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TESTING THE DOUBLE-DEFICIT HYPOTHESIS IN ARABIC LANGUAGE AMONG EMIRATI STUDENTS IN GRADE-3

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This dissertation is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Under the Supervision of Professor AbdelAziz Mustafa Sartawi

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Declaration of Original Work

I, Mahmoud Fahid Mohammad Gharaibeh, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this dissertation entitled "*Testing the Double-Deficit Hypothesis in Arabic Language among Emirati Students in Grade-3*", hereby, solemnly declare that this dissertation is my own original research work that has been done and prepared by me under the supervision of Professor AbdelAziz Mustafa Sartawi, in the College of Education at UAEU. This work has not previously been presented or published or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my dissertation have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this dissertation.

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Abstract

The purpose of this dissertation was to test the validity of the double-deficit hypothesis as applied to a sample of third-grade Arabic-speaking students in the United Arab Emirates. The double-deficit hypothesis postulates that individuals with a combination of Rapid Automatized Naming (RAN) and Phonological Awareness (PA) deficits will tend to have worse reading ability than individuals with either a RAN deficit, a PA deficit, or no deficit. Thus, the double-deficit hypothesis has been advanced as an explanation of dyslexia. Descriptive statistics were used to describe the essential feature of data in the study, and a correlational study design was applied to determine whether reading ability scores significantly lower for a double-deficit group than for a RAN deficit group, a PA deficit group, and a no-deficit group. The study's results confirmed that students who had a double deficit had significantly lower reading ability scores than other groups. The study contributed to the sparse body of empirical research on the double-deficit hypothesis among young Arabic students. The study also pinpointed differences in RAN and PA performance across groups, using an approach of post hoc analysis that has not been attempted in previous studies of this kind. The findings suggest that Arabic-language educators, specialists, and caregivers must make an added effort to address the special needs of students with double deficits, especially in light of special orthographic and other features of the Arabic language.

Keywords: Double-deficit hypothesis, dyslexia, reading ability, a reading disorder.

Title and Abstract (in Arabic)

فحص نظرية العجز الثنائي باللغة العربية من خلال طلبة الصف الثالث الابتدائي في الإمارات العربية المتحدة

الملخص

تهدف هذه الدراسة إلى فحص نظرية العجز الثنائي، حيث أشارت هذه النظرية إلى أن الطلبة الذين يعانون من عجز في مهارتي الوعي الصوتي والتسمية الأوتوماتيكية السريعة هم ذوي قدرات متدنية جدا في القراءة مقارنة بالطلبة الذين يعانون من عجز في الوعي الصوتي أو التسمية الأوتوماتيكية السريعة أو الطلبة الذين لا يعانون من عجز في هاتين المهارتين، تعتبر هذه النظرية من أحدث النظريات وأفواها في تفسير عجز القراءة ذي المنشأ العصبي. تم التحقق من صدق هذه النظرية من خلال تطبيقها على طلبة الصف الثالث الابتدائي الناطقين باللغة العربية في دولة الإمارات العربية المتحدة، ومن خلال دراسة العلاقة بين مستوى القراءة والمجموعات التالية: مجموعة الطلبة الذين يعانون من العجز الصوتي، مجموعة الطلبة الذين يعانون من عجز في التسمية الأوتوماتيكية السريعة، مجموعة الطلبة الذين يعانون من عجز في الوعي الصوتي والتسمية الأوتوماتيكية السريعة معا، وأخيرا مجموعة الطلبة الذين لا يعانون من عجز في هاتين المهارتين. أكدت نتائج الدراسة على أن الطلبة الذين يعانون من عجز ثنائي هم أضعف المجموعات السابقة في مهارة القراءة.

تعتبر هذه الدراسة التي طبقت على اللغة العربية امتداداً لدراسات أخرى تحققت من نظرية العجز الثنائي. أشارت نتائج الدراسة إلى وجود فروق ذات دلالة إحصائية بين مجموعة الطلبة الذين يعانون من عجز في الوعي الصوتي فقط ومجموعة الطلبة الذين يعانون من عجز في التسمية الأوتوماتيكية السريعة فقط من خلال استخدام (Post Hoc Analysis) والذي لم يستخدم في الدراسات السابقة. توصي الدراسة بأن على المعنيين والأخصائيين والتربويين بذل مزيدٍ من الجهود لتلبية الاحتياجات الخاصة للطلبة الذين يعانون من عجز ثنائي آخذين بعين الاعتبار خصائص اللغة العربية.

مفاهيم البحث الرئيسية: نظرية العجز الثنائي، القدرة على القراءة، عجز القراءة.

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Finally, I would like to thank my family, friends, and colleagues for their endless support during the long days and weeks spent preparing this work.

Dedication

To My Mother

A strong and gentle soul who taught me to trust in Allah, believe in hard work and that so much could be done with little

To My Father

For being my first teacher, for earning an honest living for us and for supporting and encouraging me to believe in myself.

To My Wife

The woman who is a perfect homemaker, lovely mother, successful manager and the best wife is not a myth; it's YOU. Thank you for everything.

To my beloved Children Osama and Tala

Who are the most beautiful people in my life and who taught me the true meaning of unconditional love!

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List of Abbreviations

ADA	American Dyslexia Association
BDA	British Dyslexia Association
DAA	Dyslexia Association of Australia
DDH	Double-Deficit Hypothesis
ICD	International Statistical Classification of Diseases and Related Health Problems
MSA	Modern Standard Arabic
NINDS	National Institute of Neurological Disorders and Stroke
PA	Phonological Awareness
RAN	Rapid Automatized Naming
WHO	World Health Organization

Chapter 1: Introduction

Dyslexia, also known as reading disorder (Hancock, Richlan, & Hoeft, 2017), is a widespread syndrome (Chan, Ho, Tsang, Lee, et al., 2007; Jiménez, Rodríguez, et al., 2009; Lagae, 2008; Moody et al., 2000; Paulesu et al., 2001; Shaywitz, 1998; Sprenger-Charolles, Siegel, Jimenez, & Ziegler, 2011; Wolff & Lundberg, 2002). It is also recognised the American Dyslexia Association (ADA) and The British Dyslexia Association (BDA) as a cognitive disorder that involves problems with verbal processing rapidity, verbal memory, and phonological awareness (ADA, 2017; BDA, 2016).

The UNESCO (2017) also defines dyslexia merely as "*A language-based learning disability and the most common cause of reading difficulties*". Siegel (2006) defined dyslexia as "*A reading disability [that] occurs when an individual has significant difficulty with speed and accuracy of word decoding*". A slightly different definition of dyslexia offered by the National Institute of Neurological Disorders and Stroke (NINDS) of America (2016) offered a specific definition of dyslexia as consisting of "*Difficulty with phonological processes* (*the manipulation of sounds*), *spelling, and rapid visual-verbal responding*". The WHO International Statistical Classification of Diseases and Related Health Problems (ICD) has stated that "*the central characteristic of dyslexia is a specific and significant impairment in the development of reading skills, which is not solely accounted for mental age, visual acuity problems, or inadequate schooling*" (Russell, Ryder, Norwich, & Ford, 2015).

Thus, definitions of dyslexia moved toward accepting that it is a language-based learning disability which includes difficulties with accurate word recognition and the inability to read fluently. Historically, dyslexia has begun to be recognised in the context of the spread of literacy (Castles & Friedmann, 2014). Before the sixteenth century, there were no printing presses, and literacy was an extremely uncommon phenomenon (Castles & Friedmann, 2014). Given that very few people could read, and that literacy was not an essential component of everyday life, there was no reason for dyslexia to be diagnosed. After the spread of literacy, when increasingly people began to read, the existence of dyslexia was discovered and placed in a scientific context.

However, it was not until 1896 that dyslexia was officially recognised by Pringle Morgan in the scientific literature (in Castles & Friedmann, 2014). Morgan catalogued a case of dyslexia as suffered by a British adolescent. Morgan noted the classic sign of dyslexia, the transposition of letters within words; further, Morgan acknowledged that dyslexia applied to words, not numbers. A close consideration of these phenomena led Morgan to coin the phrase *congenital word blindness* for what is now more commonly known as *Dyslexia*.

The existing definitions of dyslexia recognize possible deficits in three distinct skills—Phonological skills, naming-speed skills, and orthographic skills—as underlying dyslexia (Cirino, Israelian, et al., 2005; Duffy & McAnulty, 1990; Georgiou, Aro, et al., 2016; Lyon, 1995; Lyon, Shaywitz, & Shaywitz, 2003; Shaywitz & Shaywitz, 2008; Stanovich, 1996). In1993, Bowers and Wolf conducted research indicating that phonological skills and naming-speed skills are distinct contributors to reading ability and predicting that deficits in these two areas would be particularly pronounced among individuals with dyslexia. In the years since the debut of Bowers and Wolf's so-called *Double-Deficit Hypothesis* (DDH). The DDH has been found to be highly explanatory of reading deficits among students with dyslexia (e.g., Badian, 1997; Bowers & Wolf, 1993; Pennington, Cardoso-Martins, Green, & Lefly, 2001; Vaessen, Gerretsen, & Blomert, 2009; Wolf & Bowers, 1999). Also, an expanded version of the DDH- with orthographic skills hypothesised as a third deficit- has also been found to explain the particular reading skill deficits encountered in individuals with dyslexia (Wang, Yang, Tasi, & Chan, 2013). Because there is not yet a consensus on whether orthographic skills are indeed a deficit, or on how to measure orthographic skills (Wang et al., 2013), orthographic skills are not tested for in the current study.

The vast majority of the empirical research based on the DDH and versions thereof consists of English and European-language testing, and this limitation has been noted in DDH-based studies that are based on non-European languages (Abu-Rabia, 2007; Layes, Lalonde, Mecheri, & Rebaï, 2015; Mannai & Everatt, 2005; Saiegh-Haddad, 2005). Thus, there is limited empirical literature testing the DDH or even dyslexia among Arabic-speaking populations (Abu-Rabia, 2007; El-Ella, Sayed, Farghaly, Abdel-Haleem, & Hussein, 2004; Layes et al., 2015; Mannai & Everatt, 2005; Saiegh-Haddad, 2005). The focus of the current study is for testing the statistical significance, magnitude, and explanatory power of the DDH on the Arabic language applied to a sample of third-grade students in the United Arab Emirates (UAE). If the DDH is correct, then students identified as the lowest readers will possess deficits in both PA and naming skills. The current study's objective is to determine whether, in fact, such double deficits exist.

1.1 Statement of the Problem

The problem consists of a practical as well as a scholarly component, both of which are rooted in special considerations that apply to the Arabic language. For example, Arabic is a language with substantial orthographic depth (Share & Daniels, 2016). Arabic orthography includes 28 letters, all of which are consonants except three long vowels: أ/ a:/و/ u:/ and ي/ i:/. Diacritical dots symbolise short vowels. Most Arabic consonants have more than one written form (e.g. /k/ = ك،ـكـ،كـ) depending on whether they take place in the beginning, middle, or end of a word. It is also diglossic, in that there is a gap between Modern Standard Arabic (MSA) and the Spoken Arabic Vernacular (SAV) of different regions in the Arabic-speaking world (Leikin, Ibrahim, & Eghbaria, 2014). About Arabic diglossia, the word throat has many equivalents in different dialects:

- Alhonjarah/ الحنجرة in Modern Standard Arabic
- Alhalj/ الحلج in Gulf Arabic
- Alzor/الزور in Syro-Lebanese.
- Alhalq/الحلق in Egyptian Arabic
- Alfarjoutah/الفرجوطه in the Maghreb

Arabic has other orthographic features that could render the DDH likelier to exist among Arabic speakers—for example, regarding the absence of short vowels, the changing forms of letters depending on their placement within words, and orthographic similarities between letters (Leikin et al., 2014).

For illustration, the word كتب/ katab/, when presented without short vowels might have a number of possible readings, but when presented vowelized as in كَـتَـبَ / Kataba/ he wrote, كُـتُـبٌ / kotobon/ books, كُتِـبَ / Koteba/ it is written, the short vowels would take away any vagueness regarding the precise reading of the word. The practical component of the problem is the limited nature of dyslexia remediation or management in Arabic-language settings (Abu-Rabia, 2007; El-Ella et al., 2004;

Layes et al., 2015; Mannai & Everatt, 2005; Saiegh-Haddad, 2005), while there is a large body of research on how to both diagnose and manage dyslexia among English-speaking populations (Simos et al., 2002). For interpretation, in English, there are many effective instruction programmes, which have been developed to help students with dyslexia, e.g., multisensory programme, phonics programmes resources websites, and Davis Dyslexia Correction Programme. Also, in English, there are many International scholarly societies concerned with dyslexia research in the context of education, among these are ADA, BDA, and Dyslexia Association of Australia (DAA).

There is much less research on dyslexia management in Arabic-speaking populations (Abu-Rabia, 2007; El-Ella et al., 2004; Layes et al., 2015; Mannai & Everatt, 2005; Saiegh-Haddad, 2005). Consequently, the Arabic-speaking schoolchildren are underserved by existing approaches to dyslexia management in Arabic-language classrooms (Abu-Rabia, 2007; El-Ella et al., 2004; Layes et al., 2015).

According to Natour, Darawsheh, Sartawi, Marie, and Efthymiou (2016), this dyslexia problem has been exacerbated by the lateness of reading reform programmes in Arab countries. Natour et al. (2016) stated that "*The Arabic curriculum developers should take into thoughtfulness two important points; first, the lexical categories order which is followed later throughout the teaching process of the reading skills. Second, methods and strategies ought to be updated based on what has been confirmed by the latest researches*".

Sartawi, Al-Hilawani, and Easterbrook (1998) noted that the most comprehension and reading instruments are in English, which cause delays in the development of similar instruments in Arabic. Sartawi, Natour, and Smadi (2014) pointed that the special educational programmes in the GCC countries need more focused work, constituting another reason why the needs of Arabic-speaking students with dyslexia have been underserved.

The scholarly component of the problem is that the existing research base is insufficient to answer the question of whether the DDH truly applies to Arabic-speaking populations. There are many reasons for this gap in the literature. Sartawi et al. (2014) stated that researchers have been slow to examine not merely reading handicaps but general handicaps in the context of Arab educational systems. Natour et al. (2016) also added that educational reform is a more recent phenomenon in Arab countries, providing a delayed impetus for the diagnosis and management of dyslexia in Arab countries. Also, Sartawi et al. (1998) called attention to the difficulty of generating new instruments for reading comprehension measurement in Arabic. Thus, there are relatively few studies in which the DDH has been applied in Arabic-speaking settings (Layes et al., 2015). Some of these studies are dated and, in several cases, lacking in the statistical sophistication necessary to reach more vibrant and more informed conclusions about the applicability of the DDH among Arabic-speaking schoolchildren.

The dimensions of the problem can also be understood through a discussion of both the prevalence and the outcomes of dyslexia, which is one of the most widespread, if not the most pervasive, cognitive disorder in the world (Chan et al., 2007; Jiménez et al., 2009; Lagae, 2008; Moody et al., 2000; Paulesu et al., 2001; Shaywitz, 1998; Sprenger-Charolles et al., 2011; Wolff & Lundberg, 2002). As Siegel (2006) has argued, the prevalence of dyslexia depends on exactly how dyslexia is defined;

however, within broad parameters, Siegel estimated the global prevalence of dyslexia to be between 5% and 10% (Siegel, 2006).

The same figure was given in a more recent study conducted by Fortes et al. (2016). In an estimate of the prevalence of dyslexia in the UAE, a study concluded that incidence could be as high as 17.6% (Aboudan, Eapen, Bayshak, Al-Mansouri, & Al-Shamsi, 2011). Remarkably, the prevalence estimate of 17.6% was obtained from a sample of United Arab Emirates University students. If the forecast of Aboudan et al. (2011) is accurate, then dyslexia is widespread in the UAE, as the estimate of 17.6% far exceeds Siegel's global estimate of 5 to 10%.

1.2 Purpose of the Study

The purpose of the study is to determine whether mean reading ability scores are significantly lower for (a) readers who have combined RAN and PA deficits as opposed to (b) readers who have either a RAN deficit or a PA deficit and (c) readers who have no deficits. This approach constitutes a test of the DDH among Arabic speakers. Explaining the purpose of the study requires distinguishing between the included independent and dependent variables. The dependent variable of the study is reading performance, and the independent variables are PA and RAN. In their seminal 1993 paper, Bowers and Wolf hypothesized the existence of four groups of readers: (a) No deficit readers, (b) readers with deficits in PA but not RAN, (c) readers with deficits in RAN but not PA, and (d) readers with deficits in PA as well as RAN. Group (d), the double-deficit group, comprises what Bowers and Wolf described as worst readers.

1.3 Research Questions

The research questions of the study are as follows:

- RQ1. *Is the mean reading ability score significantly lower for individuals with a double-deficit than for individuals with RAN-only or PA-only deficits or individuals with no deficit*?
- RQ2. *What is the difference between the RAN-only deficit group and the double-deficit group in the reading ability scores*?
- RQ3. *What is the difference between the PA-only deficit group and the double-deficit group in the reading ability scores*?
- RQ4. *What is the difference between the no-deficit group and the double-deficit group in the reading ability scores*?

The means by which these research questions will be answered have been discussed and justified in the second chapter of the study.

1.4 Theoretical Foundation

The theoretical foundation of the study is the Double-Deficit Hypothesis (Bowers & Wolf, 1993). The DDH, as applied to dyslexia, predicts that individuals with dyslexia will have both phonological and rapid naming skill deficits, because, in Badian's words, "dyslexia results from an overload of deficits in skills" (Badian, 1997). The literature on dyslexia (Bacon, Parmentier, & Barr, 2013; Cutting et al., 2013; Goswami, 2015; Kronschnabel, Brem, Maurer, & Brandeis, 2014; Litt & Nation, 2014; Lobier & Valdois, 2015; Moll, Hasko, Groth, Bartling, & Schulte-Körne, 2016; Ramus, Marshall, Rosen, & van der Lely, 2013; Zoccolotti et al., 2013) suggests that dyslexia is a disorder that transcends narrow deficits; instead, dyslexia emerges from a combination of deficits, which, in turn, supports the inference that double deficits will be more common among individuals with dyslexia.

It should be noted that the DDH is not a universally accepted hypothesis. In an article (Grigorenko, 2001) that appeared seven years after the publication of Bowers and Wolf (1993) seminal proposal of the DDH, Grigorenko, in conducting a review of then-current research, wrote that “A fascinating finding is that the model implicating phonological deficit as central to dyslexia, and the lack of ability to automatize as leading to troubled reading, appears to be universal, regardless of the specific language” (Grigorenko, 2001).

Grigorenko thus championed the hypothesis that it was lack of PA, rather than either weakness in naming skill or weakness in both PA and naming an ability that best characterised individuals with dyslexia. However, scholarly work (Badian, 1997; Nelson, 2015; Norton et al., 2014; Pennington et al., 2001; Steacy, Kirby, Parrila, & Compton, 2014; Torppa, Georgiou, Salmi, Eklund, & Lyytinen, 2012; Torppa et al., 2013; Vaessen et al., 2009; Wolf & Bowers, 1999) appearing both before and after Grigorenko (2001) study suggested that individuals with dyslexia were, in fact, more likely to possess both low PA and low naming skill.

As a theory, the DDH can be considered by Henderikus’s definition of a good theory. According to Henderikus (2010), a good theory “*is normally aimed to offer an explanatory leverage on a problem, describing innovative features of a phenomenon or providing predictive utility*”. The DDH possesses all of these qualities. Regarding dyslexia, the DDH predicts that individuals with dyslexia will be more likely than non-dyslexic individuals (after controlling for variation in intelligence and related cognitive factors) to possess both PA and RAN deficits. The DDH also describes dyslexia in a novel way, regarding these two deficits, and offers a means of understanding dyslexia as the results of universal and correlated deficits, the most serious of which are PA and RAN deficits.

Thus, the DDH has the qualities of a good theory: It is testable, explanatory, and descriptive (Badian, 1997; Nelson, 2015; Norton et al., 2014; Pennington et al., 2001; Steacy et al., 2014; Torppa et al., 2012; Torppa et al., 2013; Vaessen et al., 2009; Wolf & Bowers, 1999). The research questions of the current study have been designed to test the DDH in a manner reminiscent of past testing (Badian, 1997; Nelson, 2015; Norton et al., 2014; Pennington et al., 2001; Steacy et al., 2014; Torppa et al., 2012; Torppa et al., 2013; Vaessen et al., 2009; Wolf & Bowers, 1999).

The DDH can be evaluated in the light of neurological evidence and theories about brain function (Norton et al., 2014). They pointed out that phonological deficits are associated with the left interior frontal lobe and inferior parietal region, whereas naming deficits are associated with the right cerebellar lobule VI. If the double-deficit hypothesis is correct, then, on a neuroanatomical level, individuals with dyslexia ought to have detectable deficits in their left interior frontal lobes, inferior parietal regions, and right cerebellar lobules.

Norton et al. (2014) utilised magnetic resonance imaging (MRI) to confirm that individuals with severe dyslexia were indeed more likely to possess detectable neuroanatomical deficits in their left interior frontal lobes, inferior parietal regions, and right cerebellar lobules. This finding provides some neurological and anatomical support for the verity of the DDH, and, therefore, for the DDH as a theory of dyslexia. In essence, Norton et al. (2014) findings emphasise that dyslexia is a disease that is related to brain function and anatomy and, also, that deficit associated with both phonological processing and rapid naming are core components of dyslexia.

Finally, the DDH is a theory that is limited to developmental dyslexia (Fortes et al., 2016). Dyslexia can also be acquired—for example, through an insult to the brain (Ryan et al., 2015). While there might be functional similarities between developmental dyslexia and acquired dyslexia (or Alexia), the DDH was not developed in these latter contexts and is, therefore, most applicable to a consideration of readers who are developmentally dyslexic. Thus, the theoretical foundation of the study consists of two central insights. The first insight is that the DDH is likely to be more associated with dyslexia because of neuroanatomical as well as empirical evidence that both phonological and rapid naming deficits combine in severe dyslexia. The second insight is that the DDH ought to possess substantial explanatory power in any analysis of reading performance. For these reasons, the DDH is an appropriate theoretical foundation for the study.

1.5 Benefits of the Study

There is a substantial body of empirical work on the applicability of the DDH to individuals with dyslexia and other impaired readers (Badian, 1997; Nelson, 2015; Norton et al., 2014; Pennington et al., 2001; Steacy et al., 2014; Torppa et al., 2012; Torppa et al., 2013; Vaessen et al., 2009; Wolf & Bowers, 1999). However, the most of these reearch studies have been conducted among the individuals who speak mainly English and European languages or languages that are orthographical, phonemically, and in other ways different from Arabic.

These unique features of Arabic mean that conclusions reached from DDH testing among students from non-Arabic speaking populations might not apply to Arabic students. Another overall estimate of dyslexia among Arabs estimated a prevalence of 13% (Elbeheri, Everatt, Reid & Mannai, 2006). If over 17 out of 100 Emiratis are dyslexic, and given that most cases of dyslexia are developmental, a significant proportion of Emirati students is dyslexic and in need of appropriate interventions.

If the DDH is an accurate hypothesis concerning dyslexia, then therapeutic approaches to dyslexia in the UAE and elsewhere need to be guided by the development of interventions to improve both PA and naming skills. Whatever the outcome is, results arising from an empirical test of the DDH in the UAE can guide researchers, practitioners, and policy-makers in crafting a more useful and response approach to dyslexia remediation. The generated results of this study are therefore of high relevance and importance in the context of dyslexia remediation in the UAE and, by extension, anywhere in the Arabic-speaking world. Explicitly, the results could call attention to the need of approaching the pedagogy of literacy in Arabic in a manner that addresses the difficulties posed by Arabic orthography, changing letterforms, and other unique features.

The study's other benefits include the contribution of a novel instruments of Arabic reading skills. Because most dyslexia research has been carried out in the context of English speakers, most devices of reading skill are also based on English. As discussed in greater detail in the literature part of this study, there are relatively few reading instruments in Arabic that are capable of detecting the deficits associated with dyslexia. Thus, one of the contributions of this research is a new Arabic-language reading skill measurement that can be utilised by other researchers.

1.6 Brief Overview of Methods

Descriptive statistics were used in the study with a correlational research design. The scholarly problem was identified in connection with the relationship between two kinds of deficits (RAN and PA) and reading skill. Quantitative methodology is appropriate whenever researchers attempt to model the mathematical relationship between two or more variables (Balnaves & Caputi, 2001; Bernard & Bernard, 2012; Davies & Hughes, 2014). Within quantitative methodology, there are several possible research designs. The design of the research study chosen for this study was correlational. Correlational research designs have been described as follows:

> "*The variables included in the correlational research are isolated and measured by the investigator, but they are characteristics that occur naturally in the subjects…a correlation study consists of establishing a relationship between variations in the X variable to variations in the Y variable*" (Keppel, Saufley, & Tokunaga, 1992).

In this study, the variables of PA, naming skills, and dyslexic qualities or reading skills are naturally occurring and not subject to researcher manipulation or intervention. Because of this aspect of the study, only a correlational design—as opposed to a pseudo-experimental, experimental, or survey-based design—is possible. An analysis of variance (ANOVA) will be applied to determine whether, as predicted by the DDH, the mean reading score for individuals with both RAN and PA deficits is lower than the mean reading scores for individuals with RAN-only or PA-only deficits.

1.7 Literature Review

The review of literature has been divided into five subsections. The first subsection, a historical overview of dyslexia that- provides a chronological context in which current issues relating to dyslexia—including the DDH—can be understood. The second subsection contains an overview of theories related to both dyslexia in general and the DDH in particular. The third subsection contains a discussion of empirical studies on the DDH, sorted into three conceptual categories: studies that support the DDH, studies that do not support the DDH, and studies that offer mixed support for the DDH. The fourth subsection is an overview of gaps in the literature. The fifth subsection is the conclusion of the literature review.

1.7.1 Historical Overview

It is highly likely that dyslexia have existed for centuries, if not millennia. However, the first scientific note of dyslexia was made by (Castles & Friedmann, 2014). In a scholarly article subsequently published in the *British Medical Journal*, Morgan noted his experiences with a 14-year-old patient named Percy, who was of at least ordinary intelligence and capable of conversation, but who had not succeeded in learning how to read as well as his peers (Castles & Friedmann, 2014). Morgan examined several examples of Percy's handwriting and found numerous errors. Some of the errors noted by Morgan were *carefully* for *carefully* and *Percy* for *Percy* (Castles & Friedmann, 2014).

On further examination, Morgan learned that Percy had no trouble in reading numbers. Percy's difficulties were delimited by the reading of words. After these experiences, Morgan believed that he had isolated a new disease, which he termed *congenital word blindness* (Castles & Friedmann, 2014). It is clear that Morgan was describing what subsequently came to be known as developmental dyslexia. At about the same time that Morgan published his results on what would come to be known as developmental dyslexia, Joseph Dejerine (in Graff-Radford, Benarroch, et al., 2014; Turkeltaub et al., 2014) published findings related to Alexia, the loss of reading ability pertaining to insults to the brain. Both the work of Morgan and Dejerine had made significant contributions to an ongoing series of scientific findings related to language and the brain in the nineteenth century (Binder, 2009; Fridriksson, Bonilha, & Rorden, 2007; Meuse & Marquardt, 1985).

In 1861, Paul Broca had discovered the cause of aphasia, a disorder in which individuals who were unable to speak or write could, in fact, comprehend both writing and speech (in Binder, 2009; Fridriksson et al., 2007), giving an impetus to the search for possible neurophysiological substrates or correlates of dyslexia and other disorders. However, Morgan's discovery of so-called congenital word blindness was not based on a physiological discovery, like that of Broca. After Morgan, the history of attempts to understand dyslexia was rooted in a succession of theories, paradigms, and hypotheses designed to identify the underlying cause of dyslexia.

Dyslexia is especially crucial in the context of literacy (Townend & Turner, 2000). The acquisition of literacy is the hallmark of education. However, not all students can achieve the necessary standard of learning required for functional literacy. One definition of functional literacy, the first kind of literacy that schools attempt to impart to students, is the acquisition of formal language skills specific to the student's social context; for example, in a Christocentric society, functional literacy will emphasize reading and writing, whereas, in an oral culture, functional literacy might be satisfied by storytelling (Owen & Pumfrey, 1995).

Dyslexia begins in the brain (Castles & Friedmann, 2014). Castles and Friedman (2014) indicated that at the biological level, the embryonic brain could be affected adversely by such phenomena as viral infections borne by the mother or the absorption of toxins from certain foods or medications. Also, the brain's function will to some extent be determined by genetic factors, and by the nature and kinds of stimuli to which it is exposed, both in the womb and after birth. Thus, the first place to look for the origin of literacy learning difficulties is at the biological level, which long predates a child's exposure to formal schooling or even use of language.

Dyslexia has origins in both biology and cognition. Cermak and Larkin (2001) point to research indicating that damage to the cerebellum, possibly caused by an embryo's exposure to viral infections, directly impacts the ability to read and write: "brain activation was significantly lower for the adults with dyslexia than for the controls in the right cerebellar cortex and the left cingulate gyrus when executing the- pre-learned sequence, and in the right cerebellar cortex when learning the new sequence" (Cernak & Larkin, 2001). Meanwhile, Stanovich (1988) explained that dyslexia could also have cognitive roots; for example, even a brain without a neurological deficit (such as the kind caused by cerebellar damage) can encounter literacy learning difficulties if, for example, it is not adequately exposed to, and trained in, spelling.

There is also a genetic aspect of literacy learning difficulty. Lipsitt and Spiker (1987), conducting a meta-review of studies in this field, concluded that "Specialized brain structures have evolved for the processing of language, and individual differences in the maturation (or functional efficiency) of these structures are likely to be under genetic control" (Lipsitt & Spiker, 1987).

Cognitive-biological literacy learning difficulties pose particular problems for schools and teachers. For example, Townend and Turner (2000) explained that teachers couldnot expect to teach students with dyslexia to read and write in precisely the same way as other students. Students with dyslexia require particular methods of instruction, such as the multisensory approach; e.g., "listening to *The Mayor of Casterbridge* on tape while following the text" (Townend & Turner, 2000).

The literature agrees on the centrality of the multisensory approach in students with dyslexia, but other methods receive attention as well. Brooks (2008) added that students with dyslexia might also require particular instruction in "phonics, pronunciation, enunciation, spelling, syllabification, and read out loud" (Brooks, 2008) to overcome their learning difficulty. Because of the variety of special approaches needed to address the literacy development of this population, students with dyslexia often tend to be taught in separate schools, or, when they attend school with non-dyslexic students, in sheltered conditions. However, this separation does not always take place. Corson and Edwards (1998) explained that children with dyslexia who are cognitively competent have a "strong mental processing fabric" (Corson & Edwards, 1998) and can benefit from being taught in the same environment as non-dyslexic children. Meanwhile, dyslexic children with other cognitive deficits may require a dedicated attention that would be impossible in a traditional classroom.

One way of sorting out students with dyslexia who need particular attention from those who can follow a typical literacy learning track is by means of standardized tests, which, according to Olson, Torrance, and Hildyard (1985), can include the Durrell Analysis of Reading Difficulty and WPPSI and WISC Block Design and Vocabulary subtests.

In Ireland, according to Ott (2007), students below the 10th percentile on tests of basic literacy are flagged for particular attention. This attention consists not only of different pedagogical approaches, such as the multisensory approach, but also of addressing students with dyslexia' "poor co-ordination and concentration, limited social skills and signs of emotional immaturity" (Hartas, 2006), which tend to occur as part of the package of behaviors associated with dyslexia, and must be treated concurrently in order to achieve optimal learning outcomes.

The overcoming literacy learning disabilities in students with biological deficits; therefore, requires a holistic approach, in which pedagogical devices must be complemented by counselling outside the classroom. The academic work on biological deficits in literacy learning also carries some lessons for behaviour in the home, at least for parents who are willing to plan to protect their future children from neurological harm. Shaffer and Krug (1996) explained that "Children born in the summer months spend the greatest change of developing dyslexia. The seasonal pattern may result from the exposure of women in the second trimester of pregnancy to influenza or another viral disease during the late winter" (Shaffer & King, 1996). Thus, would-be parents who wish to take every precaution against dyslexia should consider timing pregnancies accordingly or, at least, taking every precaution against viral disease during pregnancy.

When dyslexia co-occurring with other learning disabilities, it could be extremely difficult even for mental health professionals. To untangle what Blakemore-Brown

(2015) called the tapestry of disorders; for best outcomes, not only teachers and parents but also speech therapists, language therapists, paediatricians, and educational psychologists have to become involved in order to attack every possible angle of the underlying problem.

For the teacher, this information indicates that the classroom is only one arena of combat against literacy learning difficulties; a battery of therapeutic approaches must complement official pedagogy. For the parent, Blakemore-Brown's (2015) key point is that learning disorders that could lead to literacy problems must be detected as early as possible, for example by observing the behaviour of newborn babies and toddlers with special attention to their propensity for eye contact, babbling, and interactive playing. Fortunately, many learning disorders can be addressed, but they must be detected first. The remainder of this literature review consists of a discussion of theories and empirical findings related to the detection and prediction of dyslexia-associated reading difficulties through an analysis of RAN and PA deficits.

1.7.2 Theories of Dyslexia

There have been numerous theories of dyslexia advanced in the 120 years since Morgan's description of developmental dyslexia (Beeson & Insalaco, 1998; Denckla & Cutting, 1999; Shaywitz, 1998). Currently, dyslexia is understood through a combination of biological, environmental, and developmental lenses (Chan et al., 2007; Jiménez et al., 2009; Lagae, 2008; Moody et al., 2000; Paulesu et al., 2001; Shaywitz, 1998; Sprenger-Charolles et al., 2011; Wolff & Lundberg, 2002). In terms of the biological lens, substantial research in neurobiology and related disciplines has made it possible for scientists to isolate the physical correlates of dyslexia.

Cutting et al. (2013) summarised the key research in this area conducted in the past two decades (e.g., Paulesu et al., 2001; Pugh et al., 2000; Richards et al., 1999) as stated:

> "*The neural basis of dyslexia has been found to be associated with structural and functional abnormalities in left posterior perisylvian regions; in particular, functional neuroimaging studies have revealed that DYS is associated with under activation in left occipitotemporal and temporoparietal regions, and over activation in homologous right hemisphere regions as compared to typically developing readers*" (Cutting et al., 2013).

When the intervention is possible, Cutting et al. (2013) pointed out that the physiological explanation of dyslexia has found even more empirical support. There appears to be little divergence from the current consensus view that dyslexia are in fact the result of specific abnormalities in the brain. The open questions in dyslexia theory involve the extent to which genetic, epigenetic, and environmental influences act upon the underlying neurobiological correlates of dyslexia.

Some of the genetic bases of dyslexia have begun to be mapped and understood. Recent research indicates that mutations or other abnormalities in the protein DYX1C1 might be responsible for dyslexia (Tammimies et al., 2012). This research also indicates the impact of epigenetic factors related to estrogenic signalling in the expression of DYX1C1 (Tammimies et al., 2012). However, there is not a scholarly consensus that DYX1C1 variation is responsible for dyslexia (Bellini et al., 2005; Dahdouh et al., 2009; Marino et al., 2005). DCDC2, KIAA0319, and other genetic locations and structures have also been proposed as determinants of dyslexia (Darki, Peyrard-Janvid, et al., 2012). Although work on the genetic and epigenetic determinants of dyslexia is ongoing, there appears to be building evidence that a specific gene or gene cluster is, along with certain epigenetic factors, responsible for the development of dyslexia.

Finally, there is substantial evidence for the role of the environment in the development of dyslexia (Lyytinen et al., 2001; Mascheretti et al., 2013; Morton, 2004; Olson, 2002; van Bergen et al., 2011). Leaving aside the epigenetic influences of the mother's womb, dyslexia is also significantly influenced by the nature of the lived environment. Where there is an emotionally and pedagogically supportive infrastructure, individuals with dyslexia experience better academic, emotional, and professional outcomes (Lyytinen et al., 2001; Mascheretti et al., 2013; Olson, 2002; van Bergen et al., 2011). These findings suggest that environment also has a crucial role to play in the developmental paths and outcomes of dyslexia.

Morton (2004) proposed a causal model of developmental dyslexia that is presented in Figure 1 below. In this model, dyslexia is understood as arising from genes, impacting cognitive processes, and resulting in measurable behavioural outcomes. The biological stage, cognitive level, and behavioural level recognized in Morton's model are all influenced by environmental expressions as well. The DDH can be applied within the context of Morton's model as a descriptor of the specific deficits that are most likely to occur in individuals with dyslexia.

In other words, the DDH makes specific predictions about what differs in the cognitive level of students with dyslexia as compared with non-dyslexic bad readers. In this context, it is interesting to observe that Morton's model only recognizes phonological deficits—and not naming skill deficits—as existing at the cognitive level of dyslexia. The absence of naming skill deficits from Morton's model indicates that, despite the wide acceptance of the DDH, it has not entered into and informed every extant model of dyslexia. Nonetheless, with the presumption that naming skill deficits can be added to the cognitive level of Morton's model, Morton's model is fully compatible with the expression, and aetiology of dyslexia.

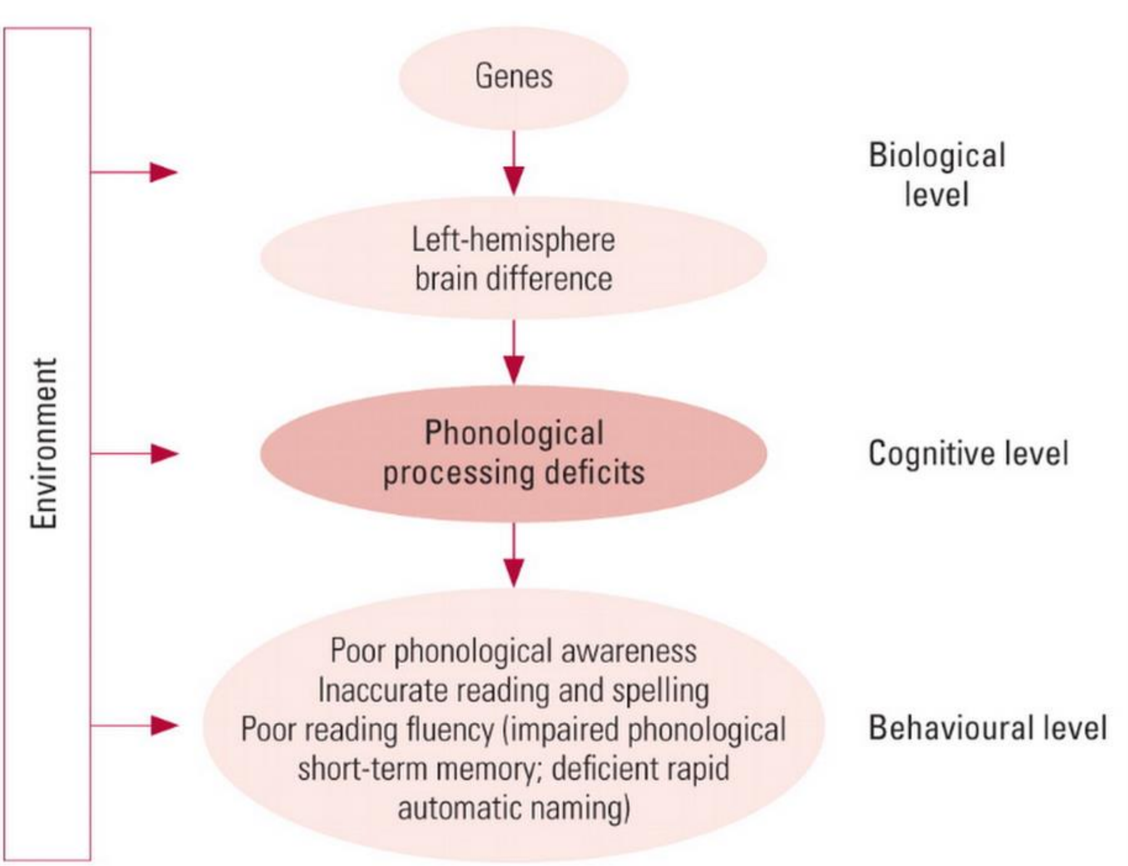

Figure 1: Morton's causal model of dyslexia. Note: Original figure based on Morton's model appearing in (Thambirajah, 2010)

One factor that is not present in Morton's (2004) model of dyslexia, but that still ought to be taken into account, is differences in language. Two studies (Landerl, Wimmer, & Frith, 1997; Ziegler & Goswami, 2005) established that differences in language could exacerbate the expression of dyslexia. For example, in languages—such as English—with a lack of reliable one-to-one consistency between graphemes and phonemes, the proportion of individuals with dyslexia is more prevalent than in languages that possess more consistency between graphemes and phonemes.

The DDH is not a novel theory, but a synthetic theory that draws heavily on earlier work. For example, in 1980, Ehri had argued that word recognition was dependent on a combination of phonological, meaning-based, and orthographic elements (Ehri, 1980). While these other theories were not explicitly named the DDH, they contained the same theoretical claim as the DDH, which is that dyslexia was likely to be characterized by more than merely phonological deficits: Naming skills, orthography, and other factors would also have to be taken into account in a more complex theory of dyslexia. This complex theory, which was termed the DDH (Bowers & Wolf, 1993), was agnostic as to the biological roots of dyslexia, being concerned solely with the functional nature of the deficits occurring among individuals with dyslexia. The DDH and related theories went on to serve as the theoretical foundation for some empirical studies, several of which will be reviewed in the remaining sections of the literature review.

Bowers and Wolf (1993) stated that, according to the DDH, both PA deficits and RAN deficits would make independent contributions to dyslexia. However, in statistical terms (Altman, 1991; Eisenhauer, 2003; Jackson, 2015; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011), there are two ways in which variables such as PA deficits and RAN deficits could make independent contributions to a dependent variable such as dyslexic status. PA deficits and RAN deficits could (a) make independent contributions that are not accretive, that is, whose respective coefficients of determination or other measures of effect size are, when added together in the separate regressions, smaller than the measures of effect size in a multivariate model; or (b) make an accretive contribution, in which the coefficient of determination of a model in which PA deficits and RAN deficits are larger than the separate coefficients of PA-only and RAN-only regressions added together. In case (b), there is an interaction between PA and RAN deficits that, in terms of the resulting reading deficits, is worse than a PA deficit alone or a RAN deficit alone. In case (a), PA and RAN are indeed independent contributors, but their combination is not necessarily worse than their isolated incidence. The research questions of the current study are designed to test version (a) of the DDH.

Finally, the DDH can be considered in light of variations in language. For example, in 1997, Landerl hypothesized that the measured prevalence of dyslexia was a function of a linguistic community's writing system (Landerl et al., 1997), and this hypothesis was further developed by other scholars (Ziegler & Goswami, 2005). These works are worth considering further for their possible contributions to an understanding of reading difficulties in Arabic. In that context, Landerl et al. (1997) main conclusion was as follows:

> "*The high error rates in English and also the kind of errors made suggest that the process of phonological recording may be organized differently for German and English children. This different organization of phonological recording may be triggered by the key orthographic feature distinguishing German and English orthography, namely the difference in the consistency of grapheme-phoneme relations for vowels. We hypothesize that the high consistency of the German grapheme-phoneme relations for single vowels allows the immediate online assembly of syllables.*

> *Therefore, problems of working memory for unconnected phonemes are less likely*" (Landerl et al., 1997).

Similar measures of grapheme-phoneme inconsistency in English and Arabic suggest that Arabic, like English, might exacerbate the prevalence of dyslexia (Abu-Rabia & Siegel, 2002; Saiegh-Haddad & Geva, 2008). Many scholars (e.g., Elbeheri et al., 2006; Sartawi, Al-Hilawani, & Easterbrooks, 1998; Sartawi, Natour, & Smadi, 2014) have argued that the special linguistic characteristics of Arabic language required assessment instruments of their own. This position was supported by El-Ella et al. (2004) with providing their reading test to assess dyslexia among Arabic-speaking schoolchildren.

1.7.3 Overview of Empirical Findings

The overview of empirical findings related to the DDH has been divided into three sections. The first section contains an overview of studies that support the existence of the DDH. The second section contains an overview of studies that do not support of the DDH. The third section contains an overview of studies that provide mixed support for the DDH. The focus of each section is on providing a general overview of studies. However, specific studies have been singled out for discussion as well.

Firstly, the research studies supporting the DDH hypothesis of this study: Perhaps the first truly important empirical study related to the validation of the DDH was that of Wolf and Bowers (1999). By 1999, there was substantial empirical evidence related to the DDH as it applied to individuals with developmental dyslexia; much of this interest likely originated from the earlier work of Bowers and Wolf (1993). Wolf and Bowers utilized a meta-review approach to evaluate the existing evidence and concluded that there was sufficient evidence for the DDH as applied to children with dyslexia.

Wolf and Bowers (1999) were not alone in reaching an early conclusion about the applicability of the DDH to dyslexics. Badian (1997) reached the same conclusion on the basis of a primary research study. In fact, Badian went further, identifying orthography as a third skill that is lacking in individuals with dyslexia: “Most of the poorest readers, nearly all of whom qualified as dyslexic, had a double or triple deficit in phonological, naming-speed, and orthographic skills” (Badian, 1997).

The meta-review conducted by Wolf and Bowers (1999) and the primary study conducted by Badian (1997) constitute important empirical behalf of the applicability of the DDH to children with dyslexia. There are numerous other studies of this kind. A recent and influential study of the predictors and correlates of dyslexia in Arabic-speaking schoolchildren was that of Layes et al. (2015). The stated purpose of Layes et al. (2015) study was to distinguish between dyslexic and non-dyslexic children in terms of three cognitive skills related to reading: (a) Visual attention, (b) RAN, and (c) working memory.

In order to achieve their intended purpose, Layes et al. (2015) carried out two experiments. In the first experiment, both normal readers and readers with dyslexia were given tasks related to literacy, visual attention, and RAN. In this experiment, Layes et al. (2015) compared dyslexic and non-dyslexic students in terms of their performance in terms of visual attention, RAN, and working memory. Next, Layes et al. (2015) determined the extent to which word reading accuracy could be predicted from visual attention and RAN. In the second experiment, Layes et al. (2015) carried out correlations of PA, working memory, word recognition, and reading comprehension as applied to both dyslexic and non-dyslexic students. The results of Layes et al. (2015) first experiment indicated support for the DDH, as readers with dyslexia were found to be inferior to normal readers in terms of both PA and RAN measures.

Abu-Rabia (2007) conducted a study on various measures of reading performance among dyslexic and non-dyslexic Arabic-speaking students in grades three, six, nine, and twelve. This study divided reading measures into i) phonology, ii) morphology (identification), iii) morphology (production), iv) syntax, v) isolated words, vi) spelling, and vii) reading comprehension. For grades three, six, nine, and twelve normal readers were found to exceed readers with dyslexia in all of these measures, at $p < 0.05$. As measured of both PA and RAN were included in Abu-Rabia's study, this study, like that of Layes et al. (2015), can be taken as confirming the DDH among a sample of Arabic-speaking schoolchildren.

Saiegh-Haddad (2005) conducted a study on the correlates of reading fluency in Arabic. Saiegh-Haddad discovered that RAN had a direct and statistically significant effect on reading fluency ($r = 0.36$), as did letter record speed ($r = 0.75$), short-term memory ($r = 0.55$), phoneme isolation in vernacular Arabic ($r = 0.36$), and phoneme isolation in MSA ($r = 0.41$). Saiegh-Haddad also created a pooled variable to represent phoneme isolation in both vernacular Arabic and Modern Standard Arabic (MSA); this pooled variable was also found to have a direct and statistically significant effect on reading fluency ($r = 0.39$).

As such, the study of Saiegh-Haddad also provided support for the DDH. However, the study was limited insofar as i) dyslexia was not treated as a separate category in the sample or accommodated in the data analysis, ii) several key regression outputs were not reported, iii) no validation information for researcher-developed scales was provided, and iv) the absence of simultaneous multivariate regression capable of testing for the independence of the statistical contributions of both PA and RAN deficits to reading fluency; of these limitations the fourth limitation (iv) is the most serious regarding testing the DDH. In the absence of partial correlation or multivariate regression, it is impossible to determine whether the correlational contributions of RAN and PA as measured by Saiegh-Haddad were truly independent.

A study conducted by Heikkila, Torppa, Aro, Narhi, and Ahonen (2015) supports the DDH, which conducted among a sample of Finnish schoolchildren. This study was part of interest because Finnish has a transparent orthography and, in this respect, is markedly different from Arabic. Heikkila and co-authors divided their survey sample into a PA-only group, a RAN-only group, a double-deficit group, and a control group with neither RAN nor PA deficits. They found that both the prevalence and the severity of reading disabilities was indeed higher among the double-deficit group. Moreover, Heikkila and co-authors confirmed that the DDH in a transparent orthography supports the inference that the DDH applies to multiple languages, and not merely to languages that lack a transparent orthography. The work of de Groot, van den Bos, Minnaert, and van den Meulen (2015) was similar to the other relevant studies but the main point of difference was that the study of the De Groot's team tested the DDH concerned with word reading fluency amongst Dutch-speaking schoolchildren. An analysis of variance found that the lowest word reading fluency was found among those children who were in the double-deficit group.

Several relevant studies are cross-sectional. For instance, Steacy et al. (2014) were using longitudinal survey across three the grades (kindergarten, first grade, and second grade) to discover that the DDH exists at all three grade levels, i.e., DDH found in multiple grade levels over time. This finding provides a form of triangulation and amplification of the other studies in support of DDH discussed in this subsection of the literature review. If the DDH were a statistical artefact, it would not be likely to be detected in the same students followed over time. Thus, longitudinal findings produced by Steacy's team did not provide support to the DDH itself but strengthened the results generated from the cross-sectional studies on the DDH.

Likewise, Cronin (2013) conducted a longitudinal survey to test the DDH by tracking the outcomes of the same students across four grade levels to find that the DDH existed across the three grades. Thus, Cronin suggested that the DDH is likely to have predictive power for the same students followed over time. So, the longitudinal survey of both Steacy et al. (2014) and Cronin (2013) could provide a firm support for the existence of the DDH as an intrinsic handicap faced by the students with severe dyslexia.

Secondly, the research studies supporting refuting DDH hypothesis of this study: The findings of Cirino et al. (2005) represent a possible discrepant case. Cirino et al. (thereafter as the Cirino's team) conducted an empirical test of the DDH on college students suffering from reading disabilities of various types including individuals categorised into PA-deficit-only, RAN-deficit-only, combined PA-and-RAN-deficit, and no-deficit groups. Nonetheless, the likelihood that many of the participants were dyslexic, and also the thoroughness of the statistical analyses employed, too make the study of the Cirino's team relevant and also notable because it is one of the relatively few studies that has not confirmed the DDH.

Cirino's team also tested the survey participants in four measures of reading achievement, these are i) Untimed decoding (measured on the WJ-R Letter-Word Identification Scale and the WJ-R Word Attack), ii) timed coding (measured on the TOWRE Sight Word Efficiency and Phonemic Decoding Efficiency scales), iii) untimed comprehension (measured on the WJ-R Passage Comprehension Scale), and iv) timed comprehension (measured on both the standard score and % correct score of the NR Reading Comprehension scale). As part of their first statistical analysis, Cirino's team utilised linear regression to measure the independent contributions of PA and RAN to each of the seven scales in the four categories of reading comprehensions. PA and RAN were found to be significant (at $p < 0.001$) contributors to both measured of untimed decoding (the WJ-R Letter-Word Identification Scale and the WJ-R Word Attack) and both measures of timed decoding (the TOWRE Sight Word Efficiency and Phonemic Decoding Efficiency scales). However, only PA was a significant contributor to untimed comprehension. Both PA and RAN were significant contributors to the ND Reading Comprehension standard score, but only PA was a contributor to the % correct score of the NR Reading Comprehension instrument. Overall, the Cirino's team found that PA had far larger effect sizes (measured as R^2) than RAN in each of the measures but for the TOWRE Sight Word Efficiency measure, for which RAN had the greater effect size.

Next, in order to test the DDH, Cirino's team regressed both PA and RAN on the dependent variables in the seven tasks associated with untimed decoding, timed decoding, untimed comprehension, and timed comprehension; moreover, they presented the mean scores of the double-deficit, single deficit (PA-deficit-only and RAN-deficit-only), and no-deficit groups in the various measures of untimed decoding, timed decoding, untimed comprehension, and timed comprehension. The Cirino's team used the multivariate regressions find that the effect sizes of the combined PA-and-RAN-deficit regressions were lower than the effect sizes of the individual PA and RAN regressions added together.

If the DDH is correct, then one of the statistical inferences that follows is that the combination of PA and RAN ought to have more explanatory power over variation in reading tasks than PA and RAN alone. Had the interaction effect hypothesised under the DDH existed among the participants in the study of the Cirino's team. then, the effect sizes of the joint PA-and-RAN-deficit regressions ought to have been greater than the individual effect sizes of the PA-deficit-only and RAN-deficit-only regressions added together. Thus, the regression results of the Cirino's team did not validate the existence of the DDH nor distinguish between dyslexic and non-dyslexic participants in their study.

The descriptive statistical analysis of the Cirino's team disconfirmed the DDH among their sample; they reported both the mean and standard deviations of each of the seven measures of reading performance in the categories of untimed decoding, timed decoding, untimed comprehension, and timed comprehension. Ideally, the Cirino's team ought to have conducted an analysis of variance (ANOVA) with Tukey's post hoc test, which would have identified the significance of differences in mean untimed decoding, timed decoding, untimed/timed comprehension scores between PA-deficit-only, RAN-deficit-only, combined PA-and-RAN-deficit, and no-deficit groups.

Using the mean and standard deviations only, it is still possible to reach statistically valid inferences about the between-group differences in untimed decoding, timed decoding, untimed comprehension, and timed comprehension. Specifically, it was found that i) the PA-deficit-only and double-deficit groups overlapped in both measures of untimed decoding, ii) the PA-deficit-only, RAN-deficit-only, and double-deficit groups overlapped in both measures of timed decoding, iii) the PA-deficit-only, RAN-deficit-only, and double-deficit groups overlapped in the single measure of untimed comprehension and iv) the PA-deficit-only, RAN-deficit-only, and double-deficit groups overlapped in both measures of timed comprehension. Cumulatively, these findings suggested that the DDH did not possess greater explanatory power over various measures of reading performance that the two single-hypothesis alternatives.

Thirdly, the mixed-support studies: In addition to studies that have either found support or a lack of support for the DDH, there are also studies that have found mixed support for the DDH. Natour, Darawsheh, Sartawi, Marie, and Efthymiou (2016) found that PA alone accounted for a statistically significant and substantial portion of the variation in predicting reading errors. If PA by itself is a significant predictor of reading deficits, then the DDH might be superfluous; however, as Natour et al. (2016) did not included RAN in their model, the study did not unambiguously support or refute the DDH.

Nelson (2015) study also provided mixed support for the DDH. Nelson studied the DDH in terms of various subskills, including word reading, spelling, reading fluency, pseudo-word reading, timed reading comprehension, and untimed reading comprehension. Nelson's statistical analysis discovered that the DDH applied in the subskills of word reading, spelling, and reading fluency. However, lower performance in the subskills of pseudo-word reading, timed reading comprehension, and untimed reading comprehension was not more pronounced in the double-deficit group in comparison to the single-deficit groups. For this reason, Nelson's study provided only mixed support for the DDH.

Abu-Rabia and Abu-Rahmoun (2012) conducted a study on differences in measures of phonological, orthographic, and working memory performance among Arabic speakers who were dyslexic and normal. The larger number of variables in study of Abu-Rabia and Abu-Rahmoun, which generated more precise information relating to the differences between dyslexic and non-dyslexic Arabic-speaking students. In particular, Abu-Rabia and Abu-Rahmoun (2012) distinction between vowelized and unvowelised tests took a key feature of Arabic, the optional diacritic indicators of vowels, into account. Another Arabic-specific adaptation made by Abu-Rabia and Abu-Rahmoun (2012) was to take Arabic roots into account when designing the different conditions. Of the various studies consulted for inclusion in the literature review, Abu-Rabia and Abu-Rahmoun (2012) study appeared to be the one that had made the most numerous and appropriate testing variations to reflect the specific characteristics of Arabic.

Abu-Rabia and Abu-Rahmoun (2012) found that normal reading students outperformed students with dyslexia in vowelized phonology, non-vowelized phonology, un-vowelized orthography, vowelized syntax, un-vowelized syntax, vowelized morphology with undisrupted root, un-vowelized morphology with disrupted root, vowelized morphology with disrupted root, un-vowelized morphology with disrupted root, vowelized reading comprehension, un-vowelized reading comprehension, vowelized word reading, vowelized pseudo-word with real root, un-vowelized pseudo-word with real root, vowelized pseudo-word with false root, un-vowelized pseudo-word with false root, vowelized words that did not fit the context, un-vowelized words that did not fit the context, working memory, spelling, and un-vowelized word reading. The only measure tested by Abu-Rabia and Abu-Rahmoun in which normal readers did not outperform the dyslexic group was that of vowelized orthography. These findings supported the general inference that dyslexia involve a cascade of deficits that cannot be localized to PA deficits, a finding that provides mixed support for the DDH.

One of the recurring themes in studies that find mixed or partial support for the DDH is the use of methods that do not include the grouping of test subjects into double-deficit groups, but the use of statistical methods that measure the contribution of either RAN or PA deficits to some measure of reading skill. Because the results of such studies are conceptually compatible with the DDH, these studies have been described, in this section of the literature review, as providing partial support for the DDH. Another of these studies is that of Wolff (2014).

Wolff tested RAN and PA contributions to different measures of reading skill in order to better isolate the contributions of each deficit. Using a structural equation model (SEM), Wolff found that RAN deficits were associated with slower reading speed whereas PA deficits were associated with poorer reading comprehension and spelling. Theoretically, these results suggest that someone with both RAN and PA deficits would be the worst reader, because such a person would combine deficiencies in reading speed, reading comprehension, and spelling. However, because Wolff did not group the participants of this study into a double-deficit group, the study did not technically support the DDH, although the results of the study certainly appeared to be compatible with the DDH. The same conclusion can be reached about the study of Abu-Rabia and Abu-Rahmoun.

A critical consideration regarding the validity of DDH sub typing has also been introduced by studies on languages like German, Dutch, Italian, and Spanish, which have a consistent orthography. In these languages, grapheme-phoneme correspondence is rather consistent, and as a result, the main difficulty for children with dyslexia is not decoding accuracy but, reading speed (e.g. Landerl, 1997; van Daal & van der Leij, 1999). In line with the results of studies on dyslexia in orthographically consistent languages, Wimmer et al. (2000) found that all three deficit groups showed close to ceiling accuracy for text and word reading, and even non-word reading accuracy was around 90%. For the reading rate, there was a clearer picture of differences. The phonological deficit group exhibited a reliable reading rate deficit for text only and showed no rate deficit at all for non-word reading. In contrast, both the naming deficit and the double-deficit groups exhibited reading rate impairments for text, words, and non-words and differed significantly from both the no-deficit and the phonological deficit group.

Some of the studies considered in this section of the literature review drew upon English, Arabic, Dutch, Italian, Spanish, German and Finish as their base languages. However, there is also a substantial body of empirical literature in Chinese. A meta-analysis conducted by Song, Georgiou, Su, and Hua (2015) surveyed findings related to Chinese reading accuracy and fluency. As a language with a pictographic structure, Chinese is substantially different from the other, alphabet-based languages that are discussed in the research literature. Thus, it is of particular interest to know how RAN and PA deficits function in Chinese.

Song et al. (2015) provided a meta-analysis of 35 studies and reached the conclusions that PA and RAN are very similarly correlated with reading accuracy. However, RAN deficits are more predictive of reading dysfluency in Chinese. As with the findings of Wolff (2014) and Abu Rabia and Abu Rahmoun (2012), the findings of Song et al. (2015) also appear to suggest that the combination of PA and RAN deficits would probably cluster in the worst readers, but their study stopped short of actually testing the DDH.

1.7.4 Gaps in the Literature

The study of Layes et al. (2015) constituted a successful test of the DDH with a population of young (Grade-4 and Grade-5) Arabic-speaking students, a rationale is needed to repeat a DDH test within the same population. Despite its research strengths, Layes et al. (2015) findings also contained weaknesses that can be improved through the application of improved research design and correspond analytical procedures. First, because Layes et al. (2015) used an independent-sample *t*-test approach in which normal readers and readers with dyslexia were contrasted on 24 different measures, their study was vulnerable to Alpha inflation. Alpha inflation takes place when the same inferential test is repeated multiple times (Kopalle & Lehmann, 1997), which is why statisticians prefer to reduce the number of statistical tests (Natrella, 2013). Given the number of separate independent samples *t*-tests conducted by Layes et al. (2015) it is likely that at least one of the tests had a *p* value.

Second, the independent- samples *t* test approach chosen by Layes et al. (2015) meant that measures of PA and RAN were not included simultaneously in any models; they were measured separately. Thus, Layes et al. (2015) findings were unable to measure the distinction between the contributions of PA-deficit-only, RAN-deficit-only, and combined PA-and-RAN-deficit measures in terms of dyslexia. Finally, because Layes et al. (2015) chose a means comparison rather than odds calculation approach, their analysis was not useful in terms of predicting the relationship between the presence of PA and RAN deficits and the presence of a dyslexia diagnosis. Thus, the research design of Layes et al. (2015) can be improved upon.

Another gap in the literature involves the use of regression. Given that the core claim of the DDH is that PA and RAN deficits make independent contributions to reading disfluency, and that regression has been frequently utilized as a means of testing this claim, researchers have omitted to make use of multicollinearity testing within regression to test the independence of PA and RAN deficits. The approach most commonly utilized in those empirical studies drawing on regression is to check the *p* values of PA and RAN independent variables and to consider these variables as making independent contributions if their respective *p* values are below 0.05. However, in linear regression, the recognized means of testing for the independent contribution of more than one independent variable is multicollinearity testing by calculation of the variance inflation factor (VIF) (Mansfield & Helms, 1982). This approach has been recommended and adopted since the end of the 1970s (Mansfield & Helms, 1982). However, none of the empirical studies reviewed in this chapter that utilized regression also reported VIFs or carried out other aspects of multicollinearity testing.

1.8 Conclusion

Dyslexia continues to be a serious problem (Bacon et al., 2013; Cutting et al., 2013; Goswami, 2015; Kronschnabel et al., 2014; Litt & Nation, 2014; Lobier & Valdois, 2015; Moll et al., 2016; Ramus et al., 2013; Zoccolotti et al., 2013). However, dyslexia is not widely studied among Arabic speakers, despite the fact that Arabic has nearly 300 million speakers, making it the fourth-largest language group in the world (Aboudan et al., 2011; Abu-Rabia, 2007; Abu-Rabia & Abu-Rahmoun, 2012; El-Ella et al., 2004). In addition, the prevalence of dyslexia among Arabic speakers is relatively high, a fact that might be attributable to some of the unique features of Arabic Language discussed earlier in this chapter and acknowledged in the literature (Aboudan et al., 2011; Abu-Rabia, 2007; Abu-Rabia & Abu-Rahmoun, 2012; El-Ella et al., 2004). There are therefore many rationales to conduct additional research on dyslexia among Arabic speakers. In this context, the study of the DDH is particularly relevant, given the substantial evidence for the DDH as an underlying factor in dyslexia (Badian, 1997; Cirino et al., 2005; Nelson, 2015; Norton et al., 2014; Pennington et al., 2001; Steacy et al., 2014; Torppa et al., 2012; Torppa et al., 2013; Vaessen et al., 2009; Wolf & Bowers, 1999).

The literature review part consisted of several distinct subsections in which contents and themes can be summarized as follows. The first subsection, a historical overview of dyslexia, provided a chronological context in which current issues relating to dyslexia—including the DDH—can be understood. In this subsection of the literature review, it was established that dyslexia and alexia were first scientifically noted in the late 19th century and that, over time, developmental dyslexia in particular has come to be understand in neurological terms.

The second subsection contained an overview of theories related to both dyslexia in general and the DDH in particular. In this subsection of the literature review, it was established both that the neurological and genetic bases for dyslexia have been isolated, and that the DDH and related theories emphasize the combination of naming skill and PA deficits as important contributors to dyslexia.

The third subsection contained a discussion of empirical studies on the DDH. In this subsection of the literature review, it was established that there is substantial support for the validity of the DDH as applied to children with dyslexia. However, the existence of discrepant studies and studies that offered mixed support for the DDH were also discussed. Overall, there appears to be more support for DDH than against DDH in the older or seminal empirical literature. In terms of Arabic in particular, it was established that i) there is support for the DDH among Arabic speakers, particularly the young Arabic speakers who also constitute the population of the current study; and ii) there is some evidence that the characteristics of Arabic will exacerbate dyslexia among a population of Arabic-speaking schoolchildren. The fourth subsection was an overview of gaps in the literature. In this subsection of the literature review, it was established that the absence of multicollinearity testing, and Alpha inflation are some of the main gaps in the existing literature.

The remainder of the study is structured as follows. The first part of chapter one introduced the problem, research topic, basic orientation of the study. The second part of chapter one introduced the literature review, contains a discussion, critical analysis, and synthesis of both theoretical and empirical findings relevant to the DDH and dyslexia. The second chapter contains a description and defence of the research methodology and design of the study. The third chapter contains the findings of the study. The fourth chapter contains the discussion of the findings of the study. The fifth chapter contains the conclusion of the study, including a relation of the findings of the study to theories and past empirical findings, an acknowledgement of the limitations of the study, recommendations for future practice, recommendations for future research, and a summative conclusion.

Chapter 2: Methods

2.1 Introduction

The purpose of the second chapter of the study is to describe and defend all relevant aspects of the research methodology and design. In order to do so, the chapter has been subdivided into several sections. First, a quantitative research methodology was justified on the basis of the research questions. Second, descriptive statistics was used and a correlational research design was justified based on the design for the study. Third, the population and the sample were discussed. Fourth, the instrumentations and measurements of the study were described. Fifth, threats to reliability and validity—and the steps taken to mitigate these threats—were discussed. Sixth, data collection was discussed. Seventh, data analysis was discussed. Eighth, the possible ethical concerns of the study were described. Finally, a brief conclusion summarized and defended the orientations of the study's methodology.

2.2 Research Methodology

There are three commonly recognized research methodologies: Quantitative, qualitative, and mixed methods (Balnaves & Caputi, 2001; Creswell, 2015; Creswell & Plano Clark, 2011; Davies & Hughes, 2014; McBurney & White, 2011; McNabb, 2010; Trochim, Donnelly, & Arora, 2015; Zikmund, 2003). Quantitative methods are recommended when variables can be measured quantitatively and when the focus of a research question is on the mathematical relationship between objectively defined variables (Balnaves & Caputi, 2001; Berger, 2013; Bernard & Bernard, 2012; Davies & Hughes, 2014; Duffy, 1987). The topic of this study was the double-deficit hypothesis (DDH), and the research questions of the study were as follows:

- RQ1. *Is the mean reading ability score significantly lower for individuals with a double-deficit than for individuals with RAN-only or PA-only deficits or individuals with no deficit*?
- RQ2. *What is the difference between the RAN-only deficit group and the double-deficit group in the reading ability scores*?
- RQ3. *What is the difference between the PA-only deficit group and the double-deficit group in the reading ability scores*?
- RQ4. *What is the difference between the no-deficit group and the double-deficit group in the reading ability scores*?

The research questions of the study could be answered through the comparison of reading scores sorted by the RAN and PA deficits of students.

2.3 Research Design

With the tradition of quantitative methodology, there are four commonly recognized types of designs: Correlational, survey-based, quasi-experimental, and experimental (Balnaves & Caputi, 2001; Berger, 2013; Bernard & Bernard, 2012; Davies & Hughes, 2014; Duffy, 1987). In correlational designs, the variables of interest pre-exist in the population, there is no researcher sorting of subjects into groups, there is no purposive intervention, and the main statistical technique is correlation between the *X* variable(s) and *Y* variable(s) of a study (Keppel, Saufley, & Tokunaga, 1992).

The distinguishing characteristic of a true experiment is the experimenter's ability to isolate the variables of interest and administer the intervention (Balnaves & Caputi, 2001). In a quasi-experiment, also known as a pseudo-experiment, the researcher has limited control, because real-world conditions might prevent the sorting of a sample into treatment and control groups, or because there are other limitations to the design and administration of an intervention (Balnaves & Caputi, 2001). Because the current study did not include an intervention that was designed by the researcher, the study is best described as correlational.

2.4 Population and Sample

The population of the study consisted of third-grade students in regular classrooms in the United Arab Emirates (UAE). Selection of the third-grade students was because they have typically mastered their native language (Kambanaros, Michaelides, & Grohmann, 2015). Therefore, third-grade students are the youngest students among whom testing of the DDH would be reliable, as testing among younger students might result in the mistaking of linguistic immaturity or other unrelated concepts for the presence of a double deficit.

The sample of the study consisted of 615 students aged 8-9 years. They are chosen from one private and four public schools who are readers of standard Arabic in the city of Al Ain. The lowest scoring twenty percent on the Arabic Reading Ability Scale of the sample were selected to undergo further investigation, to test the DDH. This selection was supported by World Health Organization (1995) which indicated that the lowest of the 20% is determined statistically, according to the normal distribution standardization of people around the world.

From this sample, 313 were female and 302 were male students. All of them were native Arabic speakers with no reported history of intellectual, speech, language, or hearing disabilities on file. Four groups were formed; 30 students with a double-deficit group, 8 were female and 22 were male students; 61 students with two single-deficit groups, 20 were female and 41 were male students; and 30 students with a no-deficit group, 8 were male and 22 were female students.

An *a priori* sample size calculation was carried out in order to determine the appropriate sample size for this study. In carrying out this analysis, the first consideration was identifying the kind of inferential statistical test to be applied, as recommended sample sizes vary depending on the kind of test that is chosen (Cohen, 2013). For this study, the choice of inferential statistical test was determined by the main research question of the study, which was as follows: Is the mean reading score significantly lower for individuals with RAN and PA deficits than for individuals with RAN-only or PA-only deficits? In this research question, the dependent variable that of reading score—as measured on the Arabic reading ability designed for this study—was continuous in nature, and the independent variable, group membership, had four possible levels (both RAN and PA deficit, RAN-only deficit, PA-only deficit, and no deficit).

Thus, the research questions could only be answered by comparing the mean reading scores for the four groups of students. When comparing the means for a single dependent variable across an independent variable with more than two levels, the appropriate parametric approach is Analysis of Variance (ANOVA). As noted, ANOVA test had four levels; the level of significance was 0.05, the chosen power was 0.95, and a moderate effect size of 0.25 was chosen. Each of these parameters was recommended by Cohen (2015) as standard inputs for an *a priori* sample size calculation for an ANOVA. G*Power 3.1.5 statistical software (Faul, Erdfelder, Buchner, & Lang, 2009) was utilized to perform the *a priori* sample size calculation. The results, presented in Figure 1 below, indicate that a sample size of 280 was recommended on the basis of the chosen inputs:

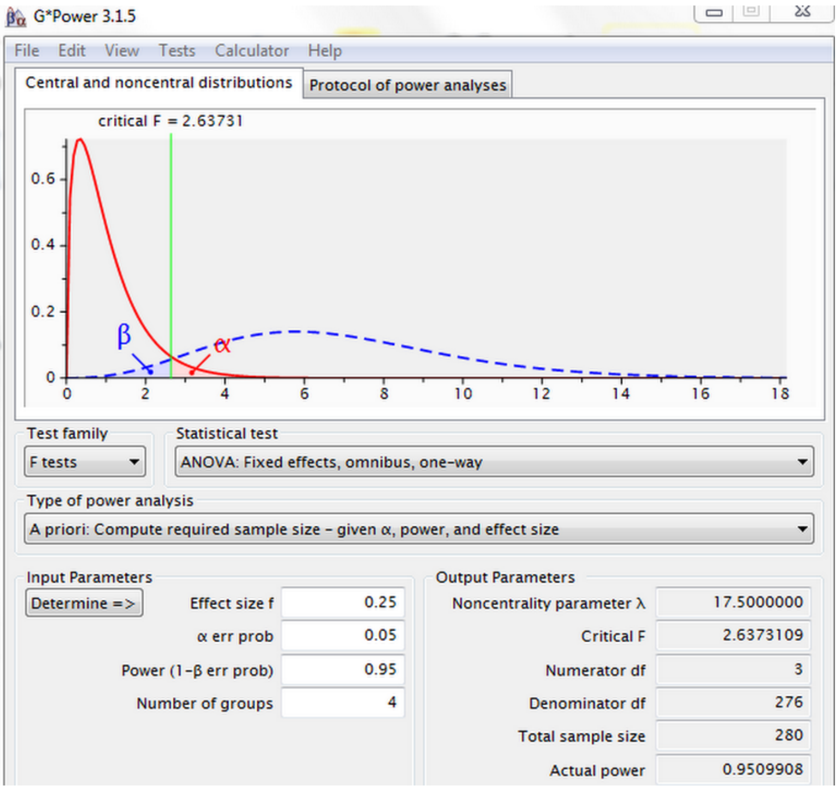

Figure 2: Recommended sample size for the study. Note: original figure generated in G*Power 3.1.15 software

There is a correlation between the sampling size and the sampling error (Bartlett, Kotrlik, & Higgins, 2001). For illustration, the greater the sample size, the smaller the standard error. In other words, the more the sample size, the closer the sample will be to the actual population. Therefore, the sample in this study is much more than 280 students, which will result in more reliable, valid and generalizable results. One of the methodological factors affecting the sample selection in the study is that the targeted population distributed across hundreds of private and public schools in Al-Ain city and the researcher has to cover these schools in order to get to each of the units in the targeted population, which is of course impossible. Accordingly, the researcher used the cluster random sampling.

Therefore, the study's sample size of 615 can be considered more than adequate for the purposes of achieving a 0.25 effect size, a 0.05 level of significance, and a 0.95

power for a four-group ANOVA. In other words, a sample of 615 people has a very high chance of (a) detecting the effect of group membership on reading scores and (b) generalizing beyond the sample of the study. These strengths of the large sample will be augmented by the randomization of the sampling process, which further ensures that study participants will be drawn from a representative cross-section of the population.

2.5 Instrumentation and Measurements

There were three instruments designed for this study: (a) An Arabic reading ability instrument (Appendix A), (b) a PA instrument (Appendix B), and (c) a RAN instrument (Appendix C). These instruments were developed by the researcher because of the absence of equivalent, psychometrically and thematically validated instruments in the Arabic language. This section of the chapter contains a discussion of each of these instruments, whereas the next section contains an overview of the reliability and validity threats associated with each one as well as a discussion of how these threats were overcome.

The Arabic reading ability scale was developed through a review of Arabic-language textbooks utilized for the first through the third grades in the UAE. Material was selected from this grade range in order to reflect the fullest possible range of material that third-grade students are responsible for understanding, including not only grade-specific material but also previously covered material. The Arabic reading ability instrument consisted of 10 questions related to the Arabic alphabet, word / pseudo-word identification and recognition, spelling, fluency, and comprehension ability. The Arabic reading ability scale was scored on a continuous scale with a maximum possible of 50; higher scores represented higher Arabic reading ability, whereas lower scores represented lower Arabic reading ability.

The PA instrument consisted of 10 sections, with each section involving 10 questions and contributing 10% to the total PA scores. The PA instrument contained questions about word discrimination like (رأى، بكى), and the child ought to tell the examiner whether these two words are rhyme or not; rhyme recognition like what word rhyme with (نائم) from the following two words (غائمْ، سامعْ); rhyme production, the child ought to tell the examiner a word that rhyme some words like (قال); syllable blending like (أســ...بو...ع), the examiner says the parts of a word and then the child must say the fragments together fast, syllable segmentation like (شُـكْـراً، شُــكْ...راً), the examiner says the word blocked and the child must break the word into parts; syllable deletion like (أبوظبي بدون أبو), the examiner say a word and the child must leave off one part; phoneme recognition like (نـهر), the examiner says a word and then the child must tell him another word that starts with the same sound, phoneme blending like (طـَ/ بيــ/ ـبٌ), the examiner says the sounds of a word slowly and the child must say the word; phoneme segmentation, the child must show the examiner the sounds in word (عـَلـِـمَ); and phoneme deletion like (نجاح بدون / ن / (جاح), the examiner says a word and leave off one sound. Cumulatively, these 10 skills encompassed the entire construct of PA as it is described in the research literature.

The RAN instrument developed for the study contained four subtests for objects, colours, numbers, and letters. Each of these four RAN subtests contained 50 items and was arranged in five rows of 10 items each. The 5 different token items for each subtest were pseudorandomised, with no item appeared consecutively on same line.

2.5.1 Reliability and Validity

With every research design, instruments chosen for the collection of data must pass the tests of validity and reliability before they can be considered good measures (Dikko, 2016). Validity is the precision in which the findings accurately reflect the data. Reliability, on the other hand, is the consistency of the analytical procedures, including accounting for personal and research method biases that may have influenced the findings (Noble & Smith, 2015).

It is important to be able to specify how reliability and validity for each of the instruments in the study were assured. Reliability and validity will be discussed separately for each of the instruments. Where necessary, special note were made of the means utilized to protect against deficiencies in reliability and validity. A pilot test was carried out in order to measure the specific reliability and validity values.

The construct validity of the PA instrument was measured through a correlation with the RAN instrument. Because the PA and RAN questionnaires measure conceptually distinct skills, it is expected that they will not be highly correlated. In fact, these two scales were not highly correlated with each other in the pilot test, $r = -0.175$, $p = 0.551$.

In terms of the RAN scale, a Cronbach's Alpha test was utilized to test the inter-correlations between the scale items. Cronbach's Alpha calculated for the RAN scale was 0.521, below the cut-off value of 0.7 ordinarily (Creswell, 2015) recommended for this statistic. However, it should be noted that Cronbach's Alpha for the RAN scale was calculated on the basis of results from only 13 students. Even instruments that have a high Cronbach's Alpha can yield a low Cronbach's Alpha when tested on small samples (Creswell, 2015).

The Cronbach's Alpha for RAN is calculated in a post hoc manner. If the Cronbach's Alpha for RAN is still below 0.7, this result will be addressed as a limitation of the study. A Cronbach's Alpha test was also conducted on the speed achieved on the four RAN items. The Cronbach's Alpha of this measure was 0.74, exceeding the cut-off value of 0.7; therefore, the RAN scale was considered reliable in terms of processing speed, even on the basis of a 13-person sample.

Thirty third-grade students participated for assessing the reliability of the instruments used in this study. For the Arabic reading ability scale, an inter-rater reliability assessment was carried out. Two raters were utilized for this assessment. A Pearson correlation analysis indicated an extremely high level of correlation between the two raters' scores, $r = 0.972$, $p < 0.0001$. This analysis indicates that the two raters were in almost perfect agreement with each other vis-à-vis the Arabic reading ability scale. For the RAN, the Pearson correlation was carried out by several raters, not a pair of raters. Nonetheless, the r value for the RAN scores as estimated by any rater was never less than 0.9, $p < 0.001$, when compared to the RAN scores as estimated by other rater. For the PA test, inter-rater reliability was never lower than $r = 0.86$, $p < 0.001$. Cumulatively, the inter-rater reliability analyses established the existence of substantial agreement between raters on the three scales utilized in this study. In conjunction with the other analyses described in this section of the chapter, there appeared to be enough evidence that the scales were methodologically appropriate.

2.6 Data Collection

Data collection for the study were discussed in the context of the correlational procedure. The sequential procedures for the study, and their associated data collection steps, are as follows:

- First, a sample of 615 students was assembled with the assistance of administrators and other managerial personnel at the five schools participating in this study. For illustration, in each school, every third-grade section participated in the study gathered in an appropriate room to complete the Arabic reading ability scale.
- Second, each participating student was directed to do the Arabic reading ability scale. Students were afforded 40 minutes to complete this instrument. Trained undergraduate examiners from the United Arab Emirates University were on hand to monitor and manage the testing process. They distributed the test papers for the participants and they checked that each student has done the test typically according to the exam instructions.
- Third, the data from the Arabic reading ability scale had utilized to form four groups. The outcomes of each student in the sample were tracked in a spreadsheet; each student's Arabic reading ability score was one of the line-items on the spreadsheet.
- Fourth, the PA test was administered individually through the monitoring of trained examiners who managed the testing process. Students needed 40 to 55 minutes to complete. Each child's PA score was recorded on a spreadsheet.
- Fifth, the RAN test was administered individually under monitoring and management of trained examiners. This test, like the PA test took 40 and 55 minutes to complete. Each child's RAN score was recorded on a spreadsheet.
- Sixth, the collected data were entered into SPSS 22 for analysis.

2.7 Data Analysis

In order to answer the research questions, data analysis is determined by the research questions of the study. And the main research question is as follows: Is the mean reading score significantly lower for individuals with RAN and PA deficits than for individuals with RAN-only or PA-only deficits? Because the research questions posited the existence of (a) a continuous dependent variable and (b) more than two levels of a nominal independent variable, it was only subject to data analysis through an ANOVA.

An ANOVA has several assumptions that need to be met for the test to be carried out (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011) . The first assumption of ANOVA is that the chosen independent variable is nominal (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011). In this study, the independent variable is the membership in one of four groups: A double-deficit group, a RAN-deficit group, a PA-deficit group, and a no-deficit group. The next assumption of ANOVA is independence of cases (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011). Because each student in the study will belong to one and only of the four groups, there is independence of cases in the study.

The students will be tested separately. It means also individual answering to all scales or tests used in this study and participants did not interact with each other in any form. Third, ANOVA should possess homogeneity of variances, even though ANOVAs are relatively robust to the heterogeneity of variances (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011).

In chapter three, the Levene Statistic for the one-way ANOVA is calculated and presented, on the understanding that a Levene Statistic whose *p* value is below .05 indicates the possibility of heterogeneity of variance in the ANOVA. Finally, an ANOVA dependent variable should possess a relatively normal distribution (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011). In order to test the normality of the Arabic reading ability scores distribution, both the Shapiro-Wilk and Kolmogorov-Smirnov Statistics were calculated, and results were presented in the third chapter.

There are two further considerations for data analysis in an ANOVA. The first consideration pertains to hypothesis testing and results. The *p* value of an ANOVA allows ANOVA-based null hypotheses to be rejected or fail to be rejected, but this *p* value and the associated results do not indicate which of the levels of the independent variable are significantly greater or less than the other levels of the independent variable with respect to their performance on the mean of a dependent variable (Altman, 1991; Kremelberg, 2010; Moore & McCabe, 2009; Natrella, 2013; Vogt & Johnson, 2011). In this study, there are four groups: A double-deficit group, a RAN-only deficit group, a PA-only deficit group, and a no-deficit group. The research questions of the study imply the following specific comparisons:

- The reading ability score of the RAN-only deficit group is to be compared with the reading ability score of the double-deficit group.
- The reading ability score of the PA-only deficit group is to be compared with the reading ability score of the double-deficit group.
- The reading ability score of the no-deficit group is to be compared with the reading ability score of the double-deficit group.

- The reading ability scores among PA deficit group, RAN deficit group, and no deficit group are to be compared.

In order to carry out these four specific comparisons, Tukey's post hoc test will be carried out after the ANOVA in case the test was statistically significant. The Tukey's post hoc test will provide a *p* value for each of these pair comparisons.

The final consideration in the ANOVA is to determine the sorting of the groups. There are four groups in the study: A double-deficit group, a RAN-only deficit group, a PA-only deficit group, and a no-deficit group. Without the existence of these groups, the ANOVA itself cannot be carried out. Therefore, it is important to be able to specify how the groups themselves were determined. Raw scores on these measures were converted to percentiles in the full sample screened.

- Children with above 50^{th} percentile scores on PA test and taking normal time on RAN test were considered to be as No Deficit (ND).
- Children demonstrating a performance below the 50^{th} percentile on PA, and taking a normal time on RAN performance were considered to have a PAD and children scoring taking a long time on RAN and above the 50th percentile on PA test were considered as NSD.
- Children who performed below the 25th percentile on PA test and taking long time on the performance on the RAN test were identified as having double-deficit.

All data analysis for the study were carried out in the SPSS software programme.

2.8 Ethical Considerations

The study is conducted in accordance with the norms of ethical best practices in research. No data was collected before obtaining institutional approval. Informed consent has been sought from the schools and the parents of the schoolchildren targeted for participation in the study. Information gathered for the study are kept private. None of the information will be disseminated by the researcher. Once the study is complete, all research information will be discarded by the researcher. Student privacy is ensured by using alphanumeric coding to track scores on the three instruments of the study (the Arabic reading ability scale, the RAN measure, and the PA measure). The use of alphanumeric coding ensured that the identity of students cannot be inferred from the raw data of the study.

2.9 Conclusion

The purpose of this chapter was to describe and defend all pertinent facets of the methodology and design of this study. A quantitative, correlational, and ANOVA-based approach was recommended to answer all of the research questions. The findings in chapter three were presented in accordance with the methodological and design approaches articulated in the second chapter of the study.

Chapter 3: Results

3.1 Introduction

The purpose of this chapter was to present the findings of the study. This purpose was achieved by (a) presenting the descriptive statistics of the study, (b) answering the research questions. The research questions were as follows:

- RQ1. *Is the mean reading ability score significantly lower for individuals with a double-deficit than for individuals with Rapid Automatized Naming (RAN)-only or Phonological Awareness (PA)-only deficits or individuals with no deficit*?
- RQ2. *What is the difference between the RAN-only deficit group and the double-deficit group in the reading ability scores*?
- RQ3. *What is the difference between the PA-only deficit group and the double-deficit group in the reading ability scores*?
- RQ4. *What is the difference between the no-deficit group and the double-deficit group in the reading ability scores*?

Descriptive statistics were calculated for RAN deficits, PA deficits, and reading ability scores. The central tendency measured in the study were mean, median, skewness, standard deviation, kurtosis, range (encompassing minimum and maximum values), and quartile values. For purposes of hypothesis testing, the Alpha associated with each research question was 0.05. Many numbers can be used for alpha in theory and in practice, the most commonly used is 0.05. The reason for this is both because agreement shows that this level is appropriate in many cases, and historically, it has been acknowledged as the standard. In addition, measures of effect size were calculated for each research question. All data analyses for the study were conducted in SPSS, version 22.0. Effect size calculations were carried out with the assistance of online software from *Psychometrika* to assist the internally displaced persons (IDPs) (Das, Haldar, Gupta, & Mitra, 2016).

3.2 Student Descriptive Statistics

Data were collected from 121 students, of these 121 students, 75 attended ABZ School, 28 attended G School, and 18 attended N School. The only participants' gender is stated here. There were 50 females and 71 males in the sample. Thirty students were in the double-deficit group, 30 students were in the RAN deficit group, 31 students were in the PA deficit group, and 30 students were in the no-deficit group.

3.2.1 Reading Ability Descriptive Statistics

The reading ability descriptive statistics are presented in Table 1 below. The reading ability assessment was designed to measure the ability of Arabic-speaking schoolchildren to decoding and receptive language skills. The test included measures of alphabet, word recognition, phonics, spelling, passage comprehension, fluency.

Table 1: Reading Ability Descriptive Statistics

	Sample Size	Mean	Standard Deviation	Minimum	Maximum
Entire Sample	131	19.32	10.16	1.5	38
Double-Deficit Group	30	8.77	3.29	1.5	13
RAN Group	30	17.14	2	14	22.60
PA Group	31	15.98	2.76	13	23.30
No-Deficit Group	30	35.50	1.25	34	38

The mean of the reading ability scores of the double-deficit group was lower than the means of the reading ability scores of each of the other three groups. The reading ability scores of the RAN- and PA-deficit groups were comparable. The reading ability scores of the no-deficit group were substantially better than those of the other three groups. In addition, the standard deviation of the double-deficit group was bigger than that in other groups which indicates more variation among students in this group.

3.2.2 Phonological Awareness Descriptive Statistics

The PA descriptive statistics are presented in Table 2 below.

Table 2: PA Descriptive Statistics

Sample Size	Mean	Standard Deviation	Minimum	Maximum
Entire Sample 121	49.62	27.26	0	99
Double-Deficit Group 30	20.63	4.59	7	26
RAN Group 30	59.40	11.25	49	86
PA Group 31	31.74	10.67	0	45
No-Deficit Group 30	87.30	5.63	25	99

Interestingly, the PA scores of the double-deficit group were even lower than the PA scores of the PA-deficit group. Once again, the no-deficit group was significantly better on this measure.

3.2.3 Rapid Automatized Naming Descriptive Statistics

RAN data were collected for four different measures: RAN scores for colours, RAN scores for objects, RAN scores for numbers, RAN scores for letters, time taken for colours, time taken for objects, time taken for numbers, and time taken for letters. For purposes of descriptive statistics, measures of central tendency were obtained for both RAN scores and RAN times. The RAN descriptive statistics are presented in Table 3.

Table 3: RAN Descriptive Statistics, the mean and the standard deviation (Based on Number of RAN Mistakes)

	Double-Deficit Group	RAN Group	PA Group	No-Deficit Group
RAN Colours Mean (SD)	1.47 (2.66)	4.67 (14.42)	1.40 (2.04)	0.47 (0.86)
RAN Colours Range	0-13	0-78	0-7	0-3
RAN Objects Mean (SD)	3.33 (8.93)	1.40 (2.53)	3.37 (5.56)	3.67 (11.44)
RAN Objects Range	0-48	0-9	0-24	0-47
RAN Numbers Mean (SD)	6.77 (12.61)	1.37 (2.02)	2.17 (4.01)	0 (0)
RAN Numbers Range	0-45	0-8	0-21	0-0
RAN Letters Mean (SD)	22.17 (19.13)	5.27 (5.21)	8.20 (11.83)	1.27 (6.75)
RAN Letters Range	0-50	0-15	0-45	0-37

For the RAN deficit group, the mean of RAN Colours mistakes was 4.67 (*SD* = 14.42), the mean of RAN Objects mistakes was 1.40 (*SD* = 2.52), the mean of RAN Numbers mistakes was 1.37 (*SD* = 2.02), and the mean of RAN Letters mistakes was 5.27 (*SD* = 5.21). Note that the discrepancy between RAN Letters mistakes and mistakes in the other RAN tests was much smaller for the RAN deficit group than for the double-deficit group, which supports the inference that dyslexia was both more widespread and more pronounced in the double-deficit group. For the PA deficit group, the mean of RAN Colors mistakes was 1.40 (*SD* = 2.04), the mean of RAN Objects mistakes was 3.37 (*SD* = 5.55), the mean of RAN Numbers mistakes was 2.17 (*SD* = 4.009), and the mean of RAN Letters mistakes was 8.20 (*SD* = 11.83).

Note that the discrepancy between RAN Letters mistakes and mistakes in the other RAN tests was much smaller for the PA deficit group than for the double-deficit group, which supports the inference that dyslexia was both more widespread and more pronounced in the double-deficit group. For the no-deficit group, the mean of RAN Colors mistakes was 0.47 (*SD* = 0.86), the mean of RAN Objects mistakes was 3.67 (*SD* = 11.44), the mean of RAN Numbers mistakes was 0.000 (*SD* = 0.000), and the mean of RAN Letters mistakes was 1.27 (*SD* = 6.75). Note that the discrepancy between RAN Letters mistakes and mistakes in the other RAN tests was much smaller for the no-deficit group than for the double-deficit group that supports the inference that dyslexia was both widespread and more pronounced in the double-deficit group.

Second, descriptive statistics were collected for RAN times. For the double-deficit group, the mean of RAN Colours time was 75.67 (*SD* = 16.08), the mean of RAN Objects time was 91.70 (*SD* = 39.33), the mean of RAN Numbers time was 85.83

(*SD* = 28.47), and the mean of RAN Letters time was 139.47 (*SD* = 50.10). The discrepancy between RAN Letters time and time in the other RAN tests is theoretically predicted, as dyslexia affects letters more so than the other components of RAN testing and would therefore cause participants to take more time on the RAN letters test. Note that skewness for all RAN test times was positive, indicating that, in each case, there were more individuals to the left rather than to the right of the respective RAN time means.

Table 4: RAN Descriptive Statistics, the mean and the standard deviation (Based on RAN Times)

	Double-Deficit Group	RAN Group	PA Group	No-Deficit Group
RAN Colors Mean (SD)	75.67 (16.09)	77.00 (25.97)	52.63 (4.98)	41.97 (6.03)
RAN Colors Range	53-123	2-140	43-61	30-57
RAN Objects Mean (SD)	91.70 (39.33)	84.20 (21.47)	54.90 (12.27)	41.47 (13.27)
RAN Objects Range	48-251	38-130	3-69	0-61
RAN Numbers Mean (SD)	85.83 (28.47)	82.23 (31.64)	51.20 (6.80)	38.97 (9.59)
RAN Numbers Range	49-180	55-210	39-64	28-60
RAN Letters Mean (SD)	139.47 (50.10)	100.77 (34.07)	54.47 (9.10)	42.87 (13.55)
RAN Letters Range	77-270	51-195	40-90	0-71

For the RAN deficit group, the mean of RAN Colours time was 77.00 (*SD* = 25.96), the mean of RAN Objects time was 84.20 (*SD* = 21.47), the mean of RAN Numbers time was 82.23 (*SD* = 31.63), and the mean of RAN Letters time was 100.77 (*SD* = 34.07). Note that the discrepancy between RAN Letters time and time in the other RAN tests was much smaller for the RAN deficit group than for the double-deficit group, which supports the inference that dyslexia was both more widespread and more pronounced in the double-deficit group.

For the PA deficit group, the mean of RAN Colours time was 52.63 (*SD* = 4.97), the mean of RAN Objects time was 54.90 (*SD* = 12.26), the mean of RAN Numbers time was 51.20 (*SD* = 6.80), and the mean of RAN Letters time was 54.47 (*SD* = 9.10). Note that the discrepancy between RAN Letters time and time in the other RAN tests was much smaller for the PA deficit group than for the double-deficit group, which supports the inference that dyslexia was both more widespread and more pronounced in the double-deficit group. In addition, it should be noted that the PA deficit group completed the RAN tasks faster than the RAN deficit group, which is theoretically expected, and which also validates the procedure utilized to sort study participants into the RAN deficit group.

For the no-deficit group, the mean of RAN Colours time was 41.97 (*SD* = 6.02), the mean of RAN Objects time was 41.47 (*SD* = 13.26), the mean of RAN Numbers time was 38.97 (*SD* = 9.58), and the mean of RAN Letters time was 42.87 (*SD* = 13.55). Note that the discrepancy between RAN Letters time and time in the other RAN tests was much smaller for the no-deficit group than for the double-deficit group, which supports the inference that dyslexia was both more widespread and more pronounced in the double-deficit group.

The roles of RAN and PA scores will be discussed further in the assumptions testing that follows at the end of the chapter. With respect to the double-deficit, one point of special interest—and an assumption underlying the separation of the sample into four groups- was that RAN, and PA deficits would be at least as large in the double-deficit group as in the RAN-only and PA-only deficit groups, respectively. An ANOVA procedure provided the means to test this critical assumption of the study.

3.3 Research Questions Answers

3.3.1 RQ1 Answer

Is the mean reading ability score significantly lower for individuals with a double-deficit than for individuals with RAN-only or PA-only deficits or individuals with no deficit?

This question was answered by using one-way analysis of variance (ANOVA) in which the predictor variable was the groups (no-deficit, the double-deficit, the RAN deficit, and the PA deficit) and the dependent variable was the reading ability score.

The results indicated that ANOVA was significant, F (3, 117) = 645.973, $p < 0.001$. Then, this significant result was followed by *post hoc* pairwise comparisons. The results of Tukey's test indicated that there were significant differences between (a) the double-deficit group and the RAN deficit group, (b) the double-deficit group and the PA deficit group, and (c) the double-deficit group and the no-deficit group. The double-deficit group's reading ability was 8.36 points lower than the RAN deficit group, 7.20 points lower than the PA deficit group, and 26.73 points lower than the no-deficit group.

The Cohen's *d* measure of effect size was calculated for these results. In order to calculate Cohen's *d*, it was first necessary to calculate means, standard deviations, and sample sizes for each of the comparison groups. These data have been presented in Table 5 below and were input into IDP's (2016) effect size calculator for Cohen's *d*. Each of the effect sizes was large, indicating that the differences are not merely statistically significant but also practically meaningful.

Table 5: Effect Sizes, RQ1

	No-Deficit	RAN Deficit	PA Deficit	Double Deficit
No-Deficit				
RAN Deficit	*d* = -10.97 (large effect)			
PA Deficit	*d* = -9.05 (large effect)	*d* = -0.48 (large effect)		
Double Deficit	*d* = -10.74 (large effect)	*d* = -3.36 (large effect)	*d* = -2.37 (large effect)	

3.3.2 RQ2 Answer

What is the difference between the RAN-only deficit group and the double-deficit group in the reading ability scores?

This question was answered through the same Tukey's post hoc test applied after ANOVA test. For RQ2, it was noted that the double-deficit group's reading ability was 8.36 points worse than the RAN deficit group, and that this difference was statistically significant at $p < 0.001$. As calculated earlier, the Cohen's *d* effect size of this comparison was -3.36, meaning a large difference (as $d > 0.8$).

3.3.3 RQ3 Answer

What is the difference between the PA-only deficit group and the double-deficit group in the reading ability scores?

This question was answered through the same Tukey's post hoc test applied after ANOVA test. For RQ3, it was noted that the double-deficit group's reading ability was 7.20 points worse than the PA deficit group, and that this difference was statistically significant at $p < 0.001$. As calculated earlier, the Cohen's d effect size of this comparison was -2.37, meaning a large difference (as $d > 0.8$).

3.3.4 RQ4 Answer

What is the difference between the no-deficit group and the double-deficit group in the reading ability scores?

This question was answered through the same Tukey's post hoc test applied after ANOVA test. For RQ4, it was noted that the double-deficit group's reading ability was 26.73 points worse than the no-deficit group, and that this difference was statistically significant at $p < 0.001$. As calculated earlier, the Cohen's d effect size of this comparison was -10.74, meaning a large difference (as $d > 0.8$).

3.4 PA and RAN Difference

The purpose of this section of the chapter is to explore the PA and RAN differences among the four groups in the study. A secondary purpose is to determine how well the double-deficit performed in PA and RAN measures when compared against the remainder of the sample. The first step in the analysis was to conduct an ANOVA, the results of which are presented in Table 6 below. As mentioned earlier, RAN test has two types of measures; the number of mistakes and the length of time as well as each of them has four subscales while PA test has only one total score.

Table 6: ANOVA, Group Comparisons by RAN and PA Measures

		Sum of Squares	df	Mean Square	F	Sig.
PA Score	Between Groups	80578.110	3	26859.370	364.632	0.000
	Within Groups	8618.402	117	73.662		
	Total	89196.512	120			
RAN Colors (Mistakes)	Between Groups	303.200	3	101.067	1.837	0.144
	Within Groups	6380.800	116	55.007		
	Total	6684.000	119			
RAN Objects (Mistakes)	Between Groups	97.092	3	32.364	0.522	0.668
	Within Groups	7191.500	116	61.996		
	Total	7288.592	119			
RAN Numbers (Mistakes)	Between Groups	774.825	3	258.275	5.763	0.001
	Within Groups	5198.500	116	44.815		
	Total	5973.325	119			
RAN Letters (Mistakes)	Between Groups	7426.225	3	2475.408	17.108	0.000
	Within Groups	16784.700	116	144.696		
	Total	24210.925	119			
RAN Colors (Time)	Between Groups	27021.367	3	9007.122	36.240	0.000
	Within Groups	28830.600	116	248.540		
	Total	55851.967	119			
RAN Objects (Time)	Between Groups	50992.200	3	16997.400	29.124	0.000
	Within Groups	67701.267	116	583.632		
	Total	118693.467	119			
RAN Numbers (Time)	Between Groups	47952.292	3	15984.097	32.791	0.000
	Within Groups	56545.300	116	487.459		
	Total	104497.592	119			
RAN Letters (Time)	Between Groups	177636.825	3	59212.275	60.154	0.000
	Within Groups	114183.767	116	984.343		
	Total	291820.592	119			

Seven out of nine ANOVAs were statistically significant; particularly, found that:

- There was a significant difference in PA score between the four groups, $F(3, 117) = 364.63$, $p < 0.001$.

- There was a significant difference in RAN Numbers (mistakes) between the four groups, F (3, 116) = 5.76, p = 0.001.
- There was a significant difference in RAN Letters (mistakes) score between the four groups, F (3, 117) = 17.11, p < 0.001.
- There was a significant difference in RAN Colours (time) between the four groups, F (3, 117) = 36.24, p < 0.001.
- There was a significant difference in RAN Objects (time) between the four groups, F (3, 116) = 29.13, p < 0.001.
- There was a significant difference in RAN Numbers (time) between the four groups, F (3, 116) = 32.79, p < 0.001.
- There was a significant difference in RAN Letters (time) between the four groups, F (3, 116) = 60.15, p < 0.001.

Conducted on PA Score, Tukey's post hoc test revealed two points of interest. First, the double-deficit group did significantly worse on PA than every other group, including the PA deficit group. Second, the PA deficit group did significantly worse on PA than the RAN deficit and no-deficit groups. Thus, the study was well-designed in terms of distinguishing the PA deficit group from the RAN deficit group, and the study found evidence that individuals with double-deficits have significantly worse PA than individuals who have PA deficits but not RAN deficits. This finding is important in its own right and has been discussed in greater detail in the fourth chapter of the study.

Table 7: Tukey's Results, PA Differences

Multiple Comparisons						
Dependent Variable: PA Score Tukey HSD						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Double Deficit Group	RAN Deficit Group	-38.767*	2.216	0.000	-44.54	-32.99
	PA Deficit Group	-11.109*	2.198	0.000	-16.84	-5.38
	No Deficit Group	-66.667*	2.216	0.000	-72.44	-60.89
RAN Deficit Group	Double Deficit Group	38.767*	2.216	0.000	32.99	44.54
	PA Deficit Group	27.658*	2.198	0.000	21.93	33.39
	No Deficit Group	-27.900*	2.216	0.000	-33.68	-22.12
PA Deficit Group	Double Deficit Group	11.109*	2.198	0.000	5.38	16.84
	RAN Deficit Group	-27.658*	2.198	0.000	-33.39	-21.93
	No Deficit Group	-55.558*	2.198	0.000	-61.29	-49.83
No Deficit Group	Double Deficit Group	66.667*	2.216	0.000	60.89	72.44
	RAN Deficit Group	27.900*	2.216	0.000	22.12	33.68
	PA Deficit Group	55.558*	2.198	0.000	49.83	61.29

*. The mean difference is significant at the 0.05 level.

Next, Tukey's post hoc analyses were conducted on two of the six RAN measures that the ANOVA found to be significant. The Tukey's test appearing in Table 8 indicates that the double-deficit group had significantly more mistakes for RAN Numbers and RAN Letters than any of the other groups.

Table 8: Tukey's Results, RAN Numbers (Mistakes) and Letters (Mistakes) differences

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
RAN Numbers	Double Deficit Group	RAN Deficit Group	5.400*	1.728	0.012	0.89	9.91
		PA Deficit Group	4.600*	1.728	0.043	0.09	9.11
		No Deficit Group	6.767*	1.728	0.001	2.26	11.27
	RAN Deficit Group	Double Deficit Group	-5.400*	1.728	0.012	-9.91	-0.89
		PA Deficit Group	-0.800	1.728	0.967	-5.31	3.71
		No Deficit Group	1.367	1.728	0.859	-3.14	5.87
	PA Deficit Group	Double Deficit Group	-4.600*	1.728	0.043	-9.11	-0.09
		RAN Deficit Group	0.800	1.728	0.967	-3.71	5.31
		No Deficit Group	2.167	1.728	0.594	-2.34	6.67
	No Deficit Group	Double Deficit Group	-6.767*	1.728	0.001	-11.27	-2.26
		RAN Deficit Group	-1.367	1.728	0.859	-5.87	3.14
		PA Deficit Group	-2.167	1.728	0.594	-6.67	2.34
RAN Letters	Double Deficit Group	RAN Deficit Group	16.900*	3.106	0.000	8.80	25.00
		PA Deficit Group	13.967*	3.106	0.000	5.87	22.06
		No Deficit Group	20.900*	3.106	0.000	12.80	29.00
	RAN Deficit Group	Double Deficit Group	-16.900*	3.106	0.000	-25.00	-8.80
		PA Deficit Group	-2.933	3.106	0.781	-11.03	5.16
		No Deficit Group	4.000	3.106	0.572	-4.10	12.10
	PA Deficit Group	Double Deficit Group	-13.967*	3.106	0.000	-22.06	-5.87
		RAN Deficit Group	2.933	3.106	0.781	-5.16	11.03
		No Deficit Group	6.933	3.106	0.121	-1.16	15.03
	No Deficit Group	Double Deficit Group	-20.900*	3.106	0.000	-29.00	-12.80
		RAN Deficit Group	-4.000	3.106	0.572	-12.10	4.10
		PA Deficit Group	-6.933	3.106	0.121	-15.03	1.16

*. The mean difference is significant at the 0.05 level.

In terms of the time taken for the RAN tests, it was found that the double-deficit group was significantly slower than the PA and no-deficit groups for RAN Colours, RAN Objects, and RAN Numbers. The double-deficit group was significantly slower than each of the three other groups in the time taken for RAN Letters.

Table 9: Tukey's Results, RAN Time Differences

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Group	(J) Group	Mean Difference	Std. Error	Sig.	95% C.I. Lower	95% C.I. Upper
RAN Colors (Time)	Double Deficit Group	RAN Deficit Group	-1.333	4.071	0.988	-11.94	9.28
		PA Deficit Group	23.033*	4.071	0.000	12.42	33.64
		No Deficit Group	33.700*	4.071	0.000	23.09	44.31
	RAN Deficit Group	Double Deficit Group	1.333	4.071	0.988	-9.28	11.94
		PA Deficit Group	24.367*	4.071	0.000	13.76	34.98
		No Deficit Group	35.033*	4.071	0.000	24.42	45.64
	PA Deficit Group	Double Deficit Group	-23.033*	4.071	0.000	-33.64	-12.42
		RAN Deficit Group	-24.367*	4.071	0.000	-34.98	-13.76
		No Deficit Group	10.667*	4.071	0.048	0.06	21.28
	No Deficit Group	Double Deficit Group	-33.700*	4.071	0.000	-44.31	-23.09
		RAN Deficit Group	-35.033*	4.071	0.000	-45.64	-24.42
		PA Deficit Group	-10.667*	4.071	0.048	-21.28	-0.06
RAN Objects (Time)	Double Deficit Group	RAN Deficit Group	7.500	6.238	0.627	-8.76	23.76
		PA Deficit Group	36.800*	6.238	0.000	20.54	53.06
		No Deficit Group	50.233*	6.238	0.000	33.97	66.49
	RAN Deficit Group	Double Deficit Group	-7.500	6.238	0.627	-23.76	8.76
		PA Deficit Group	29.300*	6.238	0.000	13.04	45.56
		No Deficit Group	42.733*	6.238	0.000	26.47	58.99
	PA Deficit Group	Double Deficit Group	-36.800*	6.238	0.000	-53.06	-20.54
		RAN Deficit Group	-29.300*	6.238	0.000	-45.56	-13.04
		No Deficit Group	13.433	6.238	0.143	-2.83	29.69
	No Deficit Group	Double Deficit Group	-50.233*	6.238	0.000	-66.49	-33.97
		RAN Deficit Group	-42.733*	6.238	0.000	-58.99	-26.47
		PA Deficit Group	-13.433	6.238	0.143	-29.69	2.83
RAN Numbers (Time)	Double Deficit Group	RAN Deficit Group	3.600	5.701	0.922	-11.26	18.46
		PA Deficit Group	34.633*	5.701	0.000	19.77	49.49
		No Deficit Group	46.867*	5.701	0.000	32.01	61.73
	RAN Deficit Group	Double Deficit Group	-3.600	5.701	0.922	-18.46	11.26
		PA Deficit Group	31.033*	5.701	0.000	16.17	45.89
		No Deficit Group	43.267*	5.701	0.000	28.41	58.13
	PA Deficit Group	Double Deficit Group	-34.633*	5.701	0.000	-49.49	-19.77
		RAN Deficit Group	-31.033*	5.701	0.000	-45.89	-16.17
		No Deficit Group	12.233	5.701	0.145	-2.63	27.09
	No Deficit Group	Double Deficit Group	-46.867*	5.701	0.000	-61.73	-32.01
		RAN Deficit Group	-43.267*	5.701	0.000	-58.13	-28.41
		PA Deficit Group	-12.233	5.701	0.145	-27.09	2.63
RAN Letters (Time)	Double Deficit Group	RAN Deficit Group	38.700*	8.101	0.000	17.58	59.82
		PA Deficit Group	85.000*	8.101	0.000	63.88	106.12
		No Deficit Group	96.600*	8.101	0.000	75.48	117.72
	RAN Deficit Group	Double Deficit Group	-38.700*	8.101	0.000	-59.82	-17.58
		PA Deficit Group	46.300*	8.101	0.000	25.18	67.42
		No Deficit Group	57.900*	8.101	0.000	36.78	79.02
	PA Deficit Group	Double Deficit Group	-85.000*	8.101	0.000	-106.12	-63.88
		RAN Deficit Group	-46.300*	8.101	0.000	-67.42	-25.18
		No Deficit Group	11.600	8.101	0.482	-9.52	32.72
	No Deficit Group	Double Deficit Group	-96.600*	8.101	0.000	-117.72	-75.48
		RAN Deficit Group	-57.900*	8.101	0.000	-79.02	-36.78
		PA Deficit Group	-11.600	8.101	0.482	-32.72	9.52

*. The mean difference is significant at the 0.05 level.

3.5 Summary of Findings

The main findings of the study were as follows, presented in order of the research questions of the study.

1) The first research question was as follows: Is the mean reading ability score significantly lower for individuals with a double-deficit than for individuals with RAN-only or PA-only deficits or individuals with no deficit? It was found that the double-deficit group's reading ability was significantly worse than that of all of the other groups.

2) The second research question was as follows: What is the difference between the RAN-only deficit group and the double-deficit group in the reading ability scores? The double-deficit group's reading ability was significantly worse than the RAN deficit group

3) The third research question was as follows: What is the difference between the PA-only deficit group and the double-deficit group in the reading ability scores? The double-deficit group's reading ability was significantly worse than the PA deficit group.

4) The fourth research question was as follows: What is the difference between the no-deficit group and the double-deficit group in the reading ability scores? The double-deficit group's reading ability was significantly worse than the no-deficit group.

Chapter 4: Discussion

The specific focus of the study was on the double-deficit hypothesis as applied to a sample of third-grade Arabic-speaking students in the UAE. The double-deficit hypothesis (Aboudan, Eapen, Bayshak, Al-Mansouri, & Al-Shamsi, 2011; Badian, 1997; Castles & Friedmann, 2014; Denckla & Cutting, 1999; Ehri, 1980; Landerl, Wimmer, & Frith, 1997; Mannai & Everatt, 2005; Moody et al., 2000; Pennington, Cardoso-Martins, Green, & Lefly, 2001; Ramus, Marshall, Rosen, & van der Lely, 2013; Siegel, 2006; Steacy, Kirby, Parrila, & Compton, 2014; Thambirajah, 2010; Torppa et al., 2013; Vaessen, Gerretsen, & Blomert, 2009) is the claim that individuals who have both RAN and PA deficits will be worse readers than (a) those readers who have RAN deficits only, (b) those readers who have PA deficits only, and (c) those readers who have neither RAN deficits nor PA deficits.

There is theoretical support for the existence of the double-deficit effect. In Morton's (2004) model, PA deficits are considered cognitive, whereas RAN deficits are considered behaviour. Thus, in Morton's theory, an individual with a double deficit would be more likely to have a higher intensity of dyslexia, given the combination of a cognitive and a behavioural deficit. Cutting et al. (2013) review of neuroimaging data established that individuals with the most severe dyslexia have detectable deficits in areas associated with both PA and RAN in the brain. Thus, the theoretical support for the double-deficit hypothesis is also neuroanatomical in nature.

Another means of testing the double-deficit hypothesis involves measuring reading abilities across numerous groups, typically (a) those readers with a double deficit, (b) those readers who have RAN deficits only, (c) those readers who have PA deficits only, and (d) those readers who have neither RAN deficits nor PA deficits. Using statistical techniques such as analysis of variance (ANOVA), it is possible to determine whether, as predicted by the double-deficit hypothesis, individuals who have the double deficit are worse than all other groups of readers.

The main finding of the dissertation was that, in fact, individuals with double deficits have lower reading abilities in Arabic. Specifically, it was found that the double-deficit group's reading ability was 8.36 points lower than the RAN deficit group (Cohen's d = -3.36, 95% confidence interval = -4.14 to -2.57), 7.20 points worse than the PA deficit group (Cohen's d = -2.37, 95% confidence interval = -3.03 to -1.71), 26.73 points lower than the no-deficit group (Cohen's d = -10.73, 95% confidence interval = -12.72 to -8.75), and that each of these pairwise differences was statistically significant at $p < 0.001$. These findings confirmed the double-deficit hypothesis with respect to the sample of the study, consisting of third-grade Arabic readers from UAE.

The findings of the study added to the body of existing empirical findings (Abu-Rabia, 2007; Badian, 1997; Cronin, 2013; de Groot et al., 2015; Heikkila et al., 2015; Layes et al., 2015; Saiegh-Haddad, 2005; Steacy et al., 2014; Wolf & Bowers, 1999) that provided unqualified support for the double-deficit hypothesis. The findings contradicted the results of Cirino et al. (2005), because Cirino et al. (2005) study refuted the double-deficit hypothesis and the current study confirmed the double-deficit hypothesis.

This study did not only confirm existing findings but also added to the body of knowledge on the double-deficit hypothesis. First, the findings included the effect sizes of group membership on reading ability, adding a measure of quantification of the double-deficit hypothesis that does not exist in the recent and seminal literature

(Abu-Rabia, 2007; Badian, 1997; Cronin, 2013; de Groot et al., 2015; Heikkila et al., 2015; Layes et al., 2015; Saiegh-Haddad, 2005; Steacy et al., 2014; Wolf & Bowers, 1999) in support of the double-deficit hypothesis. The Cohen's *d* effect sizes were reported in chapter three and also repeated at the beginning of chapter four.

Second, the findings included insights from Tukey's post hoc tests that were able to quantify group-by-group differences. This approach has not been followed in previous studies (Abu-Rabia, 2007; Badian, 1997; Cronin, 2013; de Groot et al., 2015; Heikkila et al., 2015; Layes et al., 2015; Saiegh-Haddad, 2005; Steacy et al., 2014; Wolf & Bowers, 1999) in support of the double-deficit hypothesis. The use of Tukey's posts *hoc* test meant that the study's findings were more reliable than previous findings in which neither covariate impacts, nor specific between-groups differences were quantified by researchers (Abu-Rabia, 2007; Badian, 1997; Cronin, 2013; de Groot et al., 2015; Heikkila et al., 2015; Layes et al., 2015; Saiegh-Haddad, 2005; Steacy et al., 2014; Wolf & Bowers, 1999) who otherwise found support for the double-deficit hypothesis.

Third, the findings added to the relatively small empirical knowledge base on the double deficit in Arabic (Abu-Rabia, 2007; Abu-Rabia & Abu-Rahmoun, 2012; Layes et al., 2015; Natour et al., 2016; Saiegh-Haddad, 2005). The study triangulated three previous (Abu-Rabia, 2007; Layes et al., 2015; Saiegh-Haddad, 2005) confirmations of the double-deficit hypothesis in Arabic. Some of the specific findings of these studies, in relation to the current study, are presented below; because these studies were also carried out among Arabic-speaking schoolchildren, their results are particularly relevant to the results of the current study as presented earlier in the fourth chapter.

Layes et al. (2015) created a sub-sample of 108 normal readers and 23 readers with dyslexia. The intelligence of the normal readings and readers with dyslexia was adjusted to be statistically insignificant, on the basis of an application of the Coloured Progressive Matrices to each group. The members of both the case and control group of the first experiment were drawn from the 4th and 5th grades. After an administration of the appropriate instruments, Layes et al. (2015) compared the normal and readers with dyslexia in three clustered measures: (a) Reading word accuracy, (b) reading word speed, and (c) cognitive skills. Using independent samples *t*-tests to calculate both a *t* and *p* value, and Cohen's *d* as a measure of effect size, Layes et al. (2015) discovered the existence of substantial differences between the normal reading group and the readers with dyslexia.

The normal reading group was found, at $p < 0.01$, to outperform the dyslexic reading group in every measure of reading accuracy: Total words ($t = 14.59$, $p < 0.001$, Cohen's $d = 2.55$); frequent simple words ($t = 8.28$, $p < 0.001$, Cohen's $d = 1.45$); frequent complex words ($t = 10.33$, $p < 0.001$, Cohen's $d = 1.81$); infrequent simple words ($t = 2.45$, $p < 0.01$, Cohen's $d = 0.42$); infrequent complex words ($t = 4.22$, $p < 0.001$, Cohen's $d = 0.74$); and pseudo-words ($t = 7.05$, $p < 0.001$, Cohen's $d = 1.23$). As reading accuracy is a measure of PA, these results indicated that the students with dyslexia in Layes et al. (2015) study had substantially less PA than the normal reading group, and this finding was confirmed in the current study. Layes et al. (2015) hypothesized that the scope of the discrepancies between the normal readers and the readers with dyslexia was exacerbated by the special features of the Arabic language—in particular, Arabic's non-transparent nature—that render reading difficult. This aspect of Layes et al. (2015) finding was also hypothesized to be correct in the context of the current study.

Abu-Rabia (2007) conducted a study on various measures of reading performance among dyslexic and non-dyslexic Arabic-speaking students in grades three, six, nine, and twelve. This study divided reading measures into (a) phonology; (b) morphology (identification); (c) morphology (production); (d) syntax; (e) isolated words, (f) spelling, and (g) reading comprehension. For grades 3, 6, 9, and 12 normal readers were found to exceed readers with dyslexia in all of these measures, at $p < 0.05$. As measures of both PA and RAN were included in Abu-Rabia's study, this study, like that of Layes et al. (2015), can be taken as confirming the DDH among a sample of Arabic-speaking schoolchildren. Abu-Rabia's (2007) findings were also confirmed in the current study.

Saiegh-Haddad (2005) conducted a study on the correlates of reading fluency in Arabic. This study was notable for its testing of the triple-deficit hypothesis, as, in addition to tests of PA (based in phoneme discrimination and phoneme isolation) and RAN, Saiegh-Haddad (2005) also testing for letter recoding speed, an orthographic skill. Saiegh-Haddad (2005) also tested for short-term working memory. In addition, Saiegh-Haddad's study was particularly relevant to Arabic diglossia, as the study was conducted on both spoken vernacular and MSA. Saiegh-Haddad (2005) study was carried out with a sample of 42 first-grade students from an Arab village in Palestine; these participants all spoke the same vernacular variant of Arabic. Despite its applicability as a test of the DDH, Saiegh-Haddad (2005) study was neither delimited to students with dyslexia nor distinguished between dyslexic and non-dyslexic students in its data analysis. These features of Saiegh-Haddad (2005) study were duplicated in the methodology of the current study.

Saiegh-Haddad (2005) discovered that RAN had a direct and statistically significant effect on reading fluency (r = 0.36), as did letter record speed (r = 0.75), short-term memory (r = 0.55), phoneme isolation in vernacular Arabic (r = 0.36), and phoneme isolation in MSA (r = 0.41). Saiegh-Haddad (2005) also created a pooled variable to represent phoneme isolation in both vernacular Arabic and MSA; this pooled variable was also found to have a direct and statistically significant effect on reading fluency (r = 0.39). As such, Saiegh-Haddad (2005) study provided support for both the DDH and the triple-deficit hypothesis. Saiegh-Haddad (2005) support for the DDH was confirmed in the current study. Like Layes et al. (2015); Saiegh-Haddad (2005) hypothesized that double-deficit students would have a particularly difficult time in the context of Arabic's non-transparent orthography, a hypothesis that was also upheld in the current study.

In addition, the current study contributed two novel statistical approaches; Tukey's post hoc tests, and effect size calculation to rule out demographic effects, which were not employed in previous confirmations of the double-deficit in Arabic. Thus, the study provided not only a confirmation of past findings but also a methodological expansion; because of the steps taken in the dissertation, the findings are likely to be more reliable than those obtained in past studies of the double-deficit hypothesis in Arabic. Ultimately, the findings of the study confirmed the existence of the DDH among a sample of Arabic schoolchildren and provided measures of the magnitude of the DDH—in terms of effect size—that do not appear to have been calculated before.

Chapter 5: Conclusion

5.1 Implications of the Study

The main implication of the study is that additional work needs to be done to support Arabic schoolchildren who have a double deficit. The validity of the double-deficit hypothesis suggests that schoolchildren with both RAN and PA deficits are likely to be dyslexic or, if not dyslexic, to fall into the category of the lowest-performing readers. This group of readers needs added support in order to overcome their deficits. While dyslexia cannot be cured per se, there are cases in which dyslexics have been able to reduce—and, in some cases, actually eliminate—their symptoms (Badian, 1997; Castles & Friedmann, 2014; Denckla & Cutting, 1999; Kline, 1978; Mugnaini, Lassi, La Malfa, & Albertini, 2009; Olson, 2002; Paulesu et al., 2001; Thambirajah, 2010; Wolf & Bowers, 1999; Wolff & Lundberg, 2002). If children with dyslexia with double deficits are given additional support, they might be more likely to experience reduced dyslexia symptoms or impairments over time.

For such an educational policy to be applied, however, schools need a simple and reliable way of identifying students who are more at risk. One of the contributions of this dissertation was the design of an Arabic-language reading ability scale, as well as PA and RAN measures, which can be utilized by schools to (a) identify students with a double-deficit and (b) quantify the impact of a double deficit on reading performance. Using such materials, schools in Arabic-speaking countries ought to attempt early detections of, and interventions against, dyslexia, with initial efforts focused on attending to the needs of students with double deficits. The findings of the study can be discussed in light of theories as well as part empirical findings related to the double-deficit hypothesis. The study was grounded in previous studies, discussed exhaustively in chapter one, that found an objective basis for the existing of reading disorder, which is also known as dyslexia. The findings of the study confirmed that, among any sufficiently large sample of readers, some will have pronounced difficulty in reading; this finding was predicted by nearly all of the literature reviewed in the first chapter of the study.

5.2 Limitations of the Study

The study had some limitations. One of the limitations of the study was that reading ability was measured as a single index variable rather than through numerous component scores. Similarly, PA was measured by an index variable, and RAN was measured through four tests. Elsewhere in the literature, researchers have measured more variables. For example, Abu-Rabia and Abu-Rahmoun (2012) incorporated measures relating to vowelized and un-vowelized phonology, un-vowelized orthography, vowelized and un-vowelized syntax, vowelized and un-vowelized morphology with undisrupted root, vowelized and un-vowelized morphology with disrupted root, vowelized and un-vowelized reading comprehension, vowelized word reading, vowelized and un-vowelized pseudo-word with real root, vowelized and un-vowelized words that did not fit the context, working memory, spelling, un-vowelized word reading, and vowelized orthography.

Another limitation of the study was its cross-sectional nature. The cross-sectional nature of the study meant that the findings were only applicable to the context of the third grade; the study's findings did not address the question of whether individuals with double deficits experience worsening reading performance over time. If the impact of the double-deficit worsens over time, then there would be a strong empirical case for adopting early-intervention strategies to work with students who have the double deficit. Thus, there is a need for longitudinal studies of the kind carried out by (Cronin, 2013) that can answer the question of whether individuals with double deficits experience worsening reading performance over time.

5.3 Recommendations for Professional Practice

The results indicated that students in the DD group were the most impaired readers. This is an important finding, because it suggests that students with both deficits may be in most need of identification and intervention. One recommendation supported by the study results is that Arabic-language schools ought to administer the appropriate RAN, PA, and reading ability tests. Doing so will not only allow schools to identify students who are most vulnerable to dyslexia, but also give schools the data needed to measure aggregate performance over time.

The results from this study also indicated that students in the NDG, PAD, and DDG groups performed differently on the Arabic Reading Ability Scale. The fact that the ND group outperformed the PAD, the RAND, and the DD groups on the reading ability, suggests that students in the RAND group need remediation in areas other than PAD decoding skills. Arabic-language schools ought to identify specific domains of reading with which students have difficulty and ensure that specialized support is provided within such domains. Such support should take into consideration specific orthographic features of Arabic that can affect the speed of visual word recognition as compared with other languages.

Arabic is a language written in an alphabetic system of 29 letters. All of these letters are consonants except for three, the long vowels ا (aa) و (oo) ي (ee). Most Arabic letters have more than one written form, depending on the letter's place in a word: Beginning, middle, or end as shown down in table 10, (Friedmann and Hanna, 2012).

In addition, the letters are divided into categories according to basic letter shapes, and the difference between them lies in the number of dots on, in, or under the letter. Dots appear with 15 letters, of which 10 have one dot as follows: ب (b), ج (g) خ (x) ذ (ð) ز (z) ظ (ž) ض (d) غ (Gha) ف (f) ن (N) three have two dots ت (T) ق (q) ي (j/i), and two have three dots ث (ɵ) ش (ʃ). Some of the letters can be connected with former and subsequent letters within the same word, while other letters can be connected only with former letters within the same word.

Table 10: The Arabic Letters-Different Positions

Final non ligated	Final ligated	Medial ligated	Initial (or medial non ligated)	IPA
ا	ـا	ـا	ا	a
ب	ـب	ـبـ	بـ	b
ت/ ة	ـت/ ـة	ـتـ	تـ	t
ث	ـث	ـثـ	ثـ	θ
ج	ـج	ـجـ	جـ	ʤ/g
ح	ـح	ـحـ	حـ	ħ
خ	ـخ	ـخـ	خـ	x
د	ـد	ـد	د	d
ذ	ـذ	ـذ	ذ	ð
ر	ـر	ـر	ر	r
ز	ـز	ـز	ز	z
س	ـس	ـسـ	سـ	s
ش	ـش	ـشـ	شـ	ʃ
ص	ـص	ـصـ	صـ	sˤ
ض	ـض	ـضـ	ضـ	dˤ
ط	ـط	ـطـ	طـ	tˤ
ظ	ـظ	ـظـ	ظـ	zˤ
ع	ـع	ـعـ	عـ	ʕ
غ	ـغ	ـغـ	غـ	ʁ
ف	ـف	ـفـ	فـ	f
ق	ـق	ـقـ	قـ	q
ك	ـك	ـكـ	كـ	k
ل	ـل	ـلـ	لـ	l
م	ـم	ـمـ	مـ	m
ن	ـن	ـنـ	نـ	n
ه	ـه	ـهـ	هـ	h
و	ـو	ـو	و	w/u
ي	ـي	ـيـ	يـ	j/i

These conditions can produce different types of written words namely full connected words (connected letters); partially connected words; and non-connected words (Taha, 2013). The following are examples of each of these types of words:

A non-connected word = زَرَعَ (Planting)

A partially connected word= زهور (Flowers)

A fully connected word = جـَمــَـعَ (Collect).

It should also be noted that most Arabic letters have more than one shape. The shape of each letter can differ according to its place and its connectivity with former and subsequent letters, as indicated in the table above. For instance, the basic and non-connected shape of the grapheme ش could change according to its placement within the word: عشق، شرق، عرش، جيش. Some authors postulate that the orthographic features of written Arabic can produce a visual load and thereby retard orthographic processing (Eviatar & Ibrahim, 2000). Taha, Ibrahim and Khateb (2012) indicated that the recognition of non-connected words by experienced normal readers is more time-consuming. This finding was supported by analysis brain activity, which was measured by electrophysiological measures and which showed processing differences between non-connected and connected words.

Therefore, teachers, practitioners, and educators ought to be aware of Arabic orthography, phonology, and morphology in order to direct their remediation time on different aspects of reading. The findings of the study provide evidence of the need for differentiated instruction for students in each subgroup of the DDH.

Arabic-speaking students with double-deficits will benefit from instructional and intervention models focusing on PA; however, due to their double-deficit status, remediation might be less successful. In addition to Arabic's diglossic nature (Saiegh-Haddad, 2005), two other features play essential roles in assessing reading and examining the predicative power of different processes of the Arabic language; morphology and orthography (Abu Rabia, Abu Ramouh, 2012). Most existing research has been conducted on the English language, which, unlike the transparent orthography of Arabic, which is classified as a deep orthography language (Raphiq Ibrahim, 2015). The results showed both NS measures were significantly correlated with fluency. These results indicate that naming speed ability is crucial for the fluency aspect of reading (Raphiq Ibrahim, 2015). Research on the remediation of deficits in rapid naming is effective, indicating that students continue to improve in fluency (Meyers et al., 1998a).

It is important to mention that the remediation research in Arabic focuses on PA and does not address the specific needs of a RAN deficit. Specifically, students with some RAN deficit need interventions that address fluency and automaticity. With regard to the intervention for students with a RAN deficit, intervention needs to focus on the development of fluency in reading subskills and the development of fluency-based models of instruction and intervention. Therefore, it is essential to add rapid naming remediation as recommended by Wolf and Bowers (1999). It is especially significant for teachers to understand that students with slow processing and PA deficits might be their neediest students and therefore require different types of instruction to address their specific needs.

The Arabic speakers with DD need teaching and interventions that address the double nature of their deficit status and incorporate fluency and automaticity as well as PA and decoding, and such teaching and interventions also need to take specific Arabic features into consideration. One important feature of the Arabic language that ought to be taken into attention is the way in which different words with different roots share the same pattern and thereby possess common functional meaning. The following words: ملعب (Playground) مسكن (Residence) معبد (Temple) share the same pattern مَفْعَلْ, etc. More research in Arabic is recommended to develop a fluency-based approach to reading intervention.

Such an approach ought to be designed to supplement PA instruction in the same many manner as has been developed in English and other languages. Other language programmes have been found to have potentially positive effects on fluency. Additionally, a number of repetition-based activities have been recommended. For instance, the teacher reads first, then the student reads with the teacher, followed by the student reading to the teacher. Recorded passages provide an alternative to paired-reading to improve reading fluency. In repeated reading, the student re-reads the same passage several times; in supported reading, the student reads along with a more fluent reader in such activities as paired reading.

In order to achieve this goal, teachers must have the resources and knowledge to accurately identify not only those students in need of extra help with PA, but also those students who are dysfluent and therefore in need of extra help with fluency and automaticity. Further, teachers will need assistance in matching the deficit with the most appropriate instructional model. Using only the phonological lens to assess students and employing instructional models that only focus on remediating PA deficiencies will continue to miss students who are deficient in rapid naming and will only partially remediate students with double deficits.

5.4 Recommendations for Future Scholarship

There are some recommendations for future scholarship that can be made based on the results of the current study. The first recommendation for researchers working with Arabic measures is to adopt a broader set of measures. Abu-Rabia and Abu-Rahmoun (2012) incorporated measures relating to vowelized and vowelized phonology, un-vowelized orthography, vowelized and un-vowelized syntax, vowelized and un-vowelized morphology with undisrupted root, vowelized and un-vowelized morphology with disrupted root, vowelized and un-vowelized reading comprehension, vowelized word reading, vowelized and un-vowelized pseudo-word with real root, vowelized and un-vowelized words that did not fit the context, working memory, spelling, un-vowelized word reading, and vowelized orthography. Future researchers should adopt these measures and other measures as appropriate.

Another recommendation for future scholarship is for researchers to adopt longitudinal as well as cross-sectional approaches. Only one study (Cronin, 2013) identified in the literature review took a longitudinal approach to the double-deficit hypothesis. Longitudinal approaches are important because, using the tools and techniques of time-series analysis, they can answer the question of whether individuals with double deficits experience worsening reading performance over time. The barriers of time and cost involved in longitudinal research could explain why only Cronin (2013), of all the scholars whose work was evaluated in the literature review, carried out longitudinal rather than cross-sectional research.

5.5 Conclusion

This dissertation was concerned with an assessment of the double-deficit hypothesis. The double-deficit hypothesis postulates that individuals with a combination of RAN and PA deficits will tend to have worse reading ability than individuals with either a RAN deficit, a PA deficit, or no deficit. Thus, the double-deficit hypothesis has been advanced as an explanation of dyslexia. The purpose of this dissertation was to determine the validity of the double-deficit hypothesis as applied to a sample of third-grade Arabic-speaking students in the UAE. Some descriptive statistics with a correlational study design was applied to determine whether reading ability scores are significantly lower for a double-deficit group than those of RAN deficit group, a PA deficit group, and a no-deficit group.

The findings of this research study onfirmed that students who had a double deficit had significantly lower reading ability scores than other groups. The study contributed to the sparse body of empirical research on the double-deficit hypothesis among young Arabic students. The study also pinpointed differences in RAN and PA performance across groups, using an approach to post hoc analysis that has not been attempted in previous studies of this kind. The data suggest that Arabic-language educators must make an added effort to address the special needs of students with double deficits, especially in light of special orthographic and other features of the Arabic language.

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Appendix A

الأداة المسحية للقراءة

The Screen Instrument

اسم الطالب:..

Student Name:..

Academic Year:

السؤال الأول : اقرأ الحروف التالية : (/4)

الحروف الأبجدية	**الدرجة**	الحروف الأبجدية	**الدرجة**
ب		أ	
ح		ث	
ف		هـ	
و		ي	
ك		ذ	
ع		ن	
م		ز	
س		ظ	
ت		خ	
ج		د	
ر		ص	
ط		غ	
ق		ل	
ش		ض	

السؤال الثاني: اقرأ الكلمات التالية قراءة صحيحة : (/7)

الـرِحْــلَــةِ : __________   ســمـــع : __________

مَـــعْـــلَـــمْ : __________   حـــيـــث : __________

اشْـــتَـــرِي : __________   الإنـــســـان : __________

كَـتَـــبَ : __________   الـــغـــرفـــة : __________

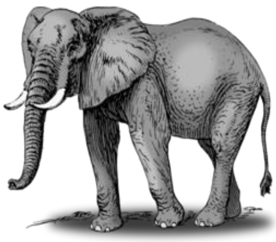
الأَسْـــنَـــانُ : __________   أســـرتـــي : __________

صَحـــــيـــحٌ : ___________ أســتطيـــع : ___________

لـَــعِـــبَ : ___________ مـــــنـــزل : ___________

<u>السؤال الثالث :</u> سم <u>الحرف</u> الذي تبدأ به الصور التالية (/3)

__________ __________ __________



__________ __________ __________

<u>السؤال الرابع :</u> أكمل الكلمة بالحرف الناقص ؟ (/5)

شـــ ح	صا ـــ	ر ـــع	أخـــ	فـاطـمـــ
يشـ ـري	زهـ ة	مشرو	ـديد	سول

<u>السؤال الخامس :</u> ركب من الحروف التالية كلمات ذات معنى : (/5)

و ض ح ب ي ر ا ط ع ش ج ك ت ف هـ س م				
....	....	....	....	....

<u>السؤال السادس</u> : ضع دائرة حول الكلمة <u>المختلفة</u> في كل سطر : (/4)

سـورُ حـورُ حـورُ حـورُ
نـــامَ قـــامَ نـــامَ نـــامَ
كَـتَـبَ كَـتَبَ كَـلْبُ كَـتَـبَ

سارَ سارَ صارَ سارَ

عامِلْ عامِلْ عملْ عامِلْ

رائعْ بارعْ رائعْ رائعْ

نائمٌ نائمٌ نائمٌ نامَ

سعيدُ سعيدُ سعدُ سعيدُ

<u>السؤال السابع:</u> حلل الكلمات التالية إلى حروف ومقاطع . (/8)

الكلمة	التحليل
فَـوْقَ	
سَـمـاءُ	
الْـبَـدْرُ	
مَــديــنَــةٌ	
نُـجـوماً	
صَــــلاةٌ	
يُــــشارِكُ	
الشَّمْسُ	

<u>السؤال الثامن :</u> ضع دائرة حول الكلمات التي فيها أخطاء إملائية : (/4)

الفراشـتُ ، طعامن ، أستطيع ، الإمارات

انتـها ، النهاية ، عندنى ، يتناول

<u>السؤال التاسع :</u> اقرأ النص ثم أجب عن الأسئلة التالية: (/5)

كان خليفة برفقة والده ووالدته حين هبطت الطائرة في مطار القاهرة ، تطلع بلهفة لرؤية أخيه أحمد الذي يدرس الطب في جامعة القاهرة ، وتذكر وعود أحمد بأن يطوف به في الاسواق والحدائق والمتاحف، ويزور معه الآثار القديمة. رأى خليفة أحمد - كما توقع- في استقبالهم والفرحة تغمر وجهه، عانقه بقوة ، ثم قبل أحمد والده ووالدته، وقادهم باتجاه السيارة التي كانت في الانتظار، حيث كان أحمد سعيدا .

1. اكتب شَخْصيات القصة **:** 1 . ... 2. ....

3 . ... 4. ....

2) كان أحمد **يدرس** : أ- الهندسة ب- التمريض ج- الطب د- الطيران

3) يدرس أحمد في **جامعة** : أ- الإمارات ب- زايد ج- القاهرة

د- أبوظبي

4) هبطت الطائرة في **مطار** : أ- بانكوك ب- أبوظبي ج- دبي د- القاهرة

5) كان خليفة : أ- سعيداً ب- حزيناً ج- باكياً د- مكتئباً

<u>السؤال العاشر:</u> أمامك قائمة كلمات غير حقيقية ، أريد منك أن تقرأ الكلمات بصوت عال وواضح : (/5)

1. لَـــرَجَ ______________	6. تَـــشْــيَــحْ ______________
2. ضَــغــُـــسَ ______________	7. خَــكْـبَــثْ ______________
3. جَـــدْرَلٌ ______________	8. هــُـمَـــنٍ ______________
4. صَــظِـيـــفاً ______________	9. ذَروزٌ ______________
5. كَــعْــسٌ ______________	10. ظـُــغِــشَ ______________

Appendix B

الأداة التشخيصية

The Diagnostic Instrument

Phonological Awareness

Student's Name:……………………… : اسم الطالب

Grade: ……....... : الصف

Age: ……………..:العمر

Test Date: ……………………….. : تاريخ التطبيق

Total Score: ………………………….. : النتيجة

صممت هذه الأداة لقياس مستوى الوعي الصوتي .

- ❖ تتضمن هذه الأداة كل من المكونات التالية :

1. تمييز الكلمات
2. اختبار السجع
3. انتاج كلمات فيها سجع
4. دمج المقاطع لتكوين كلمات
5. تحليل الكلمات إلى مقاطع
6. حذف المقاطع من الكلمات
7. تمييز الأصوات
8. دمج الأصوات
9. تحليل الأصوات
10. حذف الأصوات

- ❖ **التعليمات**

تتضمن كل فقرة فرعية تعليمات ، قد يتم تغيير الصياغة في السؤال للتأكد من فهم المفحوص للفقرات على ألا يؤثر ذلك على تعليمات تطبيق الإختبار ولتجنب مساعدة المفحوص في الوصول إلى الإجابات الصحيحة أو إضافة تعليمات . ابدأ التطبيق لكل جزء من الإختبار بعد التأكد من فهم المفحوص للفقرة . إذا لم يستطع المفحوص فهم أو تأدية المطلوب منه ، تجنب تطبيق الفقرة . انطق الكلمات بطريقة صحيحة وواضحة دون أخطاء ، عند الحاجة أعد السؤال مرة أخرى وتأكد من إعطاء وقت كافٍ للإجابة .

- ❖ وقف الإختبار

في كل جزء من الإختبار، توقف عن التطبيق إذا لم يستطع المفحوص تطبيق الأمثلة المعطاة للفقرة أو أخطأ في ثلاث كلمات متتالية.

- ❖ التصحيح

تمنح درجة واحدة للإجابة الصحيحة وصفر للإجابة الخاطئة ، مع تسجيل الإجابات الخاطئة للمفحوص .

1. تمييز الكلمات

قل للمفحوص: سأقول كلمتين ، أريد منك أن تخبرني إن كانوا متشابهتين أم مختلفتين . مثلا ، " وردة ، وردة " كلمتان متشابهتان قل لي " متشابهتين " . أما عندما أقول " بائع ، رائع " قل لي " مختلفتين " . جرب كلمة أخرى : شارع ، شارع . إذا أخبرك المفحوص الإجابة الصحيحية ، قل: أحسنت ، هما كلمتان متشابهتان . إذا كانت إجابة المفحوص غير صحيحة أو لم يجب على السؤال ، قل : شارع ، شارع كلمتان متشابهتان . مثال آخر : كبير ، كثير . إذا أجاب المفحوص إجابة صحيحة ، قل : حسنا إجابتك صحيحة الكلمتان مختلفتان . توقف لمدة ثانية ما بين الكلمات . إذا لم يفهم المفحوص المطلوب ، دربه بإعطائه مثالين إلى ثلاثة أمثلة إضافية مثلا (أزرق ، أزرق) (كلب ، لعب) . إذا كانت إجابة المفحوص خاطئة أو لم يجب على الأسئلة ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال في الفقرة بوضع يديك حول فمك عندما تقول الكلمات .

الأمثلة : (وردة ، وردة) " متشابهتين "، (بائع ، رائع) " مختلفتين " .

__________ 1. رأى ، بكى

__________ 2. طير ، طيف

__________ 3.شرب ، شرب

__________ 4.صحيح ، صريخ

__________ 5. مدينة ، مدينة

__________ 6. بدأ ، بدأ

__________ 7. داخل ، دافع

__________ 8. نظر ، نذر

__________ 9. في ، فيء

__________ 10. ولد ، ولد

المجموع : __________

2. اختبار السجع

قل للمفحوص ، أنك ستقول ثلاث كلمات أمامه وتريد منه أن يخبرك الكلمتين اللاتي تنطق متماثلة أو متشابهة في المقطع الأخير . قل له عندما أقول : أي من الكلمتين نطقت متشابهة أو مماثلة في المقطع الاخير مع كلمة " إبن " ... سجن أم رأس ؟ عليك أن تقول سجن لأن إبن و سجن تتشابه في النطق في المقطع الأخير . الآن دورك ، أي من الكلمتين نطقت متشابهة أو متماثلة مع " سعيد " شديد أم رفيع ؟ ، أي من الكلمات نطقت متشابهة مع اسم ، رسم أم بعض ؟ إذا لم يفهم المفحوص المطلوب منه ، اعط مثالين أو ثلاث أمثلة أخرى ، أي الكلمات نطقت متشابهة أو متماثلة مع أصغر: أحمر ... صغير ؟ أي الكلمات نطقت متشابهة أو متماثلة مع بعد : بعض .... غير ؟ ، إذا كانت إجابات المفحوص خاطئة أو لم يجب ، توقف عن تطبيق هذا القسم من الإختبار .

- ابدأ كل سؤال من الفقرة بـ : ما الكلمة المتماثلة أو المتشابهة في النطق في المقطع الأخير مع ______ ، توقف قليلا بعد كل كلمة .

الأمثلة : " إبن " ..... سجن أم رأس ، " سعيد " ...... شديد أم رفيع ؟

1. نائمْ : غائمْ ، سامِعْ ____________
2. شَهرْ : هَرَبَ ، زَهرْ ____________
3. أينْ : عينْ ، لَعِبَ ____________
4. حيثْ : حينَ ، ليثْ ____________
5. شَرِبَ : شاعرْ ، شَبِعَ ____________
6. صديقْ : رفيقْ ، رِفْق ____________
7. على : غفلَ ، غَلا ____________
8. أُريدْ : رفيعْ ، بعيدْ ____________
9. يمينْ : حزينْ ، حَزِنَ ____________
10. كَيفْ : كبيرْ ، ضيفْ ____________

المجموع : ____________ .

3. إنتاج كلمات (سجع)

قل للمفحوص : سأقول كلمتين فيهما تشابه أو تماثل في نطق المقطع الأخير . رأى تتماثل في النطق مع سعى ، كذلك بدا ..... غدا . الآن دورك أخبرني بكلمة تتشابه مع سار ؟ إذا لم يفهم المفحوص ، أعطه مزيدا من الامثلة ، مثالين أو ثلاثة . مثلا ، ما الكلمة التي تتشابه مع شهر ، باب ؟ . تقبل الكلمات التي يعطيها المفحوص و قد تكون بلا معنى . إذا أجاب المفحوص إجابات خاطئة أو لم يجب على الأسئلة توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة بـــ : ما الكلمة المتشابهة مع ________ .

مثلا : بدا .

1. قالَ ______________
2. رَحَبَ ______________
3. كـــُـل ______________
4. عادَ ______________
5. سمعَ ______________
6. كتبَ ______________
7. وضعَ ______________
8. عَـــمَـــلْ ______________
9. وَضـــَـــعَ ______________
10. فـــَكـــرَ ______________

المجموع : ______________

4. اختبار دمج المقاطع لتكوين كلمات .

قل للمفحوص : سأقول الأجزاء التي تتكون منها الكلمات ، اجمع المقاطع مع بعض و قل الكلمة بسرعة . توقف لمدة ثانية إلى ثانيتين بين كل مقطع . إذا قلت كلمة أبو ...... ظبي بسرعة ستبدو كأنك تقول أبو ظبي . را .... بح ستكون " رابح " . الآن ستجرب كلمة : ما الكلمة لـــ " الــ .... عين " ؟ توقف حتى يجيب المفحوص . إذا لم يفهم المفحوص ، أعطه مثالين أو ثلاثة ليتدرب على ذلك ، مثلا (ص ..ديق ، أ ... ريد) . إذا كانت إجابة المفحوص خطأ او لم يجيب على السؤال ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة بـــ ما الكلمة المكونة للمقاطع التالية .... ؟

أمثلة : أبو ..... ظ ..... بي ، الـــ .... عين .

1. أســ ..... بوع __________
2. صـــ ..... ديق __________
3. قـــ ...... ليل __________
4. حـــ....... ديث __________
5. خــو .... فٌ __________
6. سـَ .... عيد __________
7 . بــحْ ..... ـرٌ __________
8. كيـْ ...... ـفَ __________
9. مــرْ ...... ح .... باً __________
10. بنـْ .... ـتٌ __________

المجموع : __________

5. تحليل الكلمات إلى مقاطع .

قل للمفحوص ، سيتم استخدام مجموعة من الكلمات ليتم تجزئتها إلى المقاطع التي تتكون منها . كلمة " يقرأ " تتكون من مقطعين ، افصل المقطعين عن بعض وأخبرني بهما ، المقطعان هما " يقـْ ...... رأ " . حلل الكلمة السابقة إلى مقاطعها أمام المفحوص وتأكد من فهمه . قل للمحوص الآن دورك أخبرني بالمقاطع التي تتكون منها كلمة " كـُــرة " . إذا لم يفهم المفحوص ، أعد تدريبه بمثالين إلى ثلاثة امثلة : (يكتب ، يلعب ، جاهز) . إذا لم يفهم المفحوص المطلوب منه أو لم يجب على الأسئلة ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة بـــ : أخبرني بالمقاطع التي تتكون منها كلمة ________ .

أمثلة : يكتب ، يلعب ، جاهز .

___________ 1. شُـــكراً (شــُكــ - ــراً)

___________ 2. مـَنـْـزلٌ (مــنـْ - ـزِ - لٌ)

___________ 3. جـِسْـــمٌ (جسْ - ــمٌ)

___________ 4. كـــا ن (كـــا – ن)

___________5. كـــيْفَ (كــــيْ – ف)

___________6.غــُرفةٌ (غــُر – فــةٌ)

___________7. صـــَوتٌ (صــــوْ – تٌ)

___________ 8. أُ مــِّي (أمـــ - مـــي)

___________ 9. صادقْ (صـــا – دِق)

___________ 10. أبـــي (أ – بــــي)

المجموع : ____________

6. حذف المقاطع من الكلمات

قل للمفحوص ، سأقول أمامك كلمة ، سنحذف مقطعا منها . كلمة " أبو ظبي " احذف منها أبو تصبح الكلمة " ظبي " . الآن دورك ، " قل كلمة " القمر " . توقف قليلا ، قل للمفحوص أن يقول الكلمة بدون " ال " . إذا لم يفهم المفحوص ، أعطه مثالين أو ثلاثة ليتدرب ، مثلا (الْــقلم ، مدرسة ، شمسٌ) . إذا أجاب المفحوص إجابة خاطئة أو لم يجب على الأسئلة ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة من الإختبار بـــ : قل كلمة _____ بدون ______ .

أمثلة : (أبو ظبي ، القلم ، شمسٌ) .

1. كلمة "عامل" بدون "عا " ______________
2. كلمة " سعيد " بدون "س" ______________
3. كلمة " شاهـِد " بدون "هـِد " ______________
4. كلمة " يسار " بدون " ي" ______________
5. كلمة " عاصفة " بدون " عا " ______________
6. كلمة " عندنا " بدون " دنا " ______________
7. كلمة " عامل " بدون " مل " ______________
8. كلمة " شهيد " بدون " هيد " ______________
9. كلمة " عصفور " عصــ " ______________
10. كلمة " ما زال " بدون " ما " ______________

المجموع : _________________

7. تمييز الأصوات

قل للمفحوص ، سأقول أمامك كلمة ثم عليك أن تخبرني بكلمة تبدأ بنفس الصوت الذي تبدأ به . إذا قلت لك ، أعطني كلمة تبد أ بالصوت الذي تبدأ به كلمة " بات " ، يمكنك أن تقول " بارد ، بعيد ... " . الآن دورك ، أخبرني كلمة تبدأ بالصوت الذي تبدأ به كلمة " نائم " ، إذا قال المفحوص كلمة صحيحة ، قل إجابتك صحيحة ، الكلمة ________ تبدأ بنفس الصوت الذي تبدأ به كلمة " نائم " ، إذا قال المفحوص كلمة متجانسة في اللفظ مع الكلمة المعطاة ، قل له : هذا تشابه في الصوت الذي تنتهي به الكلمة ، أريد كلمة تبدأ بنفس الصوت الذي تبدأ به كلمة ___________ . إذا أجاب المفحوص إجابة خاطئة أو لم يجب ، قل له يمكنك أن تقول (نهر ، نعم) . قل له سنجرب أمثلة أخرى . ما الكلمة التي تبدأ بنفس الصوت الذي تبدأ به كلمة " خوف " ؟ إذا لم يفهم المفحوص ، جرب معه مزيدا من الأمثلة ، مثالين أو ثلاثة ، (سأل ، مشى) . إذا أجاب المفحوص إجابة خاطئة أو لم يجب ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة بـــ : قل لي كلمة تبدأ بنفس الصوت الذي تبدأ به كلمة _________ .

أمثلة : (نهر ، مشى .... سأل) .

1. كيف ____________
2. أهلاً ____________
3. رجل ____________
4. عاد ____________
5. وقت ____________
6. بلاد ____________
7. صوت ____________
8. غرفة ____________
9. لبس ____________
10. طبيب ____________

المجموع: _____________

8. اختبار دمج الأصوات

قل للمفحوص ، سأقول أمامك الأصوات التي تتكون منها أحد الكلمات ببطء ، عليك أن تخبرني بهذه الكلمة . عليك أن تقول هذه الأصوات بالطريقة التي تنطق بها في الكلمة ، توقف ما يقارب الثانية بعد كل صوت . اسمع جيدا ، أس / بو / عٌ هي " أسبوعٌ " . الآن دورك ، ما الكلمة لـلأصوات : أســْ / نا / نٌ ؟ إذا لم يفهم المفحوص ، دربه بمثالين إضافيين أو ثلاثة (ط / بيــ / ــبٌ ، عيـــ / ــدٌ) . إذا أجاب المفحوص إجابة خاطئة أو لم يجب ، توقف عن تطبيق هذا الجزء من الإختبار .

- ابدأ كل سؤال من الفقرة بـــ : ما الكلمة التي تكون الأصوات التالية ________ ؟

مثال : (ط / بيــ / ـــبٌ)

1. منـــْ / ــزِ / لٌ ____________
2. شكـــْ / راً ____________
3. أســْ / نا / نٌ ____________
4. غرْ / فــَ / ـــةٌ ____________
5. دَ / خـــَ / ـــلَ ____________
6. صا / حَ ____________
7. طــَ / عـــا / مٌ ____________
8. كـــِ / تـــا / بٌ ____________
9. لـــ / ذ يــــــ / ذٌ ____________
10. نـــ / جـــا / حٌ ____________

المجموع : ____________

9. اختبار تحليل الكلمات إلى أصوات

قل للمفحوص ، سأستخدم فاصلا لترى الأصوات التي تتكون منها الكلمة . كلمة " رحل " تتكون من الأصوات رَ / حــَ / ـلـَ . ضع فاصلا بين الصوت و الآخر مثلا ، قل كلمة " دخل " هي د / خـَ / ـلـَ . الآن دورك ، قل الأصوات التي تتكون منها كلمة ركب . إذا لم يفهم المفحوص المطلوب منه ، أعطه مزيدا من الامثلة ، مثالين أو ثلاثة . مثلا (لعب ، فكر) . للإجابة الصحيحة ، على المفحوص أن يحلل الكلمات إلى الأصوات التي تتكون منها الكلمات . إذا أجاب المفحوص إجابة خاطئة أو لم يجب ، توقف عن تطبيق هذه الجزء من الإختبار .

- ابدأ كل سؤال من هذه الفقرة بـــ : أخبرني بالأصوات التي تتكون منها كلمة ___________ .

أمثلة : لعب ، فكر .

1. عـَـلِـــم ___________
2. رَحــَــلَ ___________
3. ســَـمِـــعَ ___________
4. شهيقٌ ___________
5. وَقــَــــفَ ___________
6. نــَــظـَـرَ ___________
7. تَكــلَّــمَ ___________
8. شـَــجـَــر َ ةٌ ___________
9. ضـَحـِــكَ ___________
10. نــَــجـَــحَ ___________

المجموع : ___________

10. حذف الأصوات

قل للمفحوص ، سأقول لك مجموعة من الكلمات ، عليك أن تحذف الصوت الذي يطلب منك حذفه . إذا قلت أمامك كلمة " بلاد " قلها بدون / بـِ / فإنها تصبح " لاد " . إذا قلت لك كلمة " تـُـفــاح " قلها بدون " ت " فإنها تصبح " فاح " . الآن دورك ، قل كلمة " يعيش " بدون / ي / . إذا لم يفهم المفحوص أعطه مزيداً من التدريبات ، مثالين أو ثلاثة (نـــَـجــاح بدون نـــ ، أليف بدون أ) . إذا أجاب المفحوص إجابة خاطئة أو لم يجب توقف عن تطبيق هذه الفقرة من الإختبار .

_ ابدأ كل سؤال من هذه الفقرة بـــ : قل كلمة ______ بدون _______ .

مثال : نجاح بدون / ن / (جاح)

1. ضحك بدون / ضــَ / (حــِك) . _____________

2. قرأ بدون / قــَ / (رأى) . _____________

3. رحــَــل بدون / رَ / (حل) _____________

4. كتـــاب بدون / ك / (تاب) _____________

5. قمر بدون / ق / (مر) _____________

6. صبـــاح بدون / ص / (باح) _____________

7. ســمـــع بدون / س / (مع) _____________

8. قلـــيـــل بدون / ق / (ليل) _____________

9. تــِــلك بدون / تـِ / (لك) _____________

10. ذلــــك بدون / ذ / (لك) _____________

المجموع : _____________

❖ ملخص حول مواضيع الفقرات و ما الذي تقيسه .

1. اختبارات السجع هي كل من الإختبار الثاني و الثالث .
2. اختبارات الدمج هي كل من الإختبار الرابع و الثامن .
3. اختبارات التحليل هي كل من الإختبار الخامس و التاسع .
4. اختبارات الحذف هي كل من الإختبار السادس و العاشر .
5. اختبارات تمييز الأصوات هي كل من الإختبار الأول و السابع .

Appendix C

الأداة التشخيصية

The Diagnostic Instrument

Rapid Automatized Naming

Student's Name: ……………………… :اسم الطالب

Grade: ……....... :الصف

Age: ……………..:العمر

Test Date: ……………………….. : تاريخ التطبيق

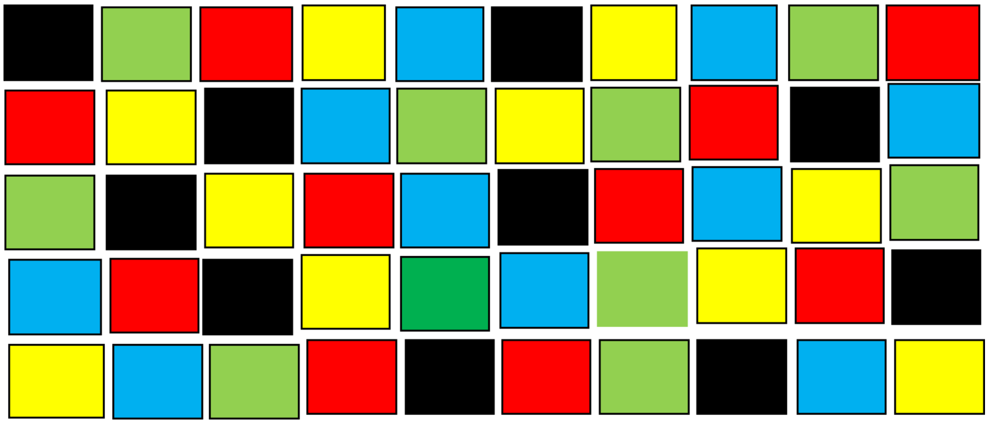
Total Score: ………………………….. : النتيجة

❖ تعليمات التطبيق

1. يتم تطبيق الإختبار على المفحوص بشكل فردي .
2. أخبر المفحوص أن عليه تسمية الأشياء التي تعرض أمامه (ألوان ، أرقام ، حروف ، صور) بأسرع وقت ممكن و بدون أخطاء .
3. عندما يفهم المفحوص التعليمات ، جهز التوقيت لتبدأ الإختبار .
4. اعط المفحوص 5 ثوان كإشارة بأنك ستبدأ الإختبار ، مثلا " جاهز ؟ أوكي ، خمسة ، أربعة ، ثلاثة ، اثنان ، واحد ، ابدأ ".
5. ابدأ بالتوقيت عندما يعطي المفحوص أول إجابة ، استمر بالتوقيت حتى ينهي المفحوص الصفحة التي تطلب منه ، سجل الوقت الذي استغرقه المفحوص في الإجابة .

الإسم : ______________________________ التاريخ : ______________

❖ **انظر إلى الصفحة ، ثم أخبرني بأسماء الألوان التي أمامك بأسرع وقت ممكن و بدون اخطاء .**



الوقت : __________________ الأخطاء : ______________________

الإسم : ______________________________ التاريخ : ______________

❖ **انظر إلى الصفحة ، ثم أخبرني بأسماء الأرقام التي أمامك بأسرع وقت ممكن و بدون اخطاء .**

2	6	9	8	5	8	5	2	9	6
5	2	8	6	9	5	8	6	2	9
6	8	9	2	5	8	6	9	5	2
8	2	5	9	6	9	2	5	6	8
6	9	2	5	8	6	2	9	8	5

الوقت : ___________________ الأخطاء : ______________________

الإسم :____________________________ **التاريخ : _____________**

❖ **انظر إلى الصفحة ، ثم أخبرني بأسماء الحروف التي أمامك بأسرع وقت ممكن و بدون اخطاء .**

ض	ق	ك	خ	ش	ك	ق	ض	خ	ش
ش	ك	خ	ق	ض	خ	ش	ق	ك	ض
ك	ش	ق	ض	خ	ق	خ	ك	ش	ض
ق	ض	ش	ك	خ	ض	ك	ش	ق	خ
خ	ق	ض	ش	ك	ش	ض	خ	ك	ق

الوقت : __________________ الأخطاء : _____________________

الإسم : ______________________ التاريخ : __________

❖ انظر إلى الصفحة ، ثم أخبرني بأسماء الصور التي أمامك بأسرع وقت ممكن و بدون اخطاء .

الوقت : ______________ الأخطاء : ________________