group comparisons questioned the validity of rapid naming as a diagnostic tool. Those with NSDs scored similarly to another deficit group on each literacy skill investigated, making them almost indistinguishable as a group. Neither single deficit group performed significantly differently from the remaining dyslexic students, who were not included in the PAD, NSD or DD groups (as they had scored above the strict deficit criteria set), yet the DD students were always the lowest performing group. Further research into the interaction of deficits in DD subjects is warranted.

Qualitative analysis offered further conflicting evidence, disproving that DD subjects are always the poorest performers, and emphasising that large-scale studies can never fully account for individual differences. Much



additional research is therefore required, as suggested within this study, before drawing definitive conclusions on the independent contribution of naming speed to literacy ability.

9986 words

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## Consent Form

Name of Investigator:

Name of Supervisors:

Name of Participant:

D.O.B:

University:

Course Studied:

*Traditionally a person with dyslexia is someone whose reading ability is significantly below what might be expected for his/ her IQ. They typically experience a range of difficulties with specific tasks; these will form the basis of our testing.*

*Data representing people with dyslexia has already been collected. However, a group of five University College London students (Department of Human Communication Science) are now collecting information from students who do not have a history of current literacy difficulties. This information will be used as a control for the existing data.*

*There is currently very little data available from large groups regarding the characteristics of dyslexia in higher education. Therefore we would be grateful if you could assist us with further research into this area, by completing a series of short tests.*

*The results may be published as articles or in books: names are not included and confidentiality is maintained. We would be grateful if you could indicate below whether you give permission for this data to be used.*

I confirm that I have been given full information about the tasks involved and the time they are likely to take.

I confirm that I have had sufficient time to consider whether or not I want to be included in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I confirm that I have not participated as a subject in any previous research studies on dyslexia conducted in this department.

I agree to take part in this study

**Date:**

**Signature:**



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**Jane Maxim**  
MA, PhD, DipCST,  
Reg.MRCSLT

**DYSLEXIA CLINIC**

*The department of Human Communication Science is an educational and research centre specialising in speech, language and literacy difficulties in children and adults. Staff are actively involved in investigating the nature, assessment and remediation of such difficulties and would be grateful if you would assist them by allowing data collected at your assessment to be used for teaching and research purposes. These data may be published in the form of articles or books. Please note that when data are presented, surnames are not included and confidentiality is maintained. We would be grateful if you could indicate below whether you give permission for these data to be used.*

**I give my permission for the following:**

**(Please tick if you agree and X if you do not)**

DATA CAN BE USED FOR TEACHING AND RESEARCH

DATA CAN BE PUBLISHED ANONYMOUSLY

**Signed:**

**Date:**

*With many thanks for your help*

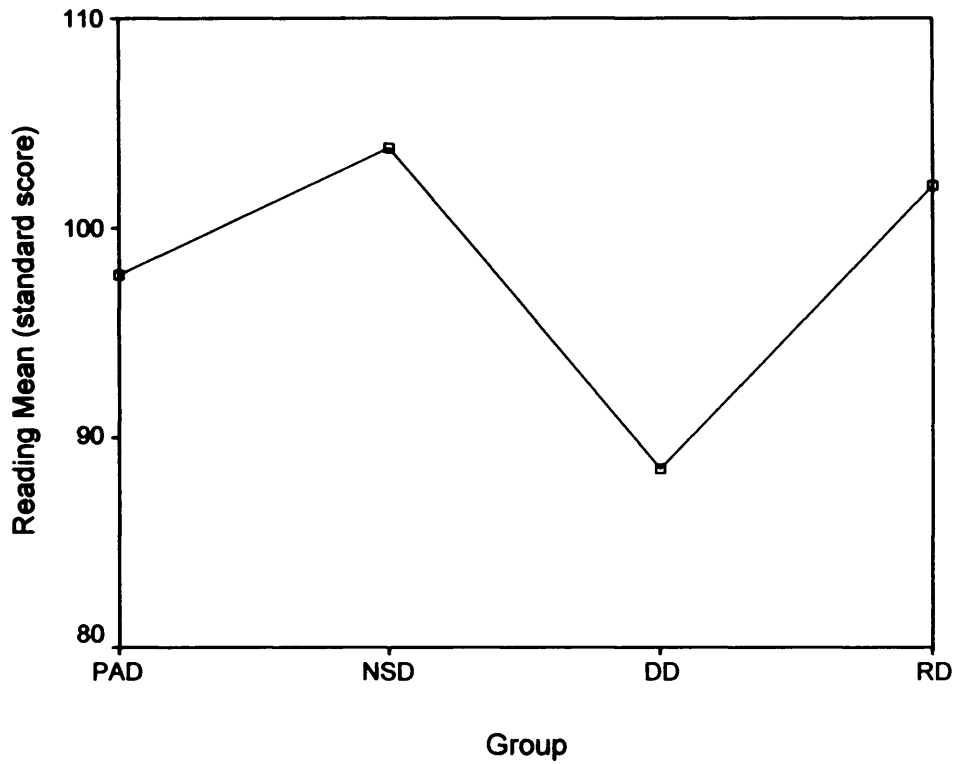
*Jane Maxim*  
*Head of Department*

## **Spoonerism Test**

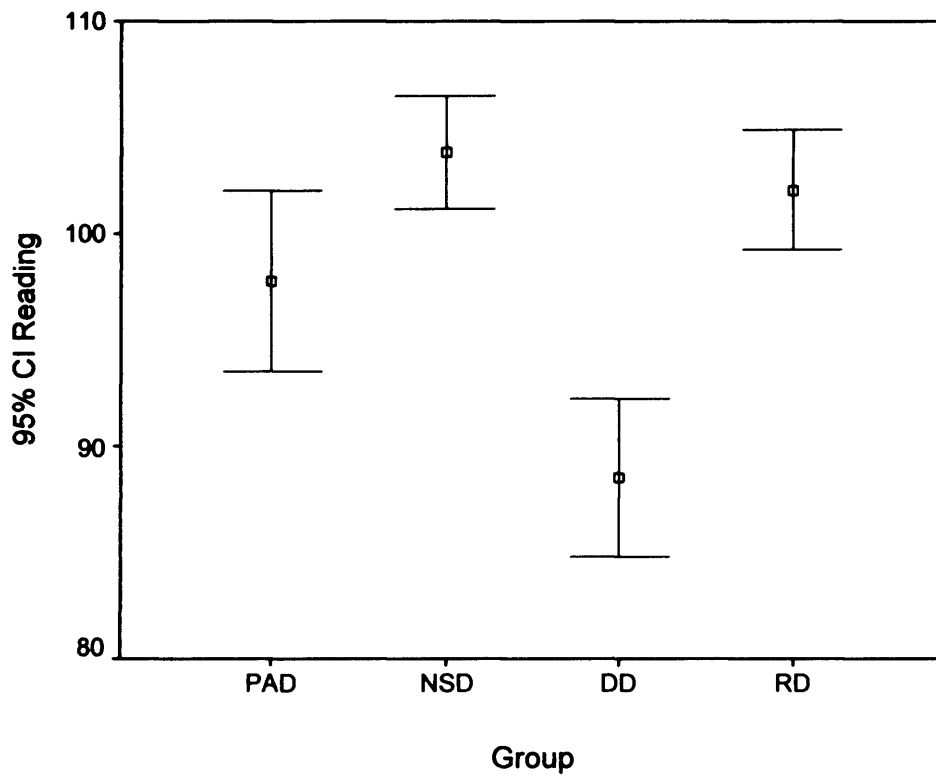
- |                      |                       |
|----------------------|-----------------------|
| 1. Sunday Times      | Tunday Simes          |
| 2. Combine Harvester | Hombine Carvester     |
| 3. Bedroom Carpet    | Kedroom Barpet        |
| 4. Channel Five      | Fannel Chive          |
| 5. Shopping Centre   | Sopping Shentre       |
| 6. Ginger Cake       | Kinjer Jake           |
| 7. Think Tank        | Tink Thank            |
| 8. Head Gardener     | Ged Hardener (hard G) |
| 9. Baseball Match    | Maseball Batch        |
| 10. Vatican City     | Satican Vity          |



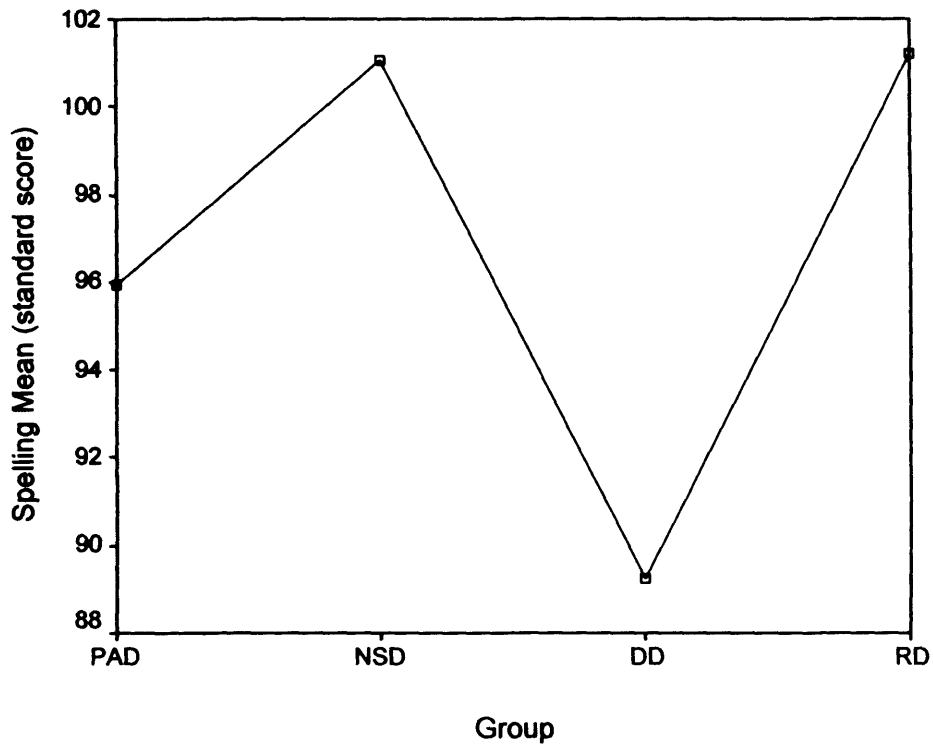
**Graph 1 Plot of the WRAT 3 Reading group means**



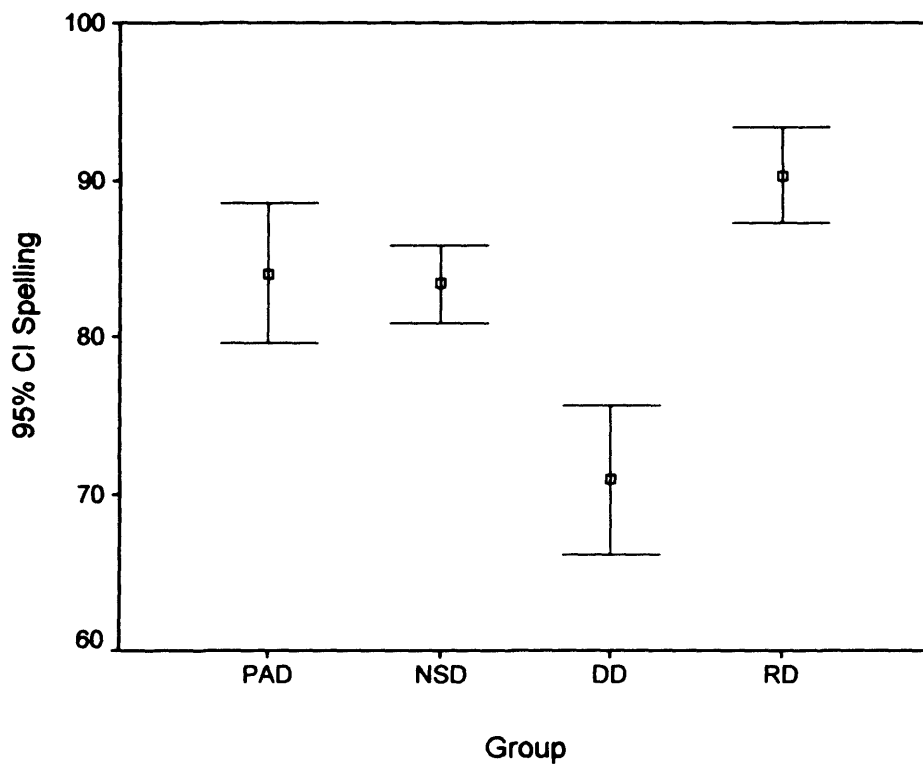
**Graph 2 Plot of 95% confidence intervals for the WRAT 3 Reading group means**



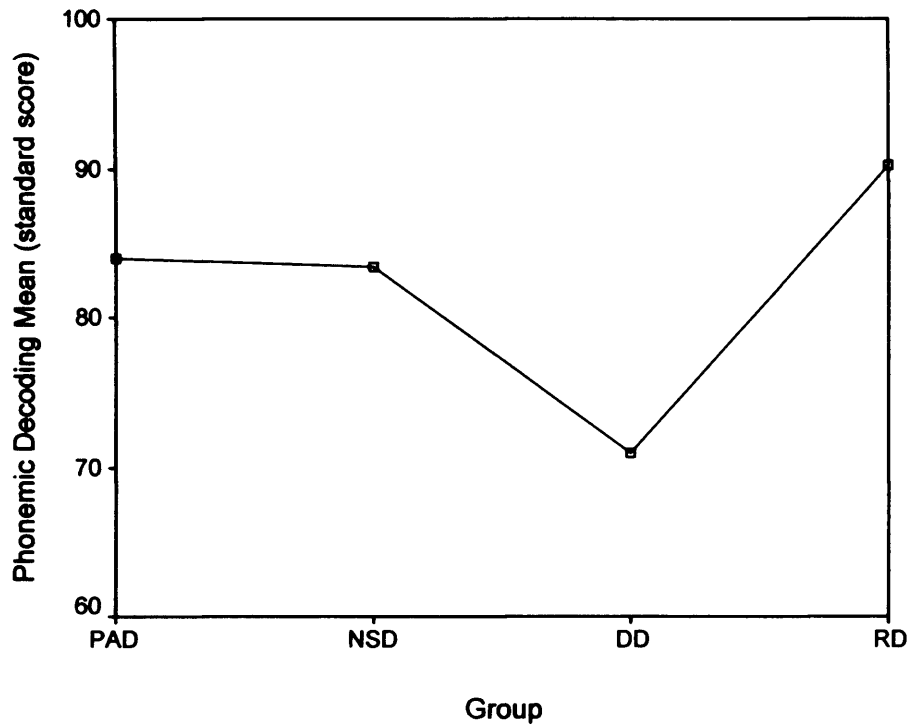
**Graph 3 Plot of the WRAT 3 Spelling group means**



**Graph 4 Plot of 95% confidence intervals for the WRAT 3 Spelling group means**



**Graph 5 Plot of the TOWRE Phonemic Decoding group means**



**Graph 6 Plot of 95% confidence intervals for the TOWRE Phonemic Decoding group means**

