Cognitive Predictors of Early Arabic Literacy: Informing the Development of Dyslexia Assessment in Bahrain

By

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Abstract

The present study attempted to identify cognitive predictors of early Arabic reading and spelling processes in the anticipation of understanding issues relevant to normal and abnormal early Arabic literacy. A literature search of predictors of reading and dyslexia across various alphabetical orthographies assisted in developing a framework for the study.

The study examined concurrent and longitudinal potential predictors by investigating a group of 171 mainstream Bahraini children from the first three grades of primary schooling, of which a subset of 116 children from grades 1 and 2 were followed up one year later.

Regression analyses of both time periods revealed that phonological awareness processing measures (rhyme and phonemes) were core cognitive predictors of early Arabic reading and spelling, in particular rhyme awareness in the initial stages of literacy attainment. In addition, early literacy attainment in the Arabic language, as conceived from the present findings, did not appear to follow the typical pattern found in other transparent orthographies; in fact it appeared closer to the English orthography.

Findings were discussed in relations to models of reading and dyslexia, and in particular with the Grain Size theory (Zeigler & Goswami, 2005). Contemplation of the position of Arabic literacy with regards to its orthography and others were specified. In addition, recommendations for the development of an Arabic assessment dyslexia tool, as well as proposals for future research, were discussed.
Acknowledgements

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Lastly, I would like to thank all those I have missed but have in one way or the other made this thesis possible. Thank you to all.
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CHAPTER 1

General Introduction:
An Overview of the Research Study on Predictors of Early Arabic Literacy
Chapter 1

General Introduction:
An Overview of the Research Study on Predictors of Early Arabic Literacy

The current research was instigated with the aim of developing an assessment tool to identify Arabic dyslexics and, in particular, for the children of Bahrain. The development of such an assessment tool required the establishment of an understanding of how the reading processes were functioning in typically developing children coming from this region of the world. In doing so, it would become possible to appreciate the main pillars governing or even participating in the progressive development of the Arabic reading process amongst typically developing Bahraini children. Once identified, it would then become possible to search for their presence amongst those children who appear unable to attain the standard of reading level expected of their age group; that is, after ensuring the absence of any physical, neurological, environmental, or other general health/clinical factors which may have resulted in such a condition. Consequently, the research presented in this thesis is only the beginning towards the fulfillment of this long-standing aim in future years to come.

In view of this, the main goal of the present research was to understand the early reading and early spelling processes of typically developing Arabic Bahraini children, by searching for predictors of early literacy acquisition. Moreover, with the Vowelized Arabic language regarded as a relatively transparent orthography it was of interest to comprehend whether the current findings would be compatible with the processes of early literacy acquisition identified in languages of similar transparency levels.

The thesis is divided into eight chapters. This first chapter is an introductory chapter providing an overview to whole thesis. The second chapter concentrates on the structure of the Arabic language, with the aim of familiarizing the reader with the Arabic language
and its orthography in the hope of enhancing awareness of issues relevant to the study. The second chapter begins by distinguishing between the various forms of the Arabic language (Classical, Formal, and Spoken), followed by details of the Arabic orthography, detailed descriptions of its phonemes and ending with an introduction to the morphological aspects of the Arabic language.

The third chapter concentrated on theories of dyslexia and their relationships to models of reading. It was based on the premise that reading difficulties associated with dyslexia research could be indicative of normal reading development. Consequently, the third chapter began by first providing the reader with an understanding of what each of the terms reading and dyslexia entail. This was followed by providing an outline of theories of dyslexia at the cognitive and biological levels of explanations. The cognitive level explanations of dyslexia included theories such as the Phonological Core Deficit hypothesis (Stanovich, 1988), the Phonological Representation hypothesis (Fowler, 1991; Swan & Goswami, 1997), the Double Deficit hypothesis (Bowers & Wolf, 1993), and the Psycholinguistic Grain Size theory (Zeigler & Goswami, 2005); whereas the biological level explanations included rationalization at the genetic level and the brain level with theories such as the Cerebellar theory (Nicolson & Fawcett, 1990; Nicolson et al., 2001) and the Magnocellular theory (Stein et al., 2001). Subsequently, an overview of models of reading was given, leading to the introduction of two interactive models of reading: the Dual Coding theory (Sadoski & Pavio, 2004), which accounts for the reading process in rather general terms; and the Dual Route model (Ellis, 2001), which accounts for reading in fairly specific terms. The chapter ended with discussions on the compatibility of those two reading models with theories of dyslexia.

The fourth chapter entailed examining predictors of literacy within a cross-linguistic perspective, concentrating only on the alphabetic script. The premise behind such an examination lay in the anticipation of understanding the process of normal reading and its difficulties in the different orthographies, as well as attaining an appreciation of how the literacy process can be affected by the attributes of the writing system. Accordingly, the
chapter began with a brief outline introducing the reader to the orthographical structure of various languages (e.g. English, French, Greek, Dutch, Spanish, German, Italian, and Hebrew). Subsequently, discussions, based on evidence from research findings in different orthographies, were presented for each potential literacy predictor focusing on phonological differences, rapid naming differences, visual and auditory differences, lexical differences, and morphological differences. This section ended with a discussion of each of the potential predictors of literacy, including brief outlines towards the feasibility of the concerned potential predictor as an effective indicator to literacy acquisition.

The fifth chapter contemplated the methodological aspects of the current research. It commenced by providing rationales for the type of study conducted as well as the choice of measures used in the study. The research was conducted over a period of two years on Bahraini mainstream school children from grades 1 to 3 of which children from grades 1 and 2 were retested the following year, when they had moved into grades 2 and 3 respectively. The chosen measures for the research consisted of eleven tasks (the Stroop task, picture arrangement, digit span, temporal order, coding, block design, picture completion, phoneme, rhyme, reading, and the spelling tasks), six of which were personally prepared and five of which were taken from the Bahraini version of the WISC III (1998). Descriptions and procedures for each prepared task were provided. Researched samples were described as well as research aims, questions, and hypotheses were specified.

The sixth and seventh chapters were the result chapters. Chapter six presented results of the first year of study and chapter seven reported findings from the second year of researching. Chapter seven also included an examination of the results from a longitudinal perspective. Prior to the reporting of the results, each of the chapters entailed stating research questions and hypotheses of appropriate concern and provided briefings on sample size and measures used. The results of the analyses in each of the chapters initially included preliminary examination of the measured variables. This was followed
by detailing the results of one-way analyses of variance which assisted in understanding the developmental patterns of learning to read and write at each study period. Subsequently, Person correlation coefficients for the variables were given to assess the degree of association between the Arabic literacy measures and potential predictors. Lastly, the results of Stepwise regression analyses were reported which in turn assisted in gaining insight into concurrent (from both chapters 6 & 7) and long-term (only from chapter 7) predictors of Arabic Literacy skills.

The eighth chapter was the final concluding phase in the thesis. Its purpose was to strive, through a discussion of its findings, to understand the early Arabic literacy process in relation to its orthography, propose a structural outline for early Arabic literacy predictors, and recommend practical implementation; especially towards the development of assessment tools. The chapter opened with a recapitulation of the main findings in the study; followed by a reconciliation of attained findings with theories of reading and dyslexia. Subsequently, the position of early Arabic predictors (as gathered from the present piece of work) within the different orthographies was discussed. This was followed by considerations of issues associated with the development of dyslexic assessment measures for children of the Arabic language. The final phase consisted of providing the reader with an idea of the limitations of the present study followed by proposals for future research in the area, before concluding with a repetition of the main findings of the work.
CHAPTER 2

The structure of the Arabic Language
Chapter 2

The structure of the Arabic Language

Introduction

According to Katzner (2002) Arabic is considered one of the major languages of the world, spoken by about 230 million people. It is one of the six official languages of the United Nations. It belongs to the Semitic language family group. Aside from Arabic the Semitic language family includes Hebrew, Phoenecian, Maltese, Syriac, Aramaic, Assyrian, Amharic, Tigrinya, Tigre, Gurage, Harari and Ge’ez. Relative to the other Semitic languages, Arabic is a great language which has flourished due to its linkages with Islam, more specifically with Islam’s holy book, the Qur’an.

There are three distinct forms of Arabic. Qura’anic or Classical Arabic, Modern or Formal Arabic, and Colloquial or Spoken Arabic. The classical Arabic is based on the Qur'an. It is a form of literary Arabic that is not used in conversations nor in non-religious texts. The Qur'an as Awde & Samano (1986) have put it "...has always been a major grammatical and linguistic authority. The existence of a commonly accepted literary standard has been a powerful and unifying force in the written language" (p. 14). However, it is very similar to the formal or Modern Standard Arabic language. The difference between the two languages is only structural in the range of vocabulary used and in sentence structuring. It could be considered that the Modern Standard Arabic Language is a simpler version (in grammar and syntax) of the Classical Arabic. Modern Standard Arabic provides a universal form of language that could be understood by all, and it is the official language which is used in the media (e.g. radio, TV, newspapers etc.) and in conversations between people of different dialects. With regards to the Colloquial or Spoken Arabic, there are about 30 different forms of them making it sometimes difficult to understand people from differing dialects. As a result, in such situations, the Modern Standard Arabic is used.
The Arabic Orthography

Arabic is an alphabetical, diacritical, right to left writing system with 28 basic letters made up of consonants and long vowels (see Table 2.1). Each of the long vowels has its equivalent short vowel (see Table 2.2). There are only three short and three long vowels. The long vowels are written within the word but the short vowels are tiny strokes placed either above and/or below each letter of the word (e.g. as in كتاب). In addition, there are two other symbols which could be placed above the letters in a word. One symbol is the ‘sukoon’ which resembles a tiny circle and represents the absence of a short vowel. The second is the ‘shedda’ and it resembles a tiny comb with three strokes facing upwards. It indicates the need for doubling the sound of the particular letter it has been placed above. The short vowels, the sukoon, and shedda (diacritics) all help towards accurate pronunciation of a word. As such Arabic is considered a highly regular, transparent language with a one to one correspondence between graphemes (letters and diacritics) and phonemes. This type of text is always preserved in the writings of the holy Qura’an, in children’s beginner’s text books, and most of children story books. However, sometimes the diacritics are absent from the writings of Arabic languages as in modern Arabic Press and novels. In such cases Arabic could be considered to display a deep orthography (Abu-Rabia, 1997a; 1997b; 1998; 2001).

Furthermore, Arabic is a homographic language with one written word holding more than one meaning. For identification of the homographic word, beginners and sometime skilled readers of Arabic need to be provided with diacritics. In the absence of diacritics, readers are required to resort to context to find the meaning and in turn deduce the correct pronunciation of the word. For example, the words 'to go' and 'gold' respectively are written in the following way ± كتاب. The removal of the diacritics will result in both words appearing identical. Therefore, the correct readings of the words will require putting the reader in the proper perspective via context which will accordingly allow for accurate word pronunciation. In the absences of both diacritics and context, accurate word reading becomes very difficult.
The Arabic script is cursive. It has no capital or small letters as in the English language. Any Arabic word is written the same way in any position in a sentence. However, Arabic letters show different writing styles depending on its position in a word (in isolation, initial, middle, and final). That is because the letters in Arabic are joined together, the shape of the letters is slightly modified to fit in with the various combinations of the other letters in a word. Thus, the form a letter will take will depend on its position in a word. From the 28 letters there are 22 letters that could connect two-ways (بـتـثـجـحـضـصـضـصـصـضـم~4

With two-way type connecters, a letter is modified according to its position within the word such that if the letter appears in the beginning of a word, the letter will have a little tail connecting it to the next letter; if the letter is in the middle, it will have two tails one connecting it to the letter before and one connecting it to the letter after it. On the other hand, if the letter appeared at the end then, it will have one tail connecting it with the letter before (see Figure 2.1).

\[\text{م} \quad \text{لحم} \quad \text{لحم} \quad \text{لحم} \]

Pronunciation  (Mokh) (Namil) (LaHam)

Meaning  (Brain) (Ant) (Meat)

Figure 2.1 - An example of how two-way connectors are modified according to their position with in a word (initial, middle, end). The letter \(m\) (in the Arabic script written as م) is given as an example*.

* The Arabic letter \(m\) is written in gray to highlight it within the word. The same conversion will be used throughout the chapter.
However, with one-way type connecters, a letter positioned at the start of a word will always be the same as it appears in isolation. For the middle and last positions there are two conditions: if the letter is positioned such that the letter before it is a two-type connecter, then it will always be connected with the letter before it from the right side with a little tail; on the other hand, if the letter before it is another one-type connecter, then it will retain the same shape as it does in isolation (see Figure 2.2).

<table>
<thead>
<tr>
<th>Initial</th>
<th>End*</th>
<th>End</th>
<th>Middle*</th>
<th>Middle</th>
</tr>
</thead>
<tbody>
<tr>
<td>دَرْس</td>
<td>خَرَوف</td>
<td>بَحْر</td>
<td>دَار</td>
<td>رَمل</td>
</tr>
</tbody>
</table>

Figure 2.2 - An example of how one-way connectors are modified according to their position within a word (initial, middle, end). The letter ر (in the Arabic script written as ر ) is given as an example. *Note how a one-way connecter connects if a two-way connecter appears before it.
Table 2.1 - A list of all the Arabic alphabet with a transliteration which gives a hint about its pronunciation. Table adapted from Awde & Samano (1986).

<table>
<thead>
<tr>
<th>Name of Letter</th>
<th>Arabic Form</th>
<th>Transliteration</th>
<th>Guid to Pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>'alif</td>
<td>ا</td>
<td>aa</td>
<td>fair</td>
</tr>
<tr>
<td>baa'</td>
<td>ب</td>
<td>b</td>
<td>big</td>
</tr>
<tr>
<td>taa'</td>
<td>ت</td>
<td>t</td>
<td>tell</td>
</tr>
<tr>
<td>thaa'</td>
<td>ث</td>
<td>th</td>
<td>think</td>
</tr>
<tr>
<td>jiim</td>
<td>ج</td>
<td>j</td>
<td>measure</td>
</tr>
<tr>
<td>Haa'</td>
<td>ح</td>
<td>H</td>
<td>No equivalent</td>
</tr>
<tr>
<td>khaa'</td>
<td>خ</td>
<td>kh</td>
<td>Scottish loch</td>
</tr>
<tr>
<td>daal</td>
<td>د</td>
<td>d</td>
<td>dead</td>
</tr>
<tr>
<td>dhal</td>
<td>ذ</td>
<td>dh</td>
<td>then</td>
</tr>
<tr>
<td>raa'</td>
<td>ر</td>
<td>r</td>
<td>Rolled r</td>
</tr>
<tr>
<td>zaay</td>
<td>ز</td>
<td>z</td>
<td>zoo</td>
</tr>
<tr>
<td>siin</td>
<td>س</td>
<td>s</td>
<td>sew</td>
</tr>
<tr>
<td>shiin</td>
<td>ش</td>
<td>sh</td>
<td>shall</td>
</tr>
<tr>
<td>Saad</td>
<td>ص</td>
<td>S</td>
<td>No equivalent</td>
</tr>
<tr>
<td>Daad</td>
<td>ض</td>
<td>D</td>
<td>No equivalent</td>
</tr>
<tr>
<td>Taa'</td>
<td>ط</td>
<td>T</td>
<td>No equivalent</td>
</tr>
<tr>
<td>DHaa'</td>
<td>ظ</td>
<td>DH</td>
<td>No equivalent</td>
</tr>
<tr>
<td>'ayn</td>
<td>ع</td>
<td>ء</td>
<td>No equivalent</td>
</tr>
<tr>
<td>ghayn</td>
<td>غ</td>
<td>gh</td>
<td>No equivalent</td>
</tr>
<tr>
<td>faa'</td>
<td>ف</td>
<td>f</td>
<td>fool</td>
</tr>
<tr>
<td>qaaf</td>
<td>ق</td>
<td>q</td>
<td>No equivalent</td>
</tr>
<tr>
<td>kaaf</td>
<td>ك</td>
<td>k</td>
<td>kitten</td>
</tr>
<tr>
<td>laam</td>
<td>ل</td>
<td>l</td>
<td>love</td>
</tr>
<tr>
<td>miim</td>
<td>م</td>
<td>m</td>
<td>mask</td>
</tr>
<tr>
<td>nuun</td>
<td>ن</td>
<td>n</td>
<td>never</td>
</tr>
<tr>
<td>Haa'</td>
<td>ه</td>
<td>h</td>
<td>happy</td>
</tr>
<tr>
<td>waaw</td>
<td>و</td>
<td>W, uu</td>
<td>Weld, food</td>
</tr>
<tr>
<td>Yaa'</td>
<td>ي</td>
<td>Y, ii</td>
<td>Yell, breeze</td>
</tr>
<tr>
<td>hamza</td>
<td>ء</td>
<td></td>
<td>No equivalent</td>
</tr>
</tbody>
</table>
Table 2.2 - Arabic long and short vowels with a transliteration which gives a hint of its pronunciation and a given example in Arabic on how each vowel is transcribed and pronounced.

<table>
<thead>
<tr>
<th>Arabic Vowels</th>
<th>Type</th>
<th>Transliteration</th>
<th>Position of the vowel</th>
</tr>
</thead>
<tbody>
<tr>
<td>ا (a)</td>
<td>Long Vowel</td>
<td>aa</td>
<td>Within the word as in the word 'book' – in Arabic kitaab كتاب</td>
</tr>
<tr>
<td>او (au)</td>
<td>Long Vowel</td>
<td>uu</td>
<td>Within the word as in the word 'worm' – in Arabic duud دود</td>
</tr>
<tr>
<td>ا (a)</td>
<td>Short Vowel</td>
<td>a</td>
<td>Above the word as in the word 'wrote' – in Arabic katab كتاب</td>
</tr>
<tr>
<td>ا (i)</td>
<td>Short Vowel</td>
<td>i</td>
<td>Above the letter as in the word 'sugar' – in Arabic sukár سكر</td>
</tr>
<tr>
<td>ي (i)</td>
<td>Long Vowel</td>
<td>ii</td>
<td>Within the word as in the word 'chair' – in Arabic kursii كرسي</td>
</tr>
<tr>
<td>ي (i)</td>
<td>Short Vowel</td>
<td>i</td>
<td>below the letter as in the word 'pool' – in Arabic birkáh بركه</td>
</tr>
</tbody>
</table>
Descriptors of Arabic Phoneme

The Arabs have given the consonant phonemes special attention (AlKalaylah & AlLibabeedi, 1990). The Arabic language consists of 34 phonemes of which 28 are consonant phonemes and 6 are vowelized phonemes.

For a precise description of an Arabic phoneme, there are three main factors that should be taken into consideration. These are:

1. The place of production (Makan Alntique): This refers to the location of the pronounced phoneme within the mouth (see Table 2.3).
2. The producer (Alnatique): This refers to the mouth part that utters the phoneme (see Table 2.3).
3. The quality of sound: This refers to the way the sound is produced which in turn depends upon the state the vocal cords and the breathing trend whilst pronouncing the phoneme. A brief explanation of each of those factors affecting the quality of sound will be given below.

With regards to the state of the vocal cords two main conditions prevail. One condition is known as the ‘Whispering’ state (Mahmoose), the other condition is known as the ‘out-spoken’ state (Majhoore).

A phoneme in the ‘Whispering’ state occurs when the wind pipes are in an opening state and the vocal cords do not meet as it is for example with /t/ ... /d/. Whereas a phoneme in the ‘out-spoken’ state occurs when the vocal cords vibrate as for example in /d/ ... /a/.

There are two possible ways for feeling the vibrations of the vocal cords. One way is by placing the tip of a finger on the larynx (upper throat) as the sound is uttered. Another way is by placing the palms of the hands over both ears as one utters the sound. With ‘outspoken’ sounds, the person should feel a clear ringing sound in all of one’s e head.
Moreover, with regard to the second factor affecting the quality of sound: the trend of breathing whilst the phoneme is being pronounced, ten breathing patterns have been determined (AlKhuli, 1990). These are as follows:

1. **The Halting Sound (Waqfi):** In this the breathing stops before uttering the sound and then it is released, e.g. /t, d/ .../ت، د/.

2. **The Friction Sound (Ihtikaki):** This occurs when the breathing pattern is continuous but disturbed as the phoneme is uttered resulting in the air rubbing against the vocal cords causing a ‘friction-like’ effect, e.g. /s, f/ .../س، ف/.

3. **The Mixed Sound (Mazji):** This is a compound sound made up of initially a ‘halting’ sound followed by a ‘friction’ sound, e.g. /j/ .../ج/.

4. **The Nasal Sound (Anfi):** In this sound the breathing passes through the nostrils as the phoneme is uttered, e.g. /m, n/ .../ن، م/.

5. **The Single-Sided Sound (Janibi):** In this the breathing passes through one side of the mouth as the phoneme is uttered, e.g. /l/ .../ل/.

6. **The Double-Sided Sound (Janabani):** In this the breathing passes through both sides of the mouth as the phoneme is uttered.

7. **The Repetitive Sound (Tikrari):** In this sound the breathing pattern is repeated several times in a consecutive manner as the phoneme is uttered, e.g. /r/ .../ر/.

8. **The Retreated Sound (Irtidadi):** This sound pattern occurs when the tip of the tongue folds back in to the center of the gum.
9. **The Vowelized Sound (Sayet):** This sound does not have a specific place when it is being uttered nor is the breathing disturbed in any way, e.g. /i, a, u/.../

10. **The Slippery Sound (Inzilaqi):** This an almost consonant sound or an almost vowelized sound, e.g. /y, w/.../

Finally, linguists have simplified phoneme description by simply noting two of the three factors mentioned above. The rationale behind this was that by knowing the producer, it was possible to predict the location of the pronunciation of a particular phoneme and vice versa. Therefore, the two main factors used in phoneme description are as follows:

1. **The place of production**
2. **The quality of the sound in terms of :**
   - The state of the vocal cords (Whispering or Out-spoken).
   - The trend of breathing (With Arabic consonant phonemes these are usually any one of the following seven trends: The halting sound, the friction sound, the mixed sound, the nasal sound, the single-sided sound, the repetitive sound, the slippery sound).

Thus, each Arabic consonant phoneme has its unique features. Detailed information regarding the precise factors associated with each phoneme is presented in Table 2.4.
Table 2.3 - Lists the various parts of the mouth that are involved in producing the sounds of the Arabic alphabets; and the location of each part within the mouth.

<table>
<thead>
<tr>
<th>The mouth part that pronounces the letter (Alnatique)</th>
<th>The location of the pronunciation within the mouth (Makan Alnatique)</th>
<th>E.g. of the letter sound in Arabic (phoneme)</th>
<th>The Equivalency in English sound (phoneme)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower lip</td>
<td>Upper lip  or Upper teeth</td>
<td>/ب، م/</td>
<td>/m, b/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ض، ل/</td>
<td>/f/</td>
</tr>
<tr>
<td>Tip of tongue</td>
<td>Gum (1)  or Teeth  or Between teeth</td>
<td>/ز، س/</td>
<td>/s, z/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ت، د/</td>
<td>/*, *, d, t/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ض، ط/</td>
<td>/*, */</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/اث، ذ/</td>
<td></td>
</tr>
<tr>
<td>Front of tongue</td>
<td>Gum  or Frontal Palate (2)</td>
<td>/ج، ش/</td>
<td>/*, */</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ي/</td>
<td>/y/</td>
</tr>
<tr>
<td>Middle of tongue</td>
<td>Frontal Palate</td>
<td>Non</td>
<td>Non</td>
</tr>
<tr>
<td>Back of tongue</td>
<td>Dorsal Palate (3)  or Epiglottis</td>
<td>/ك، خ, /</td>
<td>/*, k/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/ق/</td>
<td>/q/</td>
</tr>
<tr>
<td>Root of tongue</td>
<td>Gullet (throat)</td>
<td>/خ، ح/</td>
<td>/*, */</td>
</tr>
</tbody>
</table>

* - Refers to the absence of an exact English equivalency. However, international symbols are available (see Table 2.4).

(1) - Gum: refers only to the inner gum area of the upper front teeth.

(2) - Refers to the 'caving-in part' of the mouth; area at the front side of the palate.

(3) - Refers to the area in front of the epiglottis.
Table 2.4 - Lists Arabic consonant phonemes, each with its own description (AlKhuli, 1990).

<table>
<thead>
<tr>
<th>No.</th>
<th>Arabic Phoneme</th>
<th>Quality of sound: The trend of breathing</th>
<th>Quality of sound: State of the vocal cords</th>
<th>Place of production</th>
<th>International Phoneme Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ت</td>
<td>Halting</td>
<td>Whispering</td>
<td>Teeth</td>
<td>t.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ط</td>
<td>Halting</td>
<td>Whispering</td>
<td>Teeth / M</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ك</td>
<td>Halting</td>
<td>Whispering</td>
<td>Dorsal Palate</td>
<td>k.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Back of tongue)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ق</td>
<td>Halting</td>
<td>Whispering</td>
<td>epiglottis</td>
<td>q.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Back of tongue)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ء</td>
<td>Halting</td>
<td>Whispering</td>
<td>Larynx</td>
<td>?</td>
</tr>
<tr>
<td>6</td>
<td>ب</td>
<td>Halting</td>
<td>out-spoken</td>
<td>Upper lip</td>
<td>b.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Lower lip)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>د</td>
<td>Halting</td>
<td>out-spoken</td>
<td>Teeth</td>
<td>d.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>ض</td>
<td>Halting</td>
<td>out-spoken</td>
<td>Teeth / M</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>ج</td>
<td>Mixed</td>
<td>out-spoken</td>
<td>Gum</td>
<td>j.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Front of tongue)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>ف</td>
<td>Friction</td>
<td>Whispering</td>
<td>Upper teeth</td>
<td>f.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Lower lip)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>ث</td>
<td>Friction</td>
<td>Whispering</td>
<td>Between teeth</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of Tongue)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>س</td>
<td>Friction</td>
<td>Whispering</td>
<td>Gum</td>
<td>s.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>ص</td>
<td>Friction</td>
<td>Whispering</td>
<td>Gum / M</td>
<td>S</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Phoneme</td>
<td>Articulation</td>
<td>Segment</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------</td>
<td>--------------</td>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>ﺷ</td>
<td>Friction</td>
<td>Whispering</td>
<td>Gum (Front of tongue)</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>ﺧ</td>
<td>Friction</td>
<td>Whispering</td>
<td>Dorsal Palate (Back of tongue)</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>ﺧ</td>
<td>Friction</td>
<td>Whispering</td>
<td>Gullet /throat (Root of tongue)</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>ﺡ</td>
<td>Friction</td>
<td>Whispering</td>
<td>Larynx</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>ﺩ</td>
<td>Friction</td>
<td>out-spoken</td>
<td>Between teeth (Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>ﺣ</td>
<td>Friction</td>
<td>out-spoken</td>
<td>Gum (Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>ﺡ</td>
<td>Friction</td>
<td>out-spoken</td>
<td>Dorsal Palate (Back of tongue)</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>ﺝ</td>
<td>Friction</td>
<td>out-spoken</td>
<td>Gullet / throat (Root of tongue)</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>ﻪ</td>
<td>Nasal</td>
<td>out-spoken</td>
<td>Upper lip (Lower lip)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>ﻥ</td>
<td>Nasal</td>
<td>out-spoken</td>
<td>Gum (Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>ﻟ</td>
<td>Single-Sided</td>
<td>out-spoken</td>
<td>Gum (Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>ﺪ</td>
<td>Repetitive</td>
<td>out-spoken</td>
<td>Gum (Tip of tongue)</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>ﺔ</td>
<td>Slippery</td>
<td>out-spoken</td>
<td>Upper lip (Lower lip)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>ﻰ</td>
<td>Slippery</td>
<td>out-spoken</td>
<td>Frontal Palate (Front of tongue)</td>
<td></td>
</tr>
</tbody>
</table>

M – Refers to the addition of a deep magnified sound via moving the back of the tongue in such a way that it almost touches the backside of the roof of the mouth.
Finally, AlKhuli (1990) in analyzing the Arabic phonemes in terms of production ease and common usage (i.e. popularity) found that the more easily pronounced the phoneme the more it becomes popular and used in a language and vice versa.

AlKhuli (1990) determined the phonemes that are very popular, moderately popular and least popular which are as follows:

Most popular: ل ت ن م ع ي ر و
Moderately popular: ع ه ب د ف س ك ف ح ج
Least popular: ط ص ذ ن ذ غ ش ض ظ ز

The Morphological System of the Arabic Language

The Arabic Language displays non-concatenated morphological processes. Typically, a concatenated process is one in which formation of a word in a particular language is made up of sequences of morpheme segments connected together in a series of linear order as in the English word 'trans-transport-ion'. However, with Arabic belonging to a non-concatenated morphological process, "simple words are commonly formed on the basis of a discontinuous root of three or four consonants (e.g. /k-t-b/) between which sets of vowels are inserted (e.g. [katab] ‘he wrote’; [kitaab] ‘a book’; [kutub] ‘books’, etc.; Be’land & Mimouni, 2001: p. 83 - 4)

Vocalic morpheme

i a

Template

C V C V V C

Consonantal root

k t b

Figure 2.3 - An example of an internal representation of the word [kitaab] ‘a book’ in Arabic (adopted from Be’land & Mimouni, 2001: p. 84)
Moreover, in Arabic the prefixation, infixation, and suffixation morphological processes are very widespread (see Figure 2.4). The grounds for semantic identification of an area of lexicon is usually carried out through locating the discontinuous consonantal root, whereas the discontinuous set of vowels indicate the lexical entry and defines its functional or grammatical categories. The Arabic language is an agglutinative language where a single word can retain within it information relating to a whole English sentence. More specifically, the morphological processes of an Arabic word, such as person prefixes, negative suffixes, and tense suffixes could all be added to the consonantal root. For example an Arabic word such as [ykaatiban] can signify gender (male/female), number (one/two/more items or persons), and tense (past/present/imperative), where in this case the word [ykaatiban] has discontinuous consonantal root of [k t b] and refers to two male writers writing in the present tense. Therefore, as it can be seen that the Arabic language is a highly derivational morphological process.

**Prefixation**

[maktab] 'office'

**Infixation**

[kitaab] 'book'

**Suffixation**

[kitaabat] 'writings'

Figure 2.4 - *An example of words produced from the consonantal root of [k t b] via the morphological processes of prefixation, infixation, and suffixation.*

To summarize, the Arabic language can signify two forms of orthography: deep and shallow. In its original form, when all the diacritics are displayed, it becomes a highly transparent, shallow language with a nonconcatenated morphological processes and a homographic structure that has an agglutinative quality to it. Usually, within a single word the diacritics provide information about its phonology. In addition to accurate word pronunciation, the diacritics allow for proper semantic derivation of word meaning. Morphological processes of prefixation, infixation, and suffixation provide information about type of gender, grammar, and function.
CHAPTER 3

Theories of Dyslexia and Their Relations to Models of Reading
Chapter 3

Theories of Dyslexia and Their Relations to Models of Reading

Introduction

Of universal concern is the assurance, regardless of culture that individuals in their early years have the opportunity to gain a certain standard of literacy that would enable them to function adaptively within their settings; where literacy is defined as the "ability to read and write" (Saksena, 1970, p. 11). A distinction should be made between a person being illiterate and a person having reading difficulties. The former person is someone who has not had the opportunity to learn how to read and write, whereas the latter person is someone who was offered the opportunity to learn but found great difficulties in learning to read and write. According to the 1981 Education Act, learning difficulties had been defined as: “Any difficulty of such a nature that the child requires something more than, or different from the majority of other children of the same age in order to benefit from the education process”, (see Doyle, 1999, p.72). One such learning difficulty is dyslexia that will be dealt with and discussed in the following chapter.

Over the years dyslexia has been given many definitions, sometime under different labels. Some definition share certain similarities, others are different; although, as will be seen, all agree that it is a reading problem. Doyle (1999) in his chapter “Dyslexia Examined” provides seven definitions for dyslexia that have been put forward by renowned and highly respected bodies of authorities during the period from 1968 – 1989. These are as follows: The World Federation of Neurology (1968), the British Dyslexia Association (1989), Rutter, Tizard, and Whitmore (1970), Tansley and Panckhurst (1981), the Dyslexia Institute (1989), and the Department of Education and Science (1972; cited in Doyle, 1999).

The World Federation of Neurology (1968) defined dyslexia as: “A disorder in children who, despite conventional classroom experience, fail to attain the language
skills of reading, writing, and spelling commensurate with their intellectual abilities”.
In addition, this same Federation has also termed it as ‘Specific developmental dyslexia’ and defined it as: “A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It depends on fundamental cognitive disabilities which are frequently of constitutional origin.” As it could be seen that the World Federation of Neurology in both its definitions, perceives the learning difficulty as a disorder, in which a child of adequate ability and who despite being taught, experiences difficulties mainly in the area of reading. Whereas the British Dyslexia Association (1989) defines dyslexia as: “A specific difficulty in learning, constitutional in origin, in one or more of reading, spelling and written language which may be accompanied by difficulty in number work. It is particularly related to mastering and using written language (alphabetic, numerical and musical notation) although often affecting oral language to some degree”. In this definition, there is no mention of ability or previous teaching experiences, nor is it perceived as a disorder but appears to agree with the ‘World Federation of Neurology’ in that dyslexia is associated with difficulties mainly in the area of reading as well as other related areas, e.g. spelling and writing. On the other hand, Rutter, Tizard and Whitmore (1970) perceive dyslexia as a ‘Specific Reading Retardation’ and define it as: “An attainment on either reading accuracy or reading comprehension which was 28 months or more below the level predicted on the bases of each child’s age and short WISC IQ”. In their definition, Rutter, Tizard and Whitmore appear to agree with the above bodies on the area of difficulty being reading as well as sharing the same opinion as the ‘World Federation of Neurology’ on associating the difficulty to a child’s IQ. However, what is interesting about this definition is in the operational nature it offers in pin pointing those children with reading difficulties through displaying an attainment lag in their performances as explained in the definition.

However, Tansley and Panckhurst (1981) perceived dyslexia as a ‘Specific Learning Difficulty’ and define it as: “those who in the absence of sensory defect or overt sensory damage, have intractable learning problem in one or more of reading, writing, spelling, and mathematics, and who do not respond to normal teaching. For those children, early identification, sensitive encouragement and specific remedial
arrangements are necessary”. Tansley and Panckhurst appear to agree with World Federation of Neurology in the inability of the child to improve despite the educational opportunity offered, although they do perceive it as simply more of a problem than a disorder. In addition, the Dyslexia Institute (1989) also perceives dyslexia as ‘Specific Learning Difficulties’ but differs from Tansley and Panckhurst (1981) in that they see dyslexia in terms of deficiencies in certain areas rather than a problem. It defines it as: “organizing or learning deficiencies which restrict the student’s competencies in information processing, in motor skills and working memory, so causing limitation in some or all of the skills of speech, reading, writing, essay writing, numeracy and behaviour”. It must be noted that the Dyslexia Institute appears to perceive deficiency in a wider scope than the simple academic areas of reading, writing, spelling, and math but includes within its definition as well deficiencies in behavior, working memory, motor skills, speech, and information processing. On the other hand, The Department of Education and Science (1972) perceived dyslexia in a more restricted manner by labeling it as a ‘Specific Reading Difficulty’ and by defining it as: “A descriptive term used to indicate the problem of the relatively small portion of pupils ‘whose reading (and perhaps writing, spelling, and number) abilities are significantly below the standards which their abilities in other spheres would lead one to expect’” (Doyle, 1999).

Despite the many definitions, dyslexia at one point in time was defined within a single behavioral framework. This helped in defining dyslexia operationally. A large discrepancy between a student's scores on a standardized intelligence test and his/her score's on a standardized reading test was indicative of being dyslexic. In the early years of research this was very beneficial because it helped to give thrust to dyslexia research. However, in recent years such a perspective has received much criticism. For one, the operational definition is insensitive to an individual with low IQ, because the difference between the IQ score and the low reading score would be smaller than the cut-off point associated with a discrepancy definition (Miles & Haslum, 1986). Hence, allowing those low IQ children who may be dyslexic to pass through the web of diagnosis and not receive the necessary help that will reduce their reading difficulties. Moreover, Fletcher et al. (1992) had questioned the validity of discrepancy-based definitions of reading disability. Evidence has been found that
appears to indicate that there were no significant differences on phonological and orthographical processing tasks between dyslexics who showed a discrepancy between IQ and reading levels and those who did not show such a discrepancy (Stanovich & Siegel, 1994). Given that there were no differences between high and low IQ groups on such defining characteristics of dyslexia, there was no reason to have separated them and, as such, no obvious reason to have used a discrepancy method as a way of diagnosing dyslexia.

Another criticism comes from researchers’ attempts to explain dyslexia within different frameworks, resulting in a potential confusion in the dyslexia research and practice. For example some researchers have explained dyslexia within a biological framework (Livingstone, et al., 1991; Galaburda, 1993a; Lovegrove, 1994; Eden et al., 1996), others within a behavioral (Siegel, 1992) or cognitive (Wagner & Torgesen, 1987; Goswami & Bryant, 1990; Snowling & Nation, 1997; Snowling, 2000) or both (Snowling & Hulme, 1994). A fuller understanding of the various perspectives given to dyslexia will be given below under the title: Theories of Dyslexia. Finally, a third criticism comes from the consensus that is emerging in dyslexia research that dyslexia is a neuro-developmental disorder with a biological origin (Frith, 2002). The latter perspective lends support to Miles’ (1994) call for taxonomy in distinguishing dyslexics from non dyslexics. This he recommended doing by looking into research and 'lumping' together what usually dyslexics could and/or could not do and accordingly set up new tests or use existing tests that would tap those areas of difficulties. As research findings accumulate more precise information could be gained to determine true dyslexics and their subtypes (i.e. 'splitters' as Miles defines it because the findings are split to form a picture for the various subtypes). For this reason Miles (1994) argued that the use of discrepancy procedures was suitable but that it had been used for the wrong reason. That is according to Miles (1994), a good taxonomy, based on findings from research in different areas should at least include, a phonological component and a reasoning skill component. Since IQ tests tap on those areas therefore it was useful to have used those tests albeit not alone but with other non IQ tests as well and that the interpretation of those IQ tests should be carried out, at least, along the lines of the components specified. By determining a 'taxonomy' for dyslexia in this manner, not
only would the diagnosis of dyslexia be facilitated but in addition greater
advancement in understanding the underlying causes of dyslexia could be reached
(Miles, 1994).

Furthermore, as it will be seen, the amount of information from the research on
dyslexia is overwhelming and in order to be able to benefit from such researched
areas, it becomes important to attempt to reconcile the various findings explaining
poor reading performances within a common view. Morton & Frith (1993; 1995) have
attempted to take such a step. They looked for a neutral framework within which to
compare the effects of the different theories of dyslexia. Morton & Frith's framework
consists of three levels: biological, cognitive, and behavioral; all of which are affected
by a fourth level, the environmental level, to different extents. The apparent reading
difficulties perceived among the dyslexic population could be placed at the behavioral
level. The explanations (or causes) given to the different behaviors could be placed at
their appropriate levels: biological, cognitive or environmental. For example, the
magnocellular theory could be placed at the biological level and the phonological
deficit theory at the cognitive level. Any causal environmental factors such as
teaching provisions, socio-economic factors, cultural attitudes, and emotional states
could be placed at the environmental level. Thus, by continuing to fill in the
information into Morton & Frith's hypothetical framework, the whole picture on
dyslexia may become apparent and in turn it may help resolve any discrepancies
among findings. In addition, placing findings in such a manner may provide insights
into new areas of explanations on dyslexia. With increasing research, the framework
may give way to a theory of dyslexia close to perceiving the human repertoire as a
whole as opposed to explanations covering only part of this repertoire. It must be
noted that Morton & Frith's hypothetical framework is mentioned not so much for it
to be used in the current research but in order to introduce the idea of how the topic of
dyslexia could be perceived in the light of the growing research. For example, the
findings of the current research on the predictors of the Arabic language could be
placed at the cognitive level of Morton & Frith's hypothetical framework.

The premise in the following chapter is that reading difficulties associated with
dyslexia research could be indicative of normal reading development. By studying
theories that have been put forward as explanations for the presence of those reading
difficulties, some light could be shed on the actual reading process itself and on the
treatment of such difficulties. Therefore, this chapter discusses the compatibility
between theories of dyslexia and models of reading. The discussion begins by
clarifying the meaning of each of the two terms: dyslexia and reading. This is
followed by an overview of the most prominent theories of dyslexia and an overview
of the most prevailing models of the reading processes and the introduction of two
interactive models of reading. Subsequently, within the framework of the interactive
models, the compatibility of each model with theories of dyslexia will be discussed,
together with implication for future research.

The Meaning of the Term Dyslexia
The word 'dyslexia' comes from the Greek 'dys-', meaning difficulty with, and '-lexia',
meaning words or languages (Doyle, 1999). Hence, the word dyslexia is a mere
description given to an individual's reading difficulty that is of a specific nature and
should not be perceived as the cause for this difficulty. Dyslexia is a difficulty
characterized by an unusual balance of skills affecting the processing of information
(i.e. receiving, holding, retrieving and structuring information) and the speed of
information processing. In its broadest form, the term dyslexia can be said to
encompass two subtypes: acquired and developmental (Doyle, 1999). Acquired
dyslexia is found in adults who have learnt to read but as a result of brain damage due
to certain unfortunate events such as strokes, drugs, accidents, tumours, psychiatric
disorders or aging, they have difficulties in re-learning this process of reading again.
Developmental or congenital dyslexia is the subtype most often referred to by the
term dyslexia and is usually discussed in terms of its occurrence among children
(Doyle, 1999). Distinction of types of dyslexia was clarified in order to put the reader
in the proper perspective and for a better understanding of the interpretations of the
current research and their implications. The current research will be concerned with
developmental dyslexia. Therefore, whenever the word dyslexia appears it will refer
to developmental dyslexia, unless otherwise stated.
The Meaning of the Term Reading

Reading is a cognitive dynamic process which is self-directed by the reader in many ways and for many purposes (Gibson and Levin, 1978). Reading could involve examining symbols by sight, either in an abstract form such as when reading words or numbers or in a concrete form such as when reading road signs, or by touch such as when reading the Braille language. Each way is used for its own purpose and with the final aim of reaching a state of adaptation with the environment. More specifically, the reading process that will be of concern in the current study is one that is related to spoken languages; one which involves the translation of grapheme (e.g. letters) into sounds, giving a comprehensible piece of information in the particular language of concern.

The process of learning to read involves learning to identify words by the decoding of written symbols to sounds, in order to extract meaning and in which the reader interacts with the text to construct meaning. This construction involves the reader's ability to activate prior knowledge, use reading strategies and adapt to the reading situation. The goal of learning to read is to achieve independency, comprehension and fluency, where independency refers to the ability to read anything one can say or understand in his/her language without depending upon another's help. Comprehension refers to the ability to grasp something mentally and the capacity to understand ideas and facts. On the other hand, fluency refers to the ability to read effortlessly, smoothly, and automatically (Schreiber, 1980; Wolf & Katzir-Cohen, 2001); and where the development of accuracy and proficiency of the reading material will naturally come about in the process of developing fluency allowing for an effortless decoding of the text material and in turn for a reading that is smooth and accurate, leaving more attention to be focused on comprehension (Wolf & Katzir-Cohen, 2001). In addition, fluency development is perceived to tap on every process (orthographic, phonological, semantic, morphological and syntactic knowledge systems) and sub-skill (sub-lexical and word-level) that is involved in reading (Wolf & Katzir-Cohen, 2001).
Theories of Dyslexia

There are many different theories of dyslexia at the cognitive-behavior and biological-behavioral levels. The particular level explored depends on the interest of the researcher. However, each avenue explored adds further to the progress in the particular field of interest and despite the partiality of knowledge gained, it sheds greater perception on the overall picture of dyslexia and in turn in the way they could be handled in the future. In addition the similarities in findings helps in strengthening support for a particular theory whereas the divergence in findings helps to create new areas of exploration for further advancement in the particular area under study. Hence, whatever the results of the different levels of research are, they will all help in understanding the studied area better.

It must be noted that the use of the double terms (e.g. cognitive-behavior or biological-behavioral) rather than the use of each term in isolation is because theories are usually put forward in order to explain differences in observed behaviors and/or behaviors of individuals who are deviating from the norms of expected behaviors. Since this 'behavior' is part of a human repertoire then a rational explanation for its presence would have to lie within a framework that is either cognitive or biological or even both. And regardless of the level of explanation put forward, the 'behavior' will always be the output to it. Thus it is only logical to explain theories within two or three levels rather than only one. However, this does not necessarily specify the relationship between the levels. Such issues are for research to determine.

Overall, at the cognitive-behavioral level four main theories have been put forward as an explanation for dyslexia: the Phonological Deficit hypothesis, the Phonological Representation hypothesis, the Double Deficit hypothesis, and the Psycholinguistic Grain Size theory; whereas at the biological-behavioral level, dyslexia research has moved in four directions. Research has looked into the genetic factors associated with dyslexia, the language areas of the brain associated with dyslexia, the structure of the cerebellum in dyslexics and the function of Magnocellular/transient systems among dyslexic individuals. A brief overview of each of the above mentioned theories will be dealt within the following sections below.
Research at the Cognitive-Behavioral Level: The Phonological Deficit, the Phonological Representation, the Double Deficit Hypotheses, and the Psycholinguistic Grain Size Theory.

Some of the major cognitive theories that have been put forward to explain for dyslexics poor performance in reading were the Phonological Core Deficit hypothesis (Stanovich, 1988), the Double Deficit hypothesis (Bowers & Wolf, 1993), the Phonological Representation hypothesis (Fowler, 1991, Swan & Goswami, 1997), and the Psycholinguistic Grain Size theory (Ziegler and Goswami, 2005). Although all appear to agree that dyslexics suffer from difficulties in phonological processing, they do diverge on minor issues. A phonological deficit is the most common cognitive explanation put forward for dyslexia (Snowling, 2000: Stanovich, 1994). It is perceived as the root cause of nearly all dyslexics' difficulties. In addition, it has been suggested that there are other skills available to the dyslexics, which influences the degree they are able to compensate and develop their reading skills despite their phonological difficulties; thus giving rise to the different subtypes of dyslexia observed (Rack et. al., 1992; Snowling, 1987).

For purposes of clarification, a phonological deficit entails difficulty in making use of the information that is related to the sounds of words when processing written and oral language. The major components of phonological deficits involve phonemic awareness, sound-symbol relations, and storage and retrieval of phonological information in memory. It is in those areas of information processing where the various theories slightly diverge. Consequently, a definition of each of those major components and their role in dyslexics' reading progress will be briefly explained. This step is carried out for purpose of understanding the fine line separating the different theories mentioned and the position of research on dyslexia.

The Phonological Core Deficit hypothesis proposes that dyslexics experience difficulties in the phonological aspect of their language processing. In particular, deficits in phonological awareness make it difficult for them to learn to distinguish between the different sounds in their language system and hence hinder their progress in learning to read.
Phonemic awareness refers to the way an individual is gradually able to understand, discover, and become aware of the intricate play of meaning with sounds, such that sounds in a word could be heard clearly and the different words could be distinguished and understood. An individual with a good phonological awareness skill would be able to break down sentences into words, divide words into syllables, separate the syllables into sounds, and would be able to manipulate these parts into rhyme or other segments, delete sounds, substitute one sound for another and blend sounds together. Some of the type of tasks used to measure phonological awareness include counting phonemes, deleting phonemes, substituting phonemes, dividing words into phonemes (Rack, 1994), and finding the odd-sound out in a three or four word string (Bradley & Bryant, 1978). Studies have been able to show that with regards to phonological awareness, children with dyslexia have difficulty in this area (e.g. Bradley & Bryant, 1978; Bruck, 1993; Bruck & Treiman, 1990; Carroll & Snowling, 2004; Olson et. al., 1989; 1990).

Ramus (2004) has argued that phonological awareness is a necessary pre-requisite for the acquisition of reading. Ramus pointed out that despite reported cases of mild hearing loss, which disrupts the formation of phonological representations and often speech perception and production, the reading acquisition process in those cases could still take place (Briscoe et. al., 2001). Whilst there are dyslexic cases of mild phonological deficit, where speech perception and comprehension are intact that finds learning to read extremely difficult. Thus, implying that there must be something about normal phonological development that gets disrupted in the dyslexics but not necessarily among cases of mild hearing loss; and this Ramus argues could only be phonological awareness.

The storage of phonological information during reading entails creating a sound-based representation of the written words in working memory and eventually in the long-term memory. Deficits in the storage of phonological information result in faulty representations in memory which would lead to inaccurate applications of sound rules during reading tasks. Reading of nonsense or unfamiliar words is usually used to determine the storage aspect of phonological processing in long-term memory. By reading words that are not familiar or visually recognized, the dyslexic could only
resort to his/her knowledge of how graphemes were phonemically represented in their long-term memory and attempt to 'sound out' as they read such nonsense or unfamiliar words. Therefore, if dyslexics have a problem in the storage of phonological information then they would not be expected to perform well on such tasks. A number of studies have confirmed this in comparison to reading level-matched normal readers (Manis et. al., 1988; Olson et. al., 1989; Siegel & Ryan, 1988; Snowling, 1981), although others have failed to find such a difference (e.g. Treiman & Hirsh-Pasek, 1985; Velluntino & Scaln, 1987). However, Rack et al. (1992) have attempted to resolve the discrepancy in results among such studies. Two of the reasons they had put forward for the studies failure to find a phonological deficit among the dyslexic population were the usage of non-words that were too easy for the dyslexics and the usage of difficult tests in the matching of the groups.

Similarly, along this line of research, it has been proposed that dyslexics' phonological deficits may due to difficulties in first establishing and later in accessing adequate phonological representations (Fowler, 1991; Hulme & Snowling, 1992; Swan & Goswami, 1997). This is known as the Phonological Representation hypothesis. Hulme & Snowling (1992) have suggested that children create such representations by mapping the speech they hear on to the speech they produce and vice versa. Therefore, during development the child's language acquisition gradually accumulates a store of knowledge about the attributes of words. That is in addition to their sounds, their meanings, how they are used in sentences and their implications to the self, word attributes get established. These attributes are perceived to be organized in a system of representations which become activated during recognition of spoken words and which become retrieved during language production (Hatcher & Snowling, 2002).

The Phonological Representation hypothesis proposes that dyslexic children have difficulties in the phonological aspects of such representations of language processing. Unlike normal readers who are able to code sounds at the basic phoneme level (e.g. individual sound unit like [I] [n]), the dyslexic children's representations are more coarse grained with sound units being coded in units larger than the phoneme (e.g. rhyme sized units like -ine; -ing). In turn, this may explain why
dyslexics, who are taught to read, can learn to read familiar words encountered regularly but not infrequent words or non-words. Therefore, as a result of their coarse-grain mappings, their reading development is constrained and they find difficulties in generalizing this information. To a certain extent, because the dyslexic children's semantic and syntactic skills are within the normal range, the dyslexics can compensate for their decoding difficulties by relying on the semantic and syntactic facilitation that is offered upon reading in context (Nation & Snowling, 1998). Moreover, mappings at the phoneme level allow for the development of automaticity in reading skills and thus in reading fluency (Hatcher & Snowling, 2002). Since dyslexics are perceived to decode at a level above the phoneme level, it would be expected that their rate of reading skill would be slow. Furthermore, the phonological representation hypothesis has been perceived to offer a causal framework for all the difficulties experienced by dyslexics at the cognitive level, particularly the deficits in phonological awareness and working memory tasks (Goswami, 2000).

However, Ramus (2001) has argued that phonological representations and their processing have not been sufficiently tested. He pointed out that phonological representations embodies aspects of language processing such as phonotactic regularities, patterns of phoneme assimilation and alternation, in addition to supra-segmental knowledge concerned with syllable structure, stress, intonation and rhythm (i.e. the sub-lexical aspect of phonology), that have not been researched. Through a hypothetical task analysis of all the tasks that have been used to investigate phonological deficit, it was found that they all tap on to the sub-lexical phonological aspects of language processing; and that this was the only phonological representation that was produced by all the tasks (Ramus, 2001). Although the finding is only theoretical and empirical evidence is required, it opens up a totally new line of perspective that may shed a deeper understanding of the nature of phonological deficit and the process of reading acquisition in general.

The retrieval of phonological information from long-term memory refers to how the child remembers pronunciations of letters, word segments, or entire words. Children with dyslexia may have difficulty in this area, which leads to slow and inaccurate recall of phonological codes from memory. Naming of familiar pictures or objects
that are infrequently encountered (e.g. stethoscope), numbers, letters and colours could be taken as a measure for testing the retrieval aspect of a dyslexic's phonological processing. Individuals with dyslexia have been found to show difficulties in such tasks (Badian, 1993; Blachman, 1984; Catts, 1991). The Double Deficit hypothesis attempts to explain findings that there are some dyslexics who have a phonological processing deficit as well as a deficit in identifying visual information very rapidly (Bowers & Wolf, 1993). This theory proposes that there are two subtypes of dyslexic readers: One with a single deficit, either a naming speed or a phonological deficit and a second with a double deficit, having difficulties in both naming speed and phonological processing. In addition, the theory suggests that the second subtype of dyslexic readers are among the worst readers because with their double deficits, their compensatory routes for reading efficiently become somewhat limited. Allor (2002), in summarizing research studies that analyzed the shared and unique contributions of phonemic awareness and rapid naming to reading development, found support for the double deficit hypothesis and found that the former phonological variable (phonemic awareness) appeared to play a role in the growth of word reading skills from kindergarten up to at least grade five (Torgesen et. al., 1997); whereas the contribution of the latter phonological variable (rapid naming) appeared to be clear only in the early stages of reading development to about the second grade. Also, there was suggestive evidence that rapid naming may have uniquely contributed to explaining differences in reading abilities among older students with reading difficulties. Such evidence appears to suggest that there may be different forms of phonological processing required at different stages of reading development. In turn, it could be argued that the level of a dyslexics reading ability could be used to indicate his/her form of phonological deficit and vice versa.

Ziegler and Goswami (2005) put forward a psycholinguistic grain size theory to explain normal reading acquisition and developmental dyslexia across languages. It is argued that the way phonology is represented in a particular language, will affect the process of development of the reading acquisition in that particular language. The phonological unit of a language is referred to as grain size (Ziegler and Goswami, 2005). A grain size could range from words, syllables, onset and rime and phonemes (taken from largest to smallest grain sizes). According to this theory reading
accurately demands the acquisition of the smallest grain size (phoneme) which will occur only after formal instruction or training has begun. Prior to learning to read, children will learn to access grain sizes of words and syllables albeit at different developmental rates depending on the language of the child. With formal instruction, the extent of transparency of a particular language will affect the facilitation of gaining access into the phoneme level. Ziegler and Goswami (2005) argue that with dyslexics even in the most consistent orthographies, where the grapheme-phoneme recordings might be found to be quite high, they will still have phonological difficulties at the smallest grains sizes, in particular, in their inability to attain automaticity.

To summarize, a cognitive explanation of dyslexia entails an explanation that incorporates within it some form of phonological processing deficit. The specifics of such an explanation still require further research for clarification. What is apparent is that within an information processing model, dyslexics appear to have phonological deficits at the perception, storage, and/or retrieval areas. The nature of the phonological deficits at each of those stages of information processing has been explained within the perspectives of the different cognitive theories of dyslexia. However, there appears to be a need to perceive the phonological process as consisting of two levels: the lexical and sub-lexical level of phonology, rather than only the one level and to make use of comparative cross-cultural studies. Such an avenue of research may help reveal further information about the nature of phonological processing which could be beneficial to both the understanding of the dyslexics reading problems and the understanding of the process of reading acquisition. Furthermore, research studies should be aware that the nature of phonological processing as a pre-requisite to reading may vary at the different reading stages.
Research at the Biological-Behavioral Level: Explanations of Dyslexia at the genetic Level

Various researchers have sought to identify the genetic basis for dyslexia using different methods of genetic analysis. Research in this area has mainly focused on family studies, twin studies and molecular genetic analyses. Family studies have attempted to estimate the degree of dyslexia inheritability within different families depending on the number of infected probands. Such studies have shown that if at least one member of the family had dyslexia, there was a higher than normal probability that other members would also suffer from reading problems. The exact probability relied on the degree of relatedness. For example, it has been found (Wolf & Melngailis, 1994) that the percentage of affected siblings in a family differed depending on whether a single parent was affected or both of the parent members were affected, such that the percentage of affected siblings increased respectively from 28, 45 to 79 if only the father, if only the mother or if both parents were affected (reported from table 4 in Schulte-Korne, 2001). Similar findings were reported in other studies (Schulte-Korne et. al., 1996; Gilger et. al., 1996) despite the fact that the diagnostic criteria they had employed for determining probands and affected parents were different. However, such an observation was not considered enough for inferring a genetic influence, because families also share similar environments which would be expected to affect the members' level of reading achievement (Schulte-Korne, 2001; Wood & Grigorenko, 2001). Therefore, a means of differentiating the interaction of genetics and environmental factors was resorted to by incorporating twin studies (Schulte-Korne, 2001).

Twin studies attempt to differentiate between the influence of the heritable and environmental factors on reading and spelling by benefiting from the stronger genetic relatedness of members of monozygotic twins (MZ) to each other than members of dyzygotic twins (DZ). The two largest twin studies were the Colorado Twin Project (Castles et.al., 1999; DeFries et.al., 1987; Olson et.al., 1989) and the London Twin study (Stevenson et.al., 1987). Stevenson et al., (1987) studied the reading skills of 285 pairs of thirteen years old twins taken from the general public. They found a high heritability of spelling disability, which reached 0.75 when intelligence was
controlled. Such findings were replicated by Olsen et al., (1994). Despite the failure of the London study to find a significant heritability for word recognition, Schulte-Korne (2001) in reviewing all other twin studies have found a heritability for word reading at about 50% and concluded that overall “it appears that 50 to 60% of reading and spelling disorder variance could be explained by genetic factors” (p.988).

In addition, researchers have used twin studies to examine the heritability of phonological and orthographical processing, both of which correlate with reading and spelling abilities. Non-word reading was used as a measure for phonological processing in both the Olson et al., (1989; 1994) and in the Stevenson (1991) studies. Where as orthographic processing was measured by different means in each of these studies. In the Olson et al., (1985) study it was measured by means of a pseudo-homophone task which involved recognizing the correct orthographic pattern of a word as quickly as possible out of two presented stimuli that had similar sounds but varied at the orthographical level, e.g. rane and rain. In the Stevenson (1991) study orthographic processing was measured by means of two tests: reading of irregular or exceptional words and by a homophone recognition task which involved determining whether two stimuli sounded the same or different e.g. higher and hire. In both studies significantly high heritability was found for phonological coding. However, less influence was found for orthographic processing because only one of the tasks, the homophone recognition task in the London study showed significant results. This was taken as evidence that phonological processing was more influenced by genetics than orthographic processing. Later on, after taking into consideration methodological issues such as increasing sample size and changing the selection criteria for the probands, significantly high heritability was also found for orthographic processing (Olson et. al., 1994). Hence, eventually research supported the findings that both phonological processing and orthographical processing were under genetic influence.

Further support was derived from the use of bivariate analysis (Olson et.al., 1994). This analysis is a statistical technique derived by De Fries & Fulker (1985). However, despite the genetic influence considerable amount of variance could be explained by environmental factors such as the different quality of reading instruction or different print exposure (Cunningham & Stanovich, 1993; Olson & Wise, 1992). Moreover, reading experience was found to help improve reading of words but not help improve
performance in phonological coding tasks (Campbell & Butterworth, 1985). However, although tested on a small group of reading disabled subjects, it was found that the nature of the feedback in a reading program affected performance in phonological coding tasks (Olson et. al., 1989). Subjects who had received feedback training via the segmentation of words at the syllable level were found to be significantly advantageous to those who received whole word feedback on phonological coding tasks. Larger samples need to be tested before a conclusive decision on the importance of the nature of feedback training that is required to improve phonological deficits among the reading disabled. In addition, this could further indicate that environmental factors could succeed in reducing the effect of heritability.

Molecular genetic analyses attempts to identify the particular gene that may be responsible for the measured familiality and heritability of the phenotype (Schulte-Korne, 2001) associated with findings from research in the dyslexia field. The first linkage analysis related to dyslexia was reported in 1983 by Smith et al., who linked dyslexia to chromosome 15. Further support for this linkage has come from studies (Smith et. al., 1991; Grigorenko et. al., 1997; Morris et. al., 2000) that have differed in the size and type of family samples. These studies argue for a linkage of reading (single word reading) and spelling to the same chromosomal region on 15q thus allowing it to be considered as a possible locus for dyslexia. Moreover, linkage analyses from this work and a further four different independent studies (Smith et. al, 1991; Cardon et. al., 1994; Grigorenko et. al., 1997; Fisher et. al., 1999; Gayan et. al., 1999; Grigorenko et. al., 2000) have shown evidence of linkage between various dyslexia phenotypes (e.g. single word reading, vocabulary, spelling and phonological awareness) and chromosome 6. It remains unclear the influence of these loci on the various cognitive processes and the relative contribution of these loci on reading and spelling. In future more advanced dyslexia studies in the area of molecular genetic could help locate the precise region on chromosomes 6 and/or 15 for each of the cognitive processes related to dyslexia, thus allowing early detection of dyslexia presence through genetic mapping and in turn for early intervention to take place.

Hence, so far in the attempt to better understand dyslexia, the biological studies at the genetic level have argued for four main conclusions. Firstly, research suggests that
approximately 50 – 60 percent of spelling and reading difficulties is heritable (Schulte-Korne, 2001). Secondly, orthographic and phonological processing may be in part, heritable (Stevenson, 1991; Olson et al., 1994). Thirdly, there is indication that the type of feedback that relies on segmentation of word at the sub-word level, as opposed to a whole word correction, is more successful in improving these heritable phonological processing skills (Olson et al., 1989). Finally, research suggests that dyslexia is linked to at least two chromosomal regions: 6 and 15 (Smith et al., 1983; Smith et al., 1991; Cardon et al., 1994; Grigorenko et al., 1997; Fisher et al., 1999; Morris et al., 2000; Gayan et al., 1999; Grigorenko et al., 2000).

Research at the Biological-Behavioral Level: Explanations of Dyslexia at the Brain Level

Early research involving post-mortem examination revealed differences in the structure of the brains of dyslexic individuals and non-dyslexic individuals, particularly in the language areas. In studying the brains of four males (Galaburda et al., 1985) and three females (Humphreys et al., 1990) who were deceased adults with dyslexia and had co-morbid diagnosis including attentional problems, language delay and in one case seizure, it was found that their brains contained a number of misplaced cells (ectopias). These ectopias were found in areas which are typically cell-free (the outer layer of the cortex) and mostly located in the left hemisphere in those areas associated with language: the perisylvian language area, the superior temporal gyrus containing Wernick's area and the inferior premotor and prefrontal cortex containing Broca's area (Galaburda & Rosen, 2001). Geschwind and Galaburda (1985) proposed that despite the importance of genetic factors, there were factors that in the course of prenatal and postnatal development modified the direction and extent of the structural differences found in the brains of different individuals. Specific attention was directed to the intrauterine environment (e.g. sex hormones) as a determinant of the structural asymmetrical pattern found in the brain. It was also observed that people with such brains were often quite creative and extra-ordinary rather than handicap (Galaburda, 1993b). As a result of human autopsy, animal
models were developed in order to study the relation between the difficulties dyslexics experience when processing changing sounds and the difficulties they experience when carrying out phonemic awareness tasks (Galaburda et al, 2001). Using a freezing technique, Galaburda et al, (2001) were able to induce cortical malformation in experimental rodents similar to those found in human dyslexic brains. In their study they concluded that it could be assumed that temporal processing deficits were the result of thalamic changes, the linguistic and meta linguistic problems to cortical changes and that the cognitive deficits were related to cortical damage in the prenatal period. In addition, Galaburda et al, (2001) proposed, based on their evidence, that cortical anomalies occurred first and early during fetal development, whilst the thalamic changes were of secondary effect following cortical malformation.

Moreover, new technologies, such as magnetoencephalography (MEG), positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), have enabled researchers to identify the differences in the structure of the living brain and the active processes within it. Using the MEG, it was found that eight 18-37 years old dyslexics failed to show activation in the left inferior temporo-occipital region upon the viewing of single words (Salmelin et. al., 1996). Hence, the perception of words as specific units appeared to be impaired in dyslexic individuals. Furthermore, converging evidence from a number of neuroimaging studies using fMRI, PET and MEG have suggested that fluent reading was related to the posterior system in the left hemisphere (Pugh et. al., 2000). In particular, fluent reading appeared to be related to the temporo-parietal area in the dorsal circuit and in the occipito-temporal area in the ventral circuit. A model was proposed for the word reading of individuals with dyslexia based on research findings (Pugh et. al., 2000). In Pugh et al.’s (2000) investigation, tasks were employed that varied the demands made on visual-spatial processing, orthographic processing, simple phonological analysis, and lexical semantic processing. They found differences between the disabled readers and the non-impaired individuals in the pattern of activation in several areas of the posterior left hemisphere. In addition, the reading disabled failed to show a systematic increase in activation as the orthographic-to-phonologic processing demands increased, whilst the non-impaired individuals succeeded in showing such a modulation in their
activation pattern. In contrast to the above findings, the reading disabled in comparison to the non-impaired individuals, showed greater activation pattern in the inferior gyrus and other frontal lobe areas in response to increased phonological demands. Accordingly, it was hypothesized that the dorsal region was responsible for integration of orthographic, phonological and semantic information, whilst the ventral region was believed to be involved in the remembrance of word forms and to contribute to fluent reading. More specifically, research on behavioral data has shown that dyslexic readers appeared to struggle with phonological analysis (Shankweiler et al., 1995; Snowling, 1998b; Snowling, 2000) and integration of this information with orthographic (Stanovich & Siegel, 1994; Harm & Seidenberg, 1999) and semantic information. This is supported by findings of decreased activity in the dorsal posterior regions of the brain (hypothesized to be responsible for integration of orthographic, phonological, and semantic information) and a decreased activity in the ventral posterior regions (hypothesized to be responsible in fluent reading). In compensation for this decreased activity, dyslexic readers appeared to show increased activity in anterior regions that are responsible for pronunciations of words in an attempt to support phonological analysis of the words. Thus, this model (Pugh et al., 2000) of the brain’s functioning in readers with dyslexia appeared to be consistent with the cognitive mechanisms that have been suggested by the behavioral data.

In addition, further support for the location of impaired areas in dyslexic individuals who showed high reliance on both the inferior frontal and the posterior right hemisphere regions was provided when using magnetic source imaging (MSI), the newest of the functional imaging methods (Papanicolau et al., 2003). Four studies were carried out on three groups of children: a group diagnosed as dyslexic, a second group as at risk of dyslexia and a third group as non-dyslexic. Papanicolau et al. (2003) found that the ‘at risk’ group displayed an activation profile similar to the older children who were identified as dyslexic. The profile the dyslexic and the ‘at risk’ groups displayed was little or no activity in the left superior temporal gyrus and inferior parietal areas and strong activities in the homologous regions in the right hemisphere. Such profiles were observed in a variety of phonological decoding tasks, regardless of whether reading meaningful or meaningless words (words or pseudowords) and regardless of task difficulty, at least within the range tested.
Furthermore, the evidence (Papanicolau et al., 2003) appears to provide support for the view that dyslexia is not a pathological condition but should be considered at the lower end of the normal distribution, because appropriate instructions appeared to shift the dyslexic subjects up to normal ranges.

The abnormal auditory processing found amongst dyslexics, has led some researchers to suggest the presence of accompanying anatomical abnormalities to be present in the auditory system. Galaburda et al., (1994) in studying a group of five dyslexic individuals and seven controls found that the latter group showed no brain asymmetry; whilst in the former sample, the medial geniculate nuclei (MGN) neurons which carry auditory information to the auditory cortex on the left side of the brain, were significantly smaller than on the right, with more small neurons and few large ones present in the left MGN of dyslexics. In turn, this was taken to imply that the lack of symmetry in the structure and layout of the small to large auditory neurons to be associated with dyslexics’ experiencing difficulties in processing auditory information. However, Galaburda et al.’s (1994) study did not control for handedness nor social status, which as Eckert and Leonard (2000) after reviewing 11 studies that were dated from 1993, have shown that these two factors appear to have an effect on brain symmetry. On the other hand, Eliez et al., (2000) after controlling for those two factors was able to support Galaburda et al.’s (1994) finding. Eliez et al., (2000) in a first study to report regional brain volumes and tissue compositions for the entire brain in a well defined sample where handedness and social status were controlled for, found a decrease in the tissue volume of the temporal lobes, particularly on the left side of the brain. It should be noted that temporal lobes have been associated with auditory and visual processing (Milner, 1968; Kolb & Wishaw, 1990), in which lesions on the left side had resulted in decreased recall of the verbal and visual content including speech perception and lesions on the right side resulted in decreased recognition of tonal sequences and musical abilities (Milner, 1968). Moreover, analysis of tissue composition in the Eliez et. al. (2000) study revealed that the reduction was mainly attributable to decreased gray matter within the left temporal lobe which was suggested to reflect a regional decrease in neural number. This in turn could have resulted in the reading impairment experienced by dyslexics. Thus
suggesting that some dyslexics have anatomical abnormalities in the auditory system which may be associated with abnormal auditory processing.

In a fairly recent study, dyslexic individuals, relative to controls, were found to have a significantly smaller total cerebral volume and a reduced gyrification index, with no apparent changes in the cortical thickness, the ratio of the gray to white matter or the cross-sectional areas of the corpus callosum and medulla oblongata (Casanova et. al., 2004). The decreased gyrification in the presence of preserved cortical thickness was perceived to allow for a greater degree of cortical integration at the expense of a slower response time. Hence, indicating that the reduced brain size and the degree of neural gyrification may alter the information processing capacity.

Therefore, research at the brain level has at least indicated that there are significant minor differences between the brain structures of individuals with and without dyslexia, particularly in the language areas associated with phonological and orthographical processing and with the regions associated with speed of information processing. There is a tendency for dyslexic individuals to demonstrate asymmetrical processing, reflected in over activation of the frontal areas in the anterior regions of the brain and under activation of the posterior language regions in the left hemisphere, which appears to develop during fetal development.

**Research at the Biological-Behavioral Level: The Cerebellar Theory**

Although research at this level is still dealing with the brain, its focus is mainly on a specific region: the cerebellum (the hind-brain). The cerebellum is concerned with computing movements, directing attention, measuring time, and many other motor and cognitive functions. It is involved in guiding movements based on sensory feedback especially from vision.

The Cerebellar theory had been put forward as an explanation for dyslexia (Nicolson & Fawcett, 1990; Nicolson et. al., 2001) from biological as well as cognitive evidences on dyslexic performances. The theory advocates that a dysfunction in the cerebellum offers an explanation to all the manifestation of dyslexia. The cerebellum
is argued to affect speech articulation and more general motor processing, including balance and automatization of over learned tasks such as cycling, swimming, and reading. It is also argued to process information from the language areas and the magnocellular regions of the brain (used for visual processing) and any weakness in any or all of such processing may account for the different types of dyslexia. For example, the proponents of the Cerebellar theory entertained the idea of a distinct cerebellar and magnocellular subtypes of dyslexia (Fawcett & Nicolson, 2001). At the biological level, brain imaging studies have shown anatomical, metabolic, and activation differences in the cerebellum of dyslexics compared to controls (Rae et. al., 1998; Nicolson et. al., 1999; Brown et. al., 2001; Leonard et. al, 2001). Moreover, functional imaging studies of the cerebellum of dyslexic individuals and controls have shown reduced activation in a motor sequence task (Nicolson et. al., 1999), in a reading task (Brunswick, et. al., 1999) and in a word and non-word repetition task (McCroy et. al., 2000) of dyslexics. Since the cerebellum affects speech articulation and the automatization process, then a deficient cerebellum may lead to deficient phonological representations and, among other things, poor learning of the grapheme-phoneme correspondences. Cognitive support for the cerebellar theory comes from evidence of poor performance of dyslexics in dual tasks demonstrating impaired automatization of balance (Nicolson & Fawcett, 1990), in time estimation, in a non-motor cerebellar task (Nicolson et. al., 1995), and in a large number of motor tasks (Fawcett et. al., 1996). However, studies have been inconsistent in providing cognitive support for the biological dysfunction of the cerebellum (Yap & van der Leij, 1994; Wimmer et. al., 1998; Ramus, Pidgeon, & Frith, 2003). It has been suggested that the reason for the inconsistencies may be due to samples inclusion of co-morbid individuals having both dyslexia and some other developmental disorder such as attention deficit/hyperactivity disorder (ADHD) (Wimmer et. al., 1998). In addition, studies have failed to support that reading impairment (as well as phonological impairments) in dyslexics is mainly caused by cerebellar dysfunction (van Daal & van der Leij, 1999; Ramus, Pidgeon, & Frith, 2003; Ramus, Rosen, et. al., 2003).
**Research at the Biological-Behavioral Level: The Magnocellular Theory**

This is a unifying theory that has attempted to integrate all the findings within the visual, auditory, and tactile modalities. It has been argued that as the cerebellum receives inputs from various magnocellular systems in the brain, it is therefore expected to be affected by the general magnocellular defect (Stein et al., 2001). Thus, this theory manages to account for all manifestation of dyslexia in the different modalities through a single biological cause. However, as it will be seen that although strong evidence have been found supporting it, there are other studies that have not managed to confirm some of those findings nor have studies researched particular areas that may bare some relevancy to the theory such as the heritability of dyslexia and deficits in the somaesthetic motor skills.

For many years, the role of vision had been ignored. Some of the reasons that culminated to this were that most experts had viewed dyslexia as mostly a language problem especially since dyslexics were found having difficulties breaking sounds into their basic units and even when their reading problems had improved, they still experienced difficulties in their language sound system. At the same time, ophthalmologists could not find any differences between the eyes of good and bad readers (Hinshelwood, 1917).

However, the finding that the visual network is composed of two systems: the magnocellular system and the parvocellular system (Enroth-Cugel, & Robson, 1966; Shapley & Perry, 1986) in which it had been shown that dyslexic individuals have abnormalities associated with the magnocellular sub-system (medial and lateral geniculate nucleus) of the visual cortex (Lovegrove, Heddle, & Slaghuis, 1980; Livingstone et al., 1991; Galaburda & Livingstone, 1993; Stein & Walsh, 1997; Stein & Talcott, 1999) lead to confirmation of a number of psychophysical studies which supported the presence of two visual processing systems: sustained and transient (corresponding to the magnocellular and the parvocellular systems respectively), of which disabled readers had particular deficit in the transient system (e.g. Lovegrove, Heddle, & Slaghuis, 1980; Lovegrove et al., 1982; Martin & Lovegrove, 1984;
Slauhuis & Lovegrove, 1985). In addition, such findings lead to the expansion in the areas of dyslexia research to include the study of the visual system.

The magnocellular pathway is composed of large cells that carry out fast processes. The pathway is used for seeing motion, low contrast, stereoscopic vision, locating objects in space, and depth perception. The second pathway is composed of smaller cells, it is concerned with slower processes, and it is used to perceive color detail forms, stationary images and high contrast stimuli. The sensitivity of the magnocellular and the parvocellular components of visual processing have been assessed psychophysically using stimuli that selectively stimulated them (Merrigan & Maunsell, 1993). Such tests have shown that in some dyslexic children sensitivity to flickering stimuli (Talcott et al., 1998), to flickering low contrast coarse gratings (Mason et al., 1993) and to motion stimuli (Cornelissen et al., 1995, 1998; Eden et al., 1996; Demb et al., 1999; Stein, 2001) were lower than in normal readers, whereas no differences were found between both groups on colored and finely detailed responses.

It has been argued that the dyslexics' main problem in their experience of difficulty in learning to read lies in the persistence of information across fixations which results in the superimposition of images, hence indicating a deficiency in the transient/magnocellular pathway (Lovegrove, 1994). By removal of any such experiences of superimposition of images by the presentation of words one at a time, dyslexics' performances have been shown to improve (Hill & Lovegrove, 1992). Further confirmation comes from studies that have demonstrated that the deficit in the magnocellular pathway of the dyslexic individuals was associated with their inability to perceive the letters correctly (Talcott et al., 2000; Stein, 2001). Usually, reading requires perceiving the word stimuli visually, recognizing and remembering its orthographic form, decoding it into its corresponding sound format and producing it verbally and visually. Furthermore, proper development of orthographical skills requires high motion sensitivity and stable binocular control, both of which are dependent upon a good magnocellular functioning system. Since this system is found to be impaired among the dyslexics, therefore, it might be expected that their orthographical skills would be impaired. With the use of tests (e.g. the spelling of
irregular words such as 'yacht') that tap onto perceiving the orthographical aspects rather than the phonological aspects of reading, or pseudo-homophone tests which involve determining the correct spelling of a word from pairs of presented words that were phonetically similar but orthographically different (such as 'rain – rane'), it was found that there was a strong correlation between visual motion sensitivity and performance in the pseudo-homophone test (Talcott et. al., 2000) across the whole range of reading abilities, where good spellers had high motion sensitivity and bad spellers had low motion sensitivity. Similarly, binocular instability has been found to be correlated with most children who experience visual reading problems (Fowler & Stein, 1979; Stein & Fowler, 1980; Stein et. al., 1988; Stein & Fowler, 1993; Eden et. al., 1994). The quality of binocular fixation in a child determines the degree of steadiness in the way letters in a word appear and, in turn, determines the child's reading ability. All the above thus may help explain a dyslexic's experience when reading letters in that they appear to move around, to change places and merge with each other as has been reported by Morgan's (1896) first description of 'word blindness' when reporting the experiences of a boy named Percy.

The most convincing evidence on binocular instability in dyslexics comes from monocular occlusion studies in which covering the left eye of dyslexic children helped in improving the reading ability in some of the children (Stein & Fowler, 1985; Stein et. al., 1986). Moreover, the binocular instability experienced by dyslexics has been found to extend not only to words but to any small visual targets within any context (Riddell et. al., 1990), and dyslexics with binocular instability have been shown to neglect objects on their left visual field as opposed to their right on various types of tests such as ray figure copying, clock drawing, judgment of angles of lines, and cancellation tasks (Stein & Fowler, 1981; Eden et. al., 2003). This left neglect is an indication that there may be something abnormal about the right posterior parietal cortex of many dyslexics, particularly since these symptoms were found to be very similar to those adults whose right posterior parietal cortex had been damaged (Stein, 1994).

Over the years, with the discovery of the magno and the parvo cells and from the evidence between dyslexics and controls on signal processing, it appears that the
functional deficit in the magnocellular system is more of a general signal processing deficit that affects the different sensory and motor domains. Studies have been able to show that dyslexics not only have a deficiency in the detection of motion per se but appear to have more of a poor perceptual integrational deficit (Raymond & Sorensen, 1998). In addition, within the magnocellular theory, researchers have been able to explain poor readers’ performances not only from a visual aspect but have extended it to other modalities: auditory and touch, as well. The magno cells (large cells) that are specialized for temporal processing are present in all sensory and motor systems (Stein, 2001). In particular, the neurons in the auditory system which track the frequency and amplitude changes that distinguish phonemes are in the magnocellular divisions of the nuclei which relay auditory signals to the auditory cortex (Trussell, 1998). In line with this, Galaburda et. al. (1994) found, upon post mortem examination of dyslexic brains that neurons in the magnocellular division of the medial geniculate nucleus were distorted and smaller than in the controls.

Psychophysically, research has shown that in comparison to good readers, dyslexics required significantly larger changes in frequency or amplitude to distinguish different sounds (McAnally & Stein, 1996; Witton et. al., 1997, 1998; Menell et. al., 1999; Talcott et. al., 1999, 2000). However, dyslexics were not impaired on all auditory tasks; they only had problems in the modulations that were crucial for determining letter sounds. Dyslexics have been found to be just as good as controls at determining high rates of frequency modulation (240Hz) which are not usually required for the detection of phonemes (Moore, 1989). In many studies it has been found that subjects auditory and visual transient performance tend to be highly correlated with each other by either both being good or both being bad, suggesting that there might be a common underlying factor determining the development of all magno cells in the brain (Stein, 2001). Furthermore, using non-words such as ‘tegwop’ of which no orthographical familiarity nor meaning is present but which good readers were expected to easily produce (developed by Snowling, 1987) it was found that in groups of adults as well as in primary school children FM sensitivity was more highly correlated with measures of phonological abilities than with orthographical abilities (Stein, 2001). Such findings may argue for training dyslexics on FM sensitivity to help increase their phonological performance.
On the other hand, some researchers have argued that auditory deficits did not predict phonological deficits (Mody et. al., 1997; Schulte-Korne et. al., 1998; Bishop et. al. 1999; Marshall et. al., 2001; Rosen & Manganari, 2001; Share et. al., 2002). Moreover, not all studies on auditory processing were able to replicate findings of auditory disorders in dyslexics (Heath et. al., 1999; Hill et. al., 1999; McArthur & Hogben, 2001). Whilst in other studies only a subgroup of their dyslexic population were found to have auditory deficits (Tallal, 1980; Reed, 1989; Manis et. al., 1997; Mody et. al., 1997; Adlard & Hazan, 1998; Lorenzi et. al, 2000; Marshall et. al., 2001; Rosen & Manganari, 2001). Furthermore, upon comparison of the three major theories: the Phonological Processing Deficit theory, the Cerebellar theory, and the Magnocellular theory, support was only found for the first theory as being a sufficient cause for dyslexia; and only a portion of the dyslexic subjects were found to suffer from auditory deficit which may have aggravated the phonological processing deficit (Ramus, Rosen, et. al., 2003). Also, the nature of the auditory deficit, although not established, was not found to be consistent with the hypothesis of a rapid processing deficit related to a magnocellular dysfunction (Ramus, Rosen, et. al., 2003).

With regards to the touch modality, the large cells that detect vibration in the skin are in the dorsal column division of the somaesthetic system. Grant et. al., (1999) found reduced tactile sensitivity that was consistent with impaired magnocellular dorsal column function in dyslexics. However, Stoodley et. al., (2000) found only mild deficits in the mechanical vibrations of dyslexics. Hence, as with the auditory modality, not all dyslexics experience deficit in the touch modality.

In a related avenue of research, it has been established that there appears to be an association between antibody production and the magnocellular deficit through out the brain (Stein, 2001). The best understood linkage has been found on the major histocompatibility complex (MHC) Class 1 region located on chromosome 6 (Cardon et. al., 1994; Grigorenko et. al., 1997; Fisher et. al., 1999). Moreover, preliminary evidence has been found to suggest that certain forms of behavioral disorders (based on animal studies) may be due to maternal brain antibodies (Adinolfi, 1993). In particular to dyslexia, it has been found that mothers of some dyslexic children may develop antibodies, small quantities of which may cross the placenta and the blood
brain barrier and damage the developing magnocells (Vincent et. al., 2000). By injecting pregnant mice with serum taken from mothers with several dyslexic children, it was found that the behavioral performance of the pups on motor tests were similar to those perceived among dyslexics (Vincent et. al., 2002; 2003). However, it cannot be concluded that all dyslexia could be caused by such an antibody (Vincent et. al., 2002) or that the particular antibody is the cause to all manifestations of dyslexia; extensive research is required. It would be interesting to attempt to research the extent of relevancy of such findings on antibodies with the phonological deficit theory. In particular, whether concentration of the antibodies in dyslexic individuals varies with improvement in phonological processing.

In summary, the Magnocellular Deficit hypothesis appears to suffer in its inability to explain for the absence of sensory disorders in a portion of dyslexics and although the theory can explain for the presence of a visual or an auditory or a touch deficit, it is yet to be established whether the presence of only a particular sensory deficit or a combination of them may reflect different sub types of dyslexia. However, this should be resolved within a framework that attempts to explain the superiority of the phonological processing deficit theory over the magnocellular theory.

Models of Reading: A Brief Overview

Early models of reading were based on linear processing of information involving either a bottom-up or a top-down perspective. A bottom-up model involves the processing of information that begins from the lowest level of stringing letter sounds (phonemes) together to a more deeper level of semantic processing, where no higher level of processing would have any influence on the lower levels of processing. Some of the bottom-up theorists were Sperling (1970) and Gough (1972). Lovett (1981) pointed out that such theorist had been criticized mainly on the basis that they perceived cognition to be effectively isolated from perception. This in turn, appeared to contradict the actual definition of the processing of complex acts of information which usually were perceived to require interactions of lower and higher order processes and in which as Neisser (1967) had suggested perception in itself is an
active, cognitively influenced operation. Also, Rummelhart (1977), in criticizing the linearity processing provided a clear example in which it is explained that pronouncing certain words (e.g. read) correctly often requires the referral to the semantic and syntactic levels, hence, contradicting the main premise of the bottom-up model.

On the other hand, the top-down model consisted of processing the information in the opposite way to the bottom-up model. It begins from the deeper level of semantic processing focusing on what the reader brings to the text and continues towards moving to a lower level of processing which would involve a form of hypothesis-testing of letter-sounding relationship in order to predict the words in a text (Goodman, 1967). Supporters such as Kolers (1970) and Smith (1971) had been criticized, as mentioned in Lovett’s (1981) chapter, mainly on their failure to generate testable hypotheses and in their failure to explain how they had expected the sampling of words in a text to proceed. Moreover, the top-down model assumes that the higher level of cognitive processing is primarily concerned with facilitating word recognition, thus implying that good readers reading at a faster pace do not depend in their reading upon phonemic coding. However, such an assumption was refuted. Stanovich (1980), by reference to previous studies (e.g. Mitchell & Green, 1978; Weber, 1970) showed that good readers were more concerned in attending to graphemic information (i.e. the phonemic codes) than poor readers and that they were not necessarily more attendant to contextual cues than the unskilled readers.

The alternative perspective is most clearly presented by Rummelhart (1977) who argues that the reading process does not reflect any of the models of linear processing but rather involves more of an interactive processing. There have been many such theories of interactive processing that have been proposed. Some of which are the Context-Availability theory (Schwanenflugel, 1991), Schema theory (see Sadoski et. al., 1991), Parallel Distributed theory (Rummelhart, 1977), and the Dual Coding theory (Paivio, 1991). All of those theories share two assumptions in common. The first assumption is that there are interactions between different levels of processing during the act of reading. Second, these theories all assume that prior knowledge plays a role in reading.
In addition, in the opinion of this writer, because the reading process is a dynamic act, neither bottom-up nor top-down models are sufficient to explain it. A dynamic act could be better reflected by a processing that is interactive and not restrained by the direction in which the information is processed during the cognitive act of reading. Also, within the interactive theories, one theory, the Dual Coding theory (DCT), appears upon theoretical and logical grounds to provide a framework of the reading process that reflects more the reality of human nature than the other interactive models of reading. Apart from the DCT, the other interactive theories assume information to be processed in an abstract form with no objective reality and no association with sensory modality. The logical ground in this argument is that it is difficult to imagine how written information can be processed without use of the five human senses. Simply by taking examples from real life situations, where people get very attracted to a text they read which leads them to experience some form of emotion such as happiness, sadness, astonishment etc., it could be seen that such information when processed is not necessarily amodal in form. More specifically, a theory that lacks the use of sensory modality should be regarded with caution. However, this does not imply total acceptance of a theory that assumes its presence. Empirical research in support of it with all its other assumptions and premises is required. Sadoski & Paivio (2004) in their chapter do provide experimental evidence in support for their theory and against some of the other interactive models. They did this by investigating the accuracy of predictions generated from the DCT model relative to predictions generated from other models. Furthermore, electrophysiological support for dual processing in reading has been found by Holcomb et al., (1999).

Upon this rational, and in an attempt to come closer to the reality of the reading process, the DCT model of reading (see Figure 3.1) will be described along with the main issues surrounding the model. This will be followed by a brief explanation of how the model could be applied to reading and how findings on dyslexia can be reconciled within the DCT framework.

Moreover, as it will be seen that although the DCT model is able to explain the process of reading in general terms, it lacks the specific details involved in the actual reading process. There is an alternative interactive theory the ‘Dual Route Model’
that explains the specifics of the reading process reasonably well, although it is does not take into consideration the overall effects of the role played by the human repertoire (e.g. human senses and environmental factors) on the reading process. It must be pointed out that none of the theories: the DCT or the dual route model could independently explain the reading process as a whole with all its specific details. However, the dual route model could theoretically be accommodated within the DCT theory. Therefore, following the introduction given on the DCT model, a brief description of the Dual Route Model with a reconciliation of it within the findings on dyslexia research will be provided.

**Dual Coding Theory (DCT)**
The Dual Coding Theory (DCT) was originally developed by Paivio in 1971, as an established theory of general cognition. Over the years it was directly applied to literacy. In addition, the principles of this theory, as Sadoski and Paivio (2004) point out, could be applied to explain grapheme-phoneme correspondences, meaning of words, constructions of mental models of text episodes and imaginative responses to text.

The (DCT) theory consists of three assumptions. The first assumption is that all mental representations retain at least some external experiences from which they have been derived. The second is that there are two mental systems or codes: the verbal and the non-verbal codes. The former specializes in representing and processing language and the latter, known as the imagery system, specializes in processing non-linguistic objects and events. Each of the codes has its own characteristic units and hierarchical organization which are qualitatively different. In the verbal system, smaller systems can be synthesized into sequentially larger units, such as letters to words or that larger units could be analyzed into smaller units, retaining independence with each level of analysis. On the other hand, the information in the non-verbal system are represented in a more continuous and integrated way that is difficult to separate into discrete elements producing dynamic multimodal imagery sequences. For example, the perception of a football caught by a goal keeper in a stadium filled with cheering...
Figure 3.1 - The Dual Coding Model (DCT) modified from Sadoski & Paivio (2004), pg.1336.
crowds, where the smell of the surroundings could be perceived and the hot summer air could be felt, accompanied by personal feelings of the whole atmosphere.

The third assumption is that the two mental codes and the senses are orthogonal to each other, with the verbal code being able to perceive only through three sense modalities: visual, auditory, and haptic; and the non-verbal code being able to perceive through all the five sense modalities: visual, auditory, haptic, gustatory, and olfactory. That is, each of the mental codes is capable of retaining their own experiences as perceived through the different sense modalities and of which the perception from a particular sense modality is different in the two mental codes and independent from each other. Sadoski and Paivio (2004) provide an example of the base ball bat. In the verbal code the visual representation consists of the letters, words and phrase. On the other hand in the non-verbal code, the visual representation would consist of the image of the base ball bat. Moreover, with regards to the auditory representation of the verbal code, this would consist of speech units heard such as phoneme units and their combinations e.g. for the word 'bat', the auditory representation would be /b/ /a/ /t/. Where as, the auditory representation for the non-verbal code would consist of the environmental sounds heard from the bat e.g. the crack of the bat. A similar analysis could be carried out with the other senses.

Further more, according to the DCT model the basic units in the verbal code are the 'logogens' and in the non-verbal are the 'imagens'. These units as Sadoski and Paivio (2004) point out should be perceived as concrete, evolving and flexible as opposed to being abstract and amodal. Hence, allowing for an explanation on how knowledge could be gained and developed as contact and interaction with the environment takes place through the different sense modalities. Moreover, the model theorizes that there are three levels of processing operations that take place from the start of the cognitive act to the finishing point. These are representational, associiative, and referential. The representational processing takes place at the initial activation of the logogens or imagens, and where activation of the representations depends on individual differences and on the stimulus situation. At this stage stimulus familiarity may be sensed but not reaching a level of meaningful comprehension. This representational stage is followed by the associiative processing stage where the spread of activation
within a code in to the different modalities and between the two codes is expected to take place. The associative processing does not necessarily involve complete comprehensibility but incorporates deciphering the coded material at hand from one mode to another in order for further associative processing to be carried out until a level of comprehensibility is reached. Hence, when reading the word such as 'bat' embedded in an article on a base-ball game, this logogen at the representation level activates its phonological associations facilitating the pronunciation of the word but not necessarily making it comprehensible. Activation of further representations and associations of the remainder of the text (context) involving syntactic and semantic processing and the activation of referential processing (the third type of processing) with related imagens of the logogens surrounding the text allows for comprehension to be reached and in turn understanding that the word 'bat' refers to a wooden object that is used to hit a ball and not a word that refers to an animal. The third type of processing, referential processing, involves the spread of activation between codes that are associated with meaningful comprehension. Referential correspondences between logogens and imagens could correspond in a manner that is one to one, one to many, or none as with an abstract logogen that is difficult to form an image on. Once, text is understood, a verbal or non-verbal response could be given.

Reconciling the DCT Model with Dyslexia Research
For reconciliation to be carried out between a particular theory and findings of research, it is vital that both the theorizing of the model and the approach used in researching are at similar levels of analysis. Accordingly, since the dual coding model is a psychological model, it would be easier for it to be reconciled with dyslexia findings that are at the cognitive-behavioral level than findings at the biological-behavioral level. Therefore, in the following section, the DCT model will be reconciled mostly with dyslexia findings at the former behavioral level.

Coltheart et al., (1988) and Juel & Holmes (1981) found that poor readers were able to read concrete imageable words more accurately than abstract words. This in turn reflects the need for a reading model to include within it theorizing the presence of at least two systems for processing graphemic stimuli. The DCT model allows for such a
processing. Also, this finding reflects the need for the remembrance of some of the words read in an image format, thus reflecting a need for visual processing rather than only a single abstract processing as all interactive theories of reading (apart from the DCT) assume. The Dual reading model accommodates such a finding.

According to the Phonological Deficit hypothesis (Stanovich, 1988), the main problem of dyslexics in learning to read, lies in their lack of phonological awareness. They are unable to distinguish between the different sounds and are unable to become aware of the intricate play between the sounds. In turn, the ability to distinguish between the various sounds (phonemes) and the ability to understand how sounds are combined to form words are expected to play important roles in reading. Therefore, a theory of reading should include within its framework the ability to sense/perceive small units of auditory stimuli, the ability to combine sounds according to the grammatical structure of each language system and to understand the words they form. The DCT model with its auditory logogen, associative structures and referential connections allows for such processing to take place. More specifically, the visual and auditory representations that get developed within the verbal code over time allows for remembering how sound units get combined; in turn facilitating the process of sound-awareness and the process of translating grapheme in to phoneme.

Moreover, according to the Phonological Representation hypothesis (Fowler, 1991, Swan & Goswami, 1997), dyslexics experience difficulty in the storage of phonological information which is reflected in their inability to read non-words that are non-visually recognized. Several studies have found dyslexics to have problems with the reading of non-words (Rack et. al., 1992; Nation & Snowling, 1998). Dyslexics who have been taught to read were able to do so with familiar words that were encountered regularly but not infrequent words or non-words. It has been argued that since dyslexic children’s syntactic and semantic skills were intact, they could have compensated for their reading difficulties by relying on semantic and syntactic facilitation that is usually offered upon reading in context (Nation & Snowling, 1998). With regards to the DCT model this has two implications. The first is that there is more than one route to reading and not necessarily all are expected to lead to excellent standards in reading. The second implication is that these routes are expected to be
either within the verbal system or related to some form of referential connections within the non-verbal system. More specifically, since the ability of the dyslexic to perform better on reading of familiar words more than non-words then it could be argued that dyslexics could not be relying on using the small units of sounds to decode the words, otherwise they would be expected to do so with non-words. And since they were capable of pronouncing the familiar words they had read implies that either the processing had occurred within the same channel (verbal), if so then the DCT model can accommodate for this with its representational connections and associative structures, thus allowing for coarse grain processing and word pronunciation to take place within the verbal code; or that the stored form or picture image of the familiar words which had allowed for the ability to read such words had been retrieved, if so then the DCT model can accommodate for this as well. The presence of an imagen code allows for the visualization of graphemic patterns and the presence of referential connections with the verbal system allows for the pronunciation of those words. This in turn, stresses the importance for a reading model to include a long-term storage for phonological representations of sounds taken from the surrounding language system. The DCT model includes such an assumption within it.

As mentioned earlier in the chapter, dyslexics experience difficulties with naming of familiar pictures or objects that are infrequently encountered (e.g. stethoscope), numbers, letters and colours (Badian, 1993; Blachman, 1984; Catts, 1991). This could imply that they have difficulties in transforming the image s/he sees, in to its abstract format. Hence, assuming that a model of reading should include within its theorizing at least two systems: a verbal and a non-verbal (visual/image form) with some form of connections between both. The DCT model accommodates for such a framework as has been explained above. To extend the implication further, the dyslexics' naming difficulty could be explained within the DCT model by assuming that the process taken to transfer the information from the non-verbal to the verbal system is not functioning as expected. Therefore, the image of the picture or object in the imagen code could have one or more of the following deficits. One the imagen could not be processed correctly or quick enough. Second, the imagens may be able to process correctly but they may not be able to transfer through the correct referential
connections in order to reach the auditory logogens and get associated with the appropriate auditory-motor structures. Third, the imagen may be able to get through the appropriate referential connections but encounter difficulties with associative connections, in turn hindering the translation of the imagen code into its appropriate auditory-motor code. The above three alternatives are mere speculation and require further investigation in order to find out which of the different alternatives could reflect the naming deficits dyslexics experience.

Another aspect referred in dyslexia research is the speed of the reading process. The Dual Coding model could explain this aspect of processing within its theorizing in the following manner. According to the DCT model, printed words get decoded via the activation of the verbal-associative connections between the visual logogens and the auditory-motor logogens. These connections are assumed to occur at the representational level and they could be achieved before generating a syntactic and semantic interpretation. However, the associative processing that occurs requires some time. This time will, according to the DCT model, depend upon certain factors such as word familiarity and grapheme-phoneme consistency. This will also be the time required for activation to spread to other representations and possibly to other imagens. In turn, allowing for semantic and syntactic processing to take place and thus allowing for the words to be read and understood. In relating this to dyslexia research, dyslexics have been found to have problems with speed of processing (Torgesen et. al., 1997; Wagner et. al., 1997; Felton, 1992) and with the grapheme stimuli or image to persist across fixations (Lovegrove, 1994). To reconcile such a finding with the DCT model, it could be argued that since dyslexics have a phonological deficit, then their auditory logogen is not functioning at its best. The logogen may be activated by the printed word but because of its condition, the processing between the associative connections of the verbal-associative and the auditory motor-logogens is slowed. 'Slowed' is mentioned rather than 'completely disrupted' because dyslexics are capable of learning to read certain familiar words. In turn, this slowness allows for time to lapse and hence for the spread of activation to the imagens. However, because of the problem of the processing at the logogen side, the imagen processing gets completed, whilst the logogen is still attempting to process the information. Thus, the assumed lack of synchrony between the two processors
could be perceived to explain the persistence of the image or information across fixation and to further help explain dyslexics' ability to read isolated words, presented one at a time, better than reading a group of words presented together (Hill & Lovegrove, 1992). Also, it may help explain why poor readers are found to engage more in inner speech than good readers (Edfeldt, 1960). More specifically, since in poor readers the processing at the logogen system, as theorized above, is expected to take longer time relative to the good readers, then more associations within the logogen system would be expected to be processed. One such association that may be activated in an attempt to reach the aim of reading the words correctly could be inner speech. Although this explanation is only speculative, it allows for considering that perhaps dyslexics way of processing/activating the various associations within the logogen system is the problem rather than an actual phonological deficit per se, which in turn may lend support for Ramus's (2001) suggestion for a need for a deeper understanding of phonological deficit (in particular sub-lexical phonology) and reading acquisition in general.

Overall, reading is a cognitive act which involves perception, recognition, interpretation, comprehension and the remembrance of written information. Therefore any theory that attempts to explain the reading process should conform to broader theories of general cognition and should attempt to incorporate within it all the different aspects involved in reading. The DCT model appears to fit in with such specifications as well as appearing to be compatible with some of the findings at the cognitive-behavioral level. Two almost definite observations appear to emerge. The first is that reading appears to involve more than only a verbal single route processing, and secondly that dyslexics' reading problems appear to be related to the processing of information within the verbal system.

The Dual Route Model
Ellis (1993) presented a simple model of word recognition, the dual route model, which was compiled from reviewing several models that were in circulation at the time and which had shared several areas of broad agreements with each other. Ellis (1993) points out that although the model is in a diagrammatic form (see Figure 3.2)
its main assumption is that it is made up of a number of cognitive sub-systems that have been perceived to be partially independent and to be involved in controlling the different operations involved in word recognition. Evidence of such independence was provided from brain injured patients with abnormal reading development of whom some aspects of reading were found to be normal whilst other aspects were found to be impaired (e.g. Funnel, 1983; Paap, Noel & Johansen, 1992). A brief description of the reading model: Dual Route model as explained by Ellis (1993) will be given, followed by an attempt to reconcile some of the findings on dyslexia within the Dual Route model.

In the Dual Route model, it is proposed that word reading involves two routes: the lexical route which is assumed to process familiar words and the sub-lexical route which is involved in processing unfamiliar novel words. In addition, the model proposes that the lexical route involves two types of word processing: one for processing familiar words via the activation of word meaning (i.e. the semantic system) and a second for processing familiar words without any activation to their semantics. Both types of lexical route processing lead to the Speech Output Lexicon, where pronunciations to the familiar words are given. This last sub-cognitive system is connected to the Phoneme Level, which is perceived as a short-term memory store for holding distinctive speech sounds until they are overtly articulated in a coordinated sequence in the form of reading the word aloud. Moreover, as well as the Phoneme Level receiving inputs of familiar words via the lexical route from the Speech Output Lexicon, it also receives inputs of unfamiliar words or non-words via the sub-lexical route directly from the Visual Analysis System.

The first sub-cognitive system that is involved in the processing of printed word is the Visual Analysis System. The duties of the Visual Analysis System is to identify letters as "abstract identities" (Coltheart, 1981) and to note the positions of the letters with in words. This latter duty is important because it helps in distinguishing one word from another within a particular language (e.g. NAP vs. PAN). This processing is carried out without noting the shapes, sounds, or names of the letters to be processed.
Figure 3.2 – A simple diagrammatic functional model, the Dual Route Model, showing some of the cognitive processes involved in recognizing written words as presented by Ellis, 1993.
A familiar word would be recognized by the sub-cognitive system the Visual Input Lexicon and processed either through the semantic route or non-semantic route to the Speech Output Lexicon. The flow of information from the Visual Analysis System and the Visual Input Lexicon is assumed to be bi-directional, where information from the former system feeds into the latter system and vice versa. Moreover, it is assumed that the Visual Input Lexicon contains mental representations of past encountered words and it has the duty of recognizing whether strings of letters where previously encountered or not. In addition, it is assumed that the more frequently a word is encountered, the lower its recognition threshold is expected to be. That is, if a familiar word is perceived for the fourth time, its recognition by the Visual Input Lexicon will be faster than another familiar word recognized for the second time.

The processing of a familiar word via the semantic route is assumed to involve the information in the Visual Input Lexicon to be fed into the Semantic System. This system consists of a knowledge store for meanings of familiar words. Upon receiving the information on a familiar word from the Visual Input Lexicon, the Semantic System activates the relevant meaning of this word by providing a comprehensive description of the word that is being processed without having to activate its pronunciation. Also, it is assumed that the flow of information between the Visual Input Lexicon and the Semantic System is bi-directional, which helps in explaining the effects of sentence context in word identification and semantic priming. More specifically, reading a familiar word like 'STUDENT', causes the Visual Analysis System to encode the letter strings in its appropriate sequence (i.e. S1, T2, U3, D4, E5, N6, T7) without regard to the shapes of letters or their sounds. In turn, this will activate the recognition unit for 'STUDENT' in the Visual Input Lexicon. The assumption of lateral activation (Collins & Loftus, 1975) and the bi-directional connections between the Visual Input Lexicon and the Semantic System, together allow for the meanings of 'STUDENT' to be activated within the semantic system and for the meanings of related words (e.g. TEACHER, BOOK, and SCHOOL) to be activated as well. Therefore, if whilst reading, the word that follows (e.g. BOOK) is related to the familiar word previously encountered (e.g. STUDENT) then less input from the Visual Analysis System will be required to identify it, resulting in a more rapid recognition of this word. This phenomenon is known as semantic priming. In a
similar manner context effect could be explained. In addition, the Semantic System is assumed to involve the understanding of both spoken and written words.

Evidence for a separate sub-cognitive system for the Semantic System and for the Speech Output Lexicon comes from several sources. One from experiences of slips of the tongue where the name of an object is known but the precise articulation cannot be remembered. Second from semantic errors in texts as noted by Levin & Kaplan (1970), in which subjects whilst reading aloud replaced a word for another word with similar meanings (e.g. replacing 'may' for 'might'). And third from reading of texts that contain words that are 'homographic heterophones', in which a reader is able to provide the correct pronunciation of two words that share the same spelling but differ in pronunciation; thus implying that meanings had to be extracted before pronunciation took place. Similarly, evidence for a lexical route with no access to meaning comes from studies (e.g. Schwartz, Marin, & Saffran, 1979; Schwartz, Saffran, & Marin, 1980; Ellis, 1993) on brain damaged patients who were able to read words with little or no comprehension of what they had read.

Words that are unfamiliar or non-words are assumed to be processed via the route that connects the Visual Input Lexicon to the Phoneme Level. The connections between the two sub-cognitive systems are assumed to be direct. The Visual Input Lexicon in identifying that the letter string positions within a word is unfamiliar; it directly connects with the Phoneme Level allowing for the sounds of the letters or group of letters to be activated. The Phoneme Level is assumed to be a store for the subtleties in the 'sound system' present from the various grouping of letters within a language structure.

Evidence has shown that the two routes: lexical and sub-lexical routes may have some influence with each other (Ellis, 1993, Kay & Marcel, 1981). It was found that pronunciations of unfamiliar word and non-words could be biased by recent experiences with familiar words (Kay & Marcel, 1981). There are even those models of reading who have refused to acknowledge the presence of any distinctions between those two routes (e.g. Siedenberg & McClelland, 1989) and suggest that readers can learn the associations between print and sound at the different levels of processing (phoneme, syllable, and whole word).
To summarize, the Dual Route model proposes that for reading there are two routes: lexical and sub-lexical. The former route is assumed to be used for familiar previously encountered words and the latter route for unfamiliar words or non-words. The latter route could be perceived as a pure phonological route where words could only be read through grapheme-phoneme correspondence rules. However, reading of words via the former route does not necessarily require the assembly of phonological units but involves addressing phonological units that have already been established and retrieving them. Moreover, in the former lexical route there are two pathways to accessing pronunciation, one via meaning and another direct with no access to meaning. All routes begin at the sub-cognitive system of the Visual Input Lexicon and end at the Phoneme Level. Supportive evidence has been found for the independence of the various sub-cognitive levels of the dual route model and for two-way processing between some of the pathway connections. However, the degree of independence between the lexical and sub-lexical routes has remained controversial.

**Reconciling the Dual Route Model with Dyslexia Research**

As pointed out earlier, for reconciliation to be carried out between a particular theory and findings of research, it is important that both the theorizing of the model and the approach used in researching are on similar levels of analysis. Therefore, with the Dual Route Model being a psychological model, it will be reconciled with dyslexia findings that are at the cognitive-behavioral level.

Coltheart et al. (1988) found that poor readers were able to read concrete imageable words more accurately than abstract (low imageable) words. In addition, Coltheart et al. (1988) in controlling for frequency and imageability found that words that were acquired later in life were read less accurately than those words acquired early in life for both average and poor readers with a trend of a larger effect for poor readers. Such findings could be reconciled within the Dual Route model. It could be argued that because imageable words are expected to be acquired earlier in life than abstract words, therefore they are expected to be more familiar than abstract words; and hence are expected to be read via the lexical semantic pathway, where by the frequency of
those imageability words would allow for a lower retrieval threshold and eventually for a faster word processing.

According to the phonological deficit hypothesis (Stanovich, 1988), the main problem dyslexics face in learning to read is their lack of phonological awareness. Also, according to the dual route model, the presence of the Phoneme Level, the Speech Output Lexicon, and the interactive pathway between them would usually allow for the recognition and storage of letter sounds/phonemes and any phoneme combinations relevant to the grammatical structure of a particular language; and eventually to the production of an articulated sequencing of phoneme strings corresponding to the appropriate reading of text. Therefore, within the dual route model, a lack of phonological awareness could be perceived as the result of a deficit to any or all of those sub-cognitive systems.

Moreover, according to the Phonological Representation hypothesis (Fowler, 1991, Swan & Goswami, 1997), dyslexics experience difficulty in the storage of phonological information which is reflected in their inability to read non-words that are non-visually recognized. Several studies have found dyslexics to have problems with the reading of non-words (Rack et. al., 1992; Nation & Snowling, 1998). As it could be seen that from research on dyslexia, one of the findings suggests that a reading theory should be capable of distinguishing between familiar and non-familiar words, as well as that a reading theory should have facilities for storing phonological information and for the processing of such information. The Dual Route model could accommodate well for this, particularly since the main assumption of the model is to distinguish between the processing of familiar and unfamiliar words. More specifically, since non-words are words that have never been encountered, in turn they are expected to be processed via the sub-lexical route. A deficit at the Phoneme Level would make it difficult for dyslexic to make use of the phoneme short-term memory store usually available for the building of grapheme-phoneme correspondence required in word reading, thus making it difficult for dyslexics to read non-words.

Furthermore, another finding in dyslexia research was that dyslexics' were able to learn to read familiar words that were encountered regularly but not infrequent words
or non-words. It was argued that this was possible because of the intact syntactic and semantic skills which may have implied that the dyslexics' children may have compensated for their reading difficulties through relying on semantic and syntactic facilitation that would usually be offered upon reading in context (Nation & Snowling, 1998). Hence, suggesting that a theory of reading should include within its framework different pathways for decoding familiar and non-familiar words and that the processing of familiar words does not necessarily require grapheme-phoneme decoding but requires the inclusion of a form of semantic representations for familiar words and the facility for remembering the appropriate pronunciations of those representations. The dual route model is capable of accommodating for such features in the processing of word recognition. The presence of the lexical pathway from the Visual Analysis System to the Visual Input Lexicon via the Semantic System to the Speech Output Lexicon and the Phoneme Level would permit the dyslexic to process the familiar word as a whole through its relevant meanings in the Semantic System and to be capable of pronouncing the word as a whole via the Speech Output Lexicon despite the possibility of some form of damage to the Phoneme Level.

In addition, as mentioned earlier in the chapter, dyslexics experience difficulties with naming of familiar pictures or objects that are infrequently encountered (e.g. stethoscope), numbers, letters and colours (Badian, 1993; Blachman, 1984; Catts, 1991). According to the theory of the Dual Route model, the Visual Input Lexicon is assumed to be affected by the frequency rate of familiar inputs encounter level, such that the less likely encountered familiar inputs are expected to have higher recognition thresholds than the more likely encountered familiar inputs. In turn, reflecting the need for the former inputs to require more processing time in order for it to be recognized. Therefore, with the dyslexics showing a similar pattern of threshold sensitivity to frequency inputs, it could be argued that within the Dual Route model, those dyslexics' Visual Input Lexicon is expected to be intact. However, the difficulties of those dyslexics to eventually produce the names of infrequently encountered inputs, implies that their problem may lie in one of the lexical pathways that processes information from the Visual Input Lexicon to the Speech Output Lexicon and/or a deficit in the Speech Output Lexicon itself.
With regards to the Double Deficit hypothesis which attempts to explain for findings that there are some dyslexics who have a phonological processing deficit as well as a deficit in identifying visual information very rapidly (Torgesen et al., 1997; Wagner et al., 1997; Felton, 1992), the dual route model has the capacity of accommodating for such a hypothesis as well as its proposition of two subtypes of dyslexic readers: One with a single deficit, either a naming speed or a phonological deficit and a second with a double deficit, having difficulties in both naming speed and phonological processing. In addition, the theory suggests that the second subtype of dyslexic readers are expected to be among the worse readers because with their double deficits, their compensatory routes for reading efficiently become somewhat limited. In an attempt to accommodate for the above theory, it could be argued that according to the Dual Route model, a dyslexic with a double deficit reflects deficits at the Phoneme Level as well as problems in the Speech Output Lexicon and/or in the pathway leading to it from the Semantic system. A dyslexic with only one type of deficit, either a problem at the Phoneme Level (which responsible for phonological processing) or a problem in the Speech Output Lexicon and/or in the pathway leading to it (which in turn is responsible for naming) is expected to perform better than dyslexics who suffer from the two deficits. More specifically, a dyslexic with a single deficit is expected to have the alternative remaining routes for processing the inputs, whilst a dyslexic with a double deficit is expected to have both the processing routes suffering from some degree of damage; thus leaving very little sub-cognitive systems intact for effective processing to take place.

According to the Psycholinguistic Grain Size theory (Ziegler and Goswami, 2005), it proposes that the way phonology is represented in a particular language is expected to affect the process of development of reading acquisition in that particular language and that reading accurately demands the acquisition of the smallest grain size (phoneme) which will occur only after formal instruction or training has begun. The Dual Route model is capable of partially accommodating for the propositions of the Psycholinguistic Grain Size theory. That is, although, the Dual Route model with its Phoneme Level can accommodate for the development of a store for ‘grain size’ units and with its lexical route it can accommodate for words remembered as whole units, it is silent on issues concerning developmental progressional matters; and as such it
becomes difficult to specify within the Dual Route model whether a preschool child would be expected to use a lexical route and after school entry to be expected to switch to the sub-lexical route.

Finally, as it can be seen that the Dual Route model is capable of partially accommodating for the Psycholinguistic Grain Size theory. On the other hand, attempting to pin point the exact specificity of the propositions of the psycholinguistic grain size theory within the non-verbal code of the DCT model would be somewhat difficult to postulate. Moreover, although Ramus's (2001) argument for a need to research into the sub-lexical areas of a language such as intonations is only theoretical, it covers an area that many theories have been silent on. With each language system having its own unique sub-lexical system, which in turn has to be assimilated along with the phonological aspects of the language, it is only natural to find children from a particular culture reading in the same way but in a different manner than children from other cultures. The Dual Route model has the advantage of a theory that may incorporate such aspects within its theorizing of the reading process.

To summarize, the act of reading is a complicated cognitive process. The DCT model is a general theory of reading that could be regarded to embrace the general aspects of the cognitive processes that are involved in reading; whilst the dual route model could be perceived to help in the understanding of the finer details involved in reading, at the level of the word.
CHAPTER 4

Predictors of Literacy:
Transparent and Non-Transparent Alphabetic Orthographies
Chapter 4

Predictors of Literacy:
Transparent and Non-Transparent Alphabetic Orthographies

Introduction
In today’s world literacy has become even more important than ever. It is a method of communication within countries and across them. Children are born in their country and raised to speak its language. In most countries around the world, education is compulsory and children are expected to learn to read and write; although this process of literacy attainment is not an easy one. To get children of several abilities and individual differences, all to learn skills which are not part of human development but are expected to be acquired requires great effort. Part of the difficulty, as will be seen below, lies in that languages across the world vary in their script (alphabetic or symbolic) and orthography. Therefore, the age at which children acquire literacy varies across languages. In addition, methods of instruction have to be compatible with the orthography of a particular language in order to facilitate the process of learning. This consequently requires grasping and understanding of the particulars of a language that will help predict literacy attainment.

The aim of the following chapter is to look into the predictors of literacy in different orthographies, concentrating only on the alphabetic scripts. This cross-linguistic perspective could help in understanding the process of normal reading and its difficulties in the different orthographies as well as gaining insights into the common grounds that may arise as a result of the fact that reading is a skill that is dependent on the deciphering of a codal system. In addition, such a cross-linguistic perspective could provide a unique opportunity to see how the processes of learning to read and spell are affected by the characteristics of the writing system the child is expected to master.
Much of the research on predictors has been dominated by studies carried out on English-speaking populations (Harris & Hatano, 1999). As a result, in the following chapter the attempt will be to concentrate on the main predictors that have been found to play a role in literacy acquisition in the English language and to see whether studies carried out in the different languages share such predictors. By searching for commonalities and divergence of predictors, an effort will be made at reconciling the findings within what is known about the orthography of the language concerned.

The main predictors that will be discussed (based upon research evidence seen below) will be: phonological differences, rapid naming differences, visual and auditory differences, lexical differences and morphological differences. However, at first a brief introduction into the structure of the different orthographies will be given in order to help in the understanding of some of the findings of cross-linguistic research.

**Languages and Their Orthographies**

Languages vary in their level of transparency (consistency). A language is considered transparent when the level at which its orthography is such that each of its grapheme maps on to only one sound (phoneme). On the other hand, the more a language moves away from displaying such a pattern, the less transparent it becomes. Languages displaying such inconsistencies are known as opaque and the English language is an example of this. Languages such as vowelized Arabic and vowelized Hebrew, Spanish, Dutch, Serbo-Croatian and German are considered more transparent languages. French and Greek could be considered somewhere in the middle. Moreover, Arabic and Hebrew in their unvowelized form become opaque languages. So even when languages in their original form are consistent in their orthographies, the way they are mostly portrayed across the media, as in those two languages where vowelized texts are mostly found in text books of young children and religious texts, may have some effect on literacy acquisition, sometimes creating confusion for children moving from vowelized text to unvowelized. The problem is that such ‘quasi-transparent’ languages (termed in this
manner because the languages are transparent but they are portrayed otherwise) have not been, as far as it is known, tackled by research, except in a single study on Hebrew by Bentin et al, 1990. Neither will the following research tackle such an issue; it is only mentioned for future consideration in such areas of research.

The English language has a highly irregular orthography. For one, the 26 letters that make up the alphabet could map onto more than 40 phonemes. Secondly, the pronunciation of some initial letters in a word sometimes requires the identification of at least one to four neighboring graphemes before the first phoneme can be unambiguously determined (e.g. that vs. tap or chord vs. chore). Thirdly, the addition of a grapheme can change the pronunciation of a letter elsewhere in a word (e.g. car vs. care). Fourthly, the English language contain words that are idiosyncratic (e.g. yacht) that cannot be pronounced according to a rule or an analogy that is based on their spelling but require to be learnt separately (for more detail see Albrow, 1972; Geva & Siegel, 2000). These are just some of the irregularities in the English language that a young child has to grasp before being able to decipher the language accurately.

On the other hand, French is a relatively regular language with a transparent orthography for reading but less so for spelling. This means that for reading there is one possible phoneme associated with a certain grapheme, where as for spelling one phoneme could be spelled in more than one way. Moreover, a word in French is sensitive to contextual influences. For example, the final consonant of a word is pronounced with the initial vowel of the following word. Hence, although in written form the graphemic space is obvious for reading, it is not the case in its audible form thus reducing the level of transparency for spelling (Bruck, et al., 1997).

Similarly, Greek as French has a relatively regular language with a transparent orthography for reading but less so for spelling. Akin to French (and as will be seen for German, Spanish, and Italian) each of the graphemes in Greek is realized by a single phoneme, thus allowing for the transparency in reading. The irregularities in the spelling
arise because of several factors. Firstly, the written form of Greek has not changed from the past but the spoken form has significantly changed, thus word spelling reflects the phonetic etymology of words rather than their modern spoken form. Also, three of the five Greek vowels have two or more possible spellings, of which the determination of correct spelling requires following certain morphological rules. Thus, a child learning Greek needs to assimilate those morphological rules in order to spell well. Add to this, children have to rote-learn the spelling of certain exceptional words (Harris & Giannouli, 1999).

The German language displays regularity in reading as well as spelling. It represents a morpho-phonemic level similar to English but in a more consistent format. For example, the grapheme ‘a’ is pronounced the same way regardless of the word it is part of. Moreover, despite the fact that there are certain complexities related to the length of vowel representations in the German language, the correspondence between grapheme and phoneme are still consistent (for further detail see Eisenberg, 1988). Along similar lines Dutch, Spanish, and Italian have regular orthographies. However, in Spanish there are a few irregularities that could be deduced from simple rules (Arroyo, 1989) and in the Italian there are a few exceptional spellings that a child has to grasp to do well in spelling (for more details see Cossu, 1999).

Hebrew as Arabic is a highly regular language in its vowelized form. Hebrew has a derivational morphology similar to Arabic. Most words consist of a consonantal ‘root’ and a vocalic ‘pattern’. The entire Hebrew lexicon is based on approximately two thousand roots, where the root usually consists of three consonants and represents the Semitic core of the word. It has 22 letters and the vowels are in the form of dots and dashes that are placed below, above to the left, or within the consonants. Like the Arabic language, it is read from right to left. The acquisition of the grapheme rules and vowel decoding requires the mastering of a few rules and exception words. For further detail on Hebrew orthography see Share & Levin, (1999). Details of the Arabic language have been given in chapter 2.
Phonological Differences

The majority of the studies that have been carried out in this area have come from reading theories derived from studies on English speakers. There are those studies carried out in other alphabetical orthographies (as will be seen below), but when considered relative to the bulk of English-based studies, they are regarded as few.

It is argued that reading development is dependent on two skills, phoneme awareness and letter knowledge (Byrne, 1998) and that these skills are necessary for setting up a phonological pathway for the decoding of words (Adam, 1990; Duncan et al, 1997; Muter et al, 1998; Wagner et al., 1997). However, as it can be seen from the section on ‘Literacy and their Orthographies’ that different orthographies display different rules for mapping letters on to sounds and vice versa. Therefore, the issue that will be tackled is the attempt to establish the role of phonological awareness in the different alphabetical orthographies: transparent and non-transparent.

For the English language, an irregular orthography, it has been well established that phonological skills to be closely associated with development of word recognition in reading (Castles & Coltheart, 2004). For more transparent languages such as German, Spanish, Serbo-Croatian, Dutch, Hebrew, and Arabic, the relationship between phonological awareness and reading have also been found to be associated together (Wimmer, Lande & Schneider, 1994; Jimenez-Gonzalez & Juan, 1997; Lukatela & Turvey, 1995; de Jong & van der Leij, 1999; Patel, Snowling & de Jong, 2004; Bentin & Leshem 1993; Kozminsky & & Kozminsky 1993/94; Abu Rabia, Share & Mansour, 2003). A similar finding has been found for languages considered to be the middle range such as French and Greek (Sprenger-Charolles, Siegel, & Bechennec, 1997; Giannouli & Harris, 1997, cited in Harris & Giannouli, 1999).

In reviewing studies carried on different orthographies, certain considerations require attention. One, the degree of effect of phonological awareness has on reading acquisition in the different orthographies; second, the duration of this effect on future reading
development; and third, the association between the transparency of a language and the level of phonological awareness that is operating as a predictor to future reading acquisition.

With regards to the first consideration, it appears that deficit in phonological awareness has more devastating effect in irregular orthographies than more regular ones. In a study, by Landerl, Wimmer & Frith (1997), which compared the reading and the phonological processing abilities between English and German dyslexics, it was found that English dyslexics made more reading errors than German dyslexics. English dyslexic children’s reading accuracy was strongly influenced by word frequency. Their accuracy dropped from number words to one- and two-syllable frequent words and further dropped for long and infrequent words. Whilst, the German dyslexic children were able to accurately read three-syllable infrequent words and even master most of the corresponding non-words. A justifiable explanation for this finding was given in terms of the differences in the orthography of both languages. It was suggested that there is a qualitative as well as a quantitative phonological coding differences between the two languages (Wimmer, Landerl & Frith, 1999). More specifically, the organization of the process of phonological coding is different for English children than for the German children, where by these different organizations are triggered by the main features that distinguish the two languages from each other. This main feature is related to the difference in the consistency of the grapheme-phoneme relations for vowels. It was argued that German orthographic system with its transparency serves as a protective factor because the German children were able to rely on the high rate of consistency between grapheme and phoneme that they had experienced from their language, in the past to help decipher the infrequent and non-words. Where as, as it has been shown that in English Language only 60% of the cases in which the vowel pronunciation will be consistent for monosyllabic CVC words which share the same vowel grapheme (Treiman, Mullennix, Bijeljac-Babic & Richmond-Welty, 1995) the English children were less able to rely on their codal experience due to the lower rate of consistency in their orthography than the German children. This appears to be in line with Spencer’s (2001) argument that: “Transparent
orthographies are very efficient because they do not make heavy demands on memory and require a much more limited activation of brain regions, making them more accessible to dyslexic children; deeper orthographies being more memory dependent and requiring greater activation of the brain may actually prevent dyslexic children from achieving reading fluency” (p.227). In proofing his argument Spencer (2001) referred to his study on the English language and to other studies carried on more regular orthographies (Turkey: Oney & Goldman, 1984; Italian: Cossu et al., 1995; German: Landerl et al., 1997) to demonstrate that the wider the frequency of the make-up words in a particular language (as in the English language) the more it contributes to reading and spelling difficulties; and he referred to a PET scan study carried out on groups of English, French and Italian dyslexics (Paulesu et al., 2001), where it was found that dyslexics in general demonstrated a deficit in areas associated with deep language processing (left planum temporale) but were capable of maintaining normal functioning in areas associated with shallow language processing (middle, inferior, and superior temporal gyri).

Therefore, as it could be seen that in a regular orthography, a poor reader with a deficit in phonological awareness could rely on the grapheme–phoneme consistency pattern of his/her transparent language structure to decode the letters that make up the different words. In turn, increasing the reading accuracy rate relative to a poor reader from a more irregular orthography of whom with his/her phonological awareness deficit and his/her inability to rely on his/her language system to decipher words, is placed in a much more difficult situation than the former reader from a more transparent orthography.

Although the reading accuracy of poor readers from more transparent orthographies, such as the German and Italian languages, are usually perceived to be higher than those poor readers from less transparent orthographies, such as the English language, their reading speed is perceived to remain slow (Landerl, Wimmer, & Frith, 1997; Wimmer, 1993; Cossu, 1999). In a study which carried out a cross-linguistic investigation on the reading skills of English and Dutch children, it was found that in both languages phoneme
awareness (as measured by accuracy and reaction time) was a significant predictor of reading and that as expected the Dutch children were relatively more accurate and faster than the English children of the same age for reading words and non-words and that the Dutch group were faster at completing the phoneme deletion task (Patel, Snowling & de Jong, 2004). This occurred despite the fact that the English cohorts had an extra year of schooling. However, the expected differences in accuracy measures between the two groups were smaller than expected. This was explained in terms of the new approach English children receive in the present day instruction; an approach that is based on training in phonological awareness and a systematic phonics approach. In turn, this was expected to help keep the English cohorts closer to the children in transparent orthographies. Moreover, Landrel (2000) has shown that in training English children from grades 1-4 on an approach that is heavily based on a phonics approach, these children’s performance on non-words was almost as accurate and fast as German children and better than those from a mixed British curriculum. In addition, Bradley and Bryant (1983) in a longitudinal study found that training in phonological awareness, in particular in onset and rime, helped, at least in the English language, put the trained children ahead of their peers by eight months in reading and seventeen months in spelling. In a similar manner it was found that in a more regular orthography such as Hebrew that generally age and schooling improved children’s performance in segmentation tasks and that the effect of schooling was four times larger than the effect of age (Bentin, Hammer & Cahan, 1991).

Thus as it can be seen that training in phonological awareness puts children from an irregular orthography closer to being on the road to reaching literacy accuracy as well as helping them to increase their processing speed in phonologically based tasks; and that at least in a transparent orthography like Hebrew schooling appears to help improve performance in phonological awareness. In addition, it appears that in more regular orthographies, reaction time is a better predictor of reading than word reading accuracy.
With regards to the second consideration, the duration of the effect of phonological awareness as a predictor of later reading development, few studies have been found investigating such an aspect on phonological predictors (e.g. Stanovich, Cunningham and Cramer, 1984; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wagner, Torgesen, Rashotte, Hetch, Barker, Burgess, Donahue, & Garon, 1997; Hogan, Catts, & Little, 2005); of which most have been conducted on English speakers. In Stanovich, Cunningham and Cramer (1984), it was found that the predictive strength of a particular type of phonological awareness measure (e.g. rime measures) appeared to drop after the age of about six years among the sampled English speaking cohorts. Similarly, in Hogan, Catts, & Little (2005), assessments on phonological awareness provided information about reading in kindergarten but lost its predictive power in second grade. However, in Torgesen, Wagner, Rashotte, Burgess, & Hecht (1997) and Wagner, Torgesen, Rashotte, Hetch, Barker, Burgess, Donahue, & Garon (1997) found that phonological awareness continued to explain literacy growth at least through fourth grade. Those studies attempted to go beyond that of simply predicting later literacy development towards searching for a causal explanation for it. This was done by taking into account autoregressive effects of prior reading level into their analyses of the results. This in turn may explain the discrepancies with other studies that have not found phonological awareness ability to predict later reading development. On the other hand, a more appropriate reason may be due the fact that Torgesen, Wagner, Rashotte, Burgess, & Hecht (1997) sample came from diverse socio-economic backgrounds as well as not much significant gains in reading were found between third grade and fifth grade. In fact, only ten percent (greater than 1 standard deviation) of the students in fifth grade who had made gains or had attained average reading performance. Therefore, although the students may have been in fifth grades but their reading age may have been of a lower grade; consequently, making it difficult to compare findings across studies. In addition, it must be admitted that Torgesen, Wagner, Rashotte, Burgess, & Hecht (1997) do point out that their results have to be regarded with caution.
Studies that have looked into predictors of literacy development have either been cross-sectional (al-Mannai & Everatt, 2005; Anthony, Lonigan, Burgess, Driscoll, Phillips & Cantor, 2002; Lonigan, Burgess, Anthony, Barker, 1998) or longitudinal, studying cohorts from different age groups but usually within the range of about 2 years to about second to fourth grades (Catts, Fey, Tomblin, Zhang, 2002; Catts, Fey, Zhang, Tomblin, 2001; Pennington & Lefly, 2001 Scarborough, 1990). Furthermore, in those studies that have investigated predictors of future reading achievement, it has been found that phonological awareness was not the only predictor capable of predicting children at risk of future reading difficulties, other meta-linguistic abilities (e.g. letter identification, expressive vocabulary, print concept knowledge, rapid naming) have as well been found to play a role (Foulin, 2005; Simpson & Everatt, 2005; Chiappe, Chiappe, & Gottardo, 2004; Fowler & Swainson, 2004; Catts, Fey, Zhang, & Tomblin, 2001; Lonigan, Burgess, Anthony, 2000; Chaney, 1992; Scarborough, 1990). Moreover, it has been found that the relationship between the meta-linguistic abilities in predicting future literacy development was not perceived as unidirectional but as a reciprocal relationship with metalinguistic abilities promoting growth of literacy which in turn is expected to help promote further gains in literacy and metalinguistic awareness (Lazo, Pumfrey, & Peers, 1997). Although phonological awareness could be considered as a predictor of future reading achievement, it could not be considered as the strongest. Letter Knowledge was perceived as the strongest predictor of literacy level at six years (Gallagher, Frith, Snowling, 2000) and five years of age (Pennington & Lefly, 2001). Furthermore, phonemic awareness did not appear as a predictor in some studies only at the age of five years (Scarborough, 1990). Acting as a predictor, does not necessarily imply that all subjects showing deficits in the concerned predictors will have reading difficulties (McCardle, Scarborough, & Catts, 2001). In all, it appears that the different predictors predicting future literacy achievement, at least from amongst English speaking children, could be considered under the umbrella of phonological related processors (i.e. verbal measures, e.g. letter identification, expressive vocabulary, print concept knowledge, rapid naming). Therefore, to see whether after six years phonological processors potency drop, more studies with cohorts from different orthographies, with an age range of longer time...
span, and with reading-age levels determined are required. In addition, more cross-comparative studies are necessary in order to determine the duration strength of the different phonological measures in predicting future reading performances; also, whether this duration varies between transparent and non-transparent orthographies.

To consider phonological awareness as a predictor of literacy, it must be viewed in terms of its levels, in which studies have shown that the level of phonological awareness that it is perceived to predict literacy in an alphabetic script varies according to the orthography of its language. Harris & Giannouli (1999) have pointed out that phonological awareness could be perceived in terms of implicit and explicit phonological awareness. The former involves the ability to be aware of sounds at the level of the syllable or sub-syllable units; whilst the latter involves the ability to identify and manipulate sound units at the level of the phoneme.

With regards to explicit phonological awareness, it has been shown that for regular orthographies such as German, Italian and Spanish and for irregular orthographies such as English (Wimmer, Landerl, & Frith, 1999; Cossu, 1999; Goswami, 1999a) that not only phonemic awareness is positively correlated with a child’s subsequent reading and spelling achievement but as well plays a central role in the learning to read process. In addition, explicit phonemic awareness has been found to develop after a child learns to read (Harris & Giannouli, 1999). There is suggestive evidence that instruction in reading appears to provide the necessary foundation for the development and promotion of phonological awareness because it has been found that at least among the group of illiterate Serbo-Croatian women (Lukatela, Carello, Shankweiler, & Liberman, 1995), illiterate Arab (Share and Breznitz, 1997, cited in Share & Levin, 1999, p. 103), and illiterate Portuguese (Morais, Cary, Alegria, & Bertelson, 1979) speakers who were tested, little or no phonological awareness was detected for them. On the other hand, Adrian, Alegria, & Morais (1995) had found in two groups of Spanish speaking subjects (illiterate and rudimentary readers) that phonemic awareness did not necessarily develop as a result of linguistic or cognitive maturation.
However, the picture for implicit phonological awareness appears to be somewhat different. Its importance varies with the degree of orthographic regularity present in an alphabetic script. In irregular languages, implicit phonological awareness predicts early reading success (Bradley & Bryant, 1983; Lundberg, Frost & Peterson, 1988; Hoien & Lundberg, 1988; Stuart & Coltheart, 1988). Where as, in more regular languages, at least in the case of the German language, implicit phonological awareness appeared to predict later rather than early success in reading and spelling (Wimmer, Landerl & Schneider, 1994). Moreover, implicit phonological awareness has been argued to develop before a child begins to learn to read or to have any exposition to prints (Cossu, Shankweiler, Liberman, Katz, & Tola, 1988).

It must be pointed out that letter knowledge was found to help predict early reading success. Although speculative, letter knowledge may be perceived to be related to explicit phonological awareness in regular (Wimmer, Landerl, Linortner & Hummer, 1991) and in irregular orthographies (Stuart & Coltheart, 1988 and Johnston, Anderson, & Holligan, 1996). Ehri (1987) argued that recognition of the letters in an alphabetic system and the sounds they present facilitates the development of an alphabetic strategy which aids in the recognition of the individual graphemes and their corresponding sounds. Thus, it appears that letter knowledge may help pave the path to reaching phonemic detection.

Along similar lines, but in using more precise terminologies than Harris & Giannouli (1999), Goswami (1999a) perceived phonological awareness in terms of syllables, rime and onset, and phoneme awareness. Goswami (1999a), in providing evidence from Goswami & Bryant (1990) paper, suggested that the sequencing of phonological processing in a child is similar across different linguistic orthographies. It was argued that phonological processing in a child begins with syllable processing that moves on to rime and onset processing followed by phonemic processing; and where phoneme development was not perceived to emerge only after instruction in reading had begun. Ziegler and Goswami (2005) in a cross linguistic comparison that involved reviewing studies from different orthographies (Turkish: Durgunolu & Oney, 1999; Italian: Cossu,
Shankweiler, Liberman, Katz, & Tola, 1988; Greek: Harris & Giannouli, 1999; French: Demont & Gambert, 1996; and English: Liberman, Shankweiler, Fischer, & Carter, 1974) found that in both regular and irregular orthographies, syllable awareness developed prior to phoneme awareness and that kindergarten children in transparent orthographies such as Turkish, Italian, and Greek showed a higher syllable awareness reaching ceiling level by first grade than less transparent orthographies such as French and English. In addition, high phoneme awareness appeared only in first grade with the transparent orthographies in the lead, where the percentage of correct phoneme awareness in the Turkish, Italian, Greek, French, and English studies were 94, 90, 100, 61, and 70 percent respectively (see table 1, p. 5, Ziegler & Goswami, 2005). Also, studies on English and German children have shown that onset and rime were present prior to learning to read (Bradley & Bryant, 1983; Wimmer, Landerl, & Schneider, 1994). Moreover, Anthony et al., (2003) found that for the same level of linguistic unit, children were observed to being able to detect phonological information before being able to manipulate such information, and that children were capable of blending phonological information before being able of performing tasks that involve deletion of phonological information. Furthermore, Anthony & Lonigan (2004) by using confirmatory factor analysis and structural equation modeling to precisely quantify the longitudinal relationship among the phonological skills, used data sets from four studies (Wagner et al., 1997; Lonigan, Burgess, Anthony, & Barker, 1998; Muter, Hulme & Snowling, 1997; Muter, Hulme, Snowling & Tylor, 1997) and found that apart from rhyme production measures, rhyme sensitivity and phonemic sensitivity measures were markers of the same underlying ability and that any finding to the contrary was due to ignoring floor effects, ceiling effects and inappropriate use of exploratory factor analysis. In addition, earlier research (Anthony et al., 2003) has lead Anthony & Lonigan (2004) to hold the view that sensitivity to the different phonological measures should not be perceived as 'temporally discrete' or as a 'sequential progression' but more as a developmental 'quasi-parallel' progression (see p. 52, Anthony & Lonigan, 2004). More specifically, it has been argued that phonological awareness should be perceived as one measure which displays a developmental trend that begins with younger children being sensitive to larger linguistic units and older children being
sensitive to both larger and smaller linguistic units, thus implying that the development of the awareness of the linguistic units is expected to develop progressively and sequentially as children grow without having to be totally independent or discrete in their progression with the expectation of some overlap. Furthermore, it is important to perceive phonological awareness not only in terms of its linguistic units but also in terms of what other cognitive abilities (e.g. detection, manipulation, etc.) a phonological task that is used for testing a particular linguistic unit involves. Hence, the task is expected not only to be sensitive to measuring the linguistic unit but in addition compatible with the child's cognitive capabilities. In contrast Savage (2001) in reviewing Goswami's (1999b) paper has cast doubt on the relationship between rhyme awareness and reading and argued for the evidence found among the English Studies as being controversial; and pointed out that rhyme training did not appear to be important for the development of reading. However, Goswami (2001) in a well developed argument was able to defend the stand for rhyme being an important phonological predictor in the English language.

In taking the investigation on phonological development a step further, Goswami (1999a) presented three cross-linguistic studies comparing English and French, English and Greek, and English, French, and Spanish (Gosswami, Gombert & De Barrera, 1998; Goswami, Porpodas & Wheel-Wright, 1997); using non-words made up from real words that followed different orthographic and phonological patterns. In those studies, it was found that the spelling units that corresponded to rime were most salient to the young English readers, fairly salient to the young French readers, and not at all salient to the young Spanish and Greek readers. From the results of those studies, Goswami (1999a) concluded that children from different orthographies appeared to develop different orthographic representations of which rime units appeared to operate in the learning to read of non-transparent scripts; and that phonemic units appeared to operate in the learning to read of transparent scripts and which usually developed in the very early stages of the learning to read process.
Therefore, with regards to the third consideration concerning the association between the transparency of a language and the level of phonological awareness that is operating as a predictor to future reading acquisition, from the above it appears that the level of phonological awareness that is most predictive of literacy development varies with the phonology of a language and the orthographic units that they represent in a particular language. In regular languages phoneme or explicit phonological awareness is a good predictor of future reading performances; and for an irregular language such as English rime or implicit phonological awareness is a good predictor of future literacy progress. Thus, the orthographic unit that the phonology of a language makes salient to its learner could act as a good predictor for future reading development. However, whether it could be considered as the best predictor further researching into this area is required. Moreover, being a good predictor does not imply that other forms of phonological processing (e.g. detection ability, manipulation ability, storage ability etc.) are not at work adding to their effect on literacy. Therefore, it is important for research to determine the relevant phonological processing in a more holistic manner, to determine the effect that each type of processing adds to literacy development, and to determine the developmental trend of the various phonological processing that is compatible with the way children cognitively develop across the different age groups.

**Rapid Naming**

Most of the findings on rapid naming have come from English-based studies. As it is known the English language is an irregular language with a low-level transparent orthographic structure, therefore it would not be advisable to generalize findings from such studies across to languages with more transparent structures. However, findings from such English-based studies could be used in guiding research in more transparent languages and used as yardsticks against which to compare degrees of discrepancy and/or similarity between transparent and non-transparent languages and to attempt relate the resultant findings with the make up of a particular language.
For a non-transparent language such as the English language, numerous studies have provided support for the predictive value of rapid naming in literacy development (for reviews see, Bowers & Ishaik, 2003; Semrud-Clikerman, Guy, Griffin, & Hynd, 2000; Wolf, Bowers, Biddle, 2000). And for more transparent orthographies, studies have been able to provide a similar support in the following languages: Greek, Spanish, Italian, German, Dutch, and Arabic (Nikolopoulos, Goulandris, Hulme, & Snowling, in press; Guardia, 2003; Di Filippo, Brizzolara, Chilosi, De Luca, Judica Pecini, Spinelli, & Zoccolotti, 2005; Wimmer, 1993; Landerl & Wimmer, 2000; Aarnoutse, van Leeuwe, & Verhoeven, 2005; de-Jong & Vrielink, 2004; van den Bos, Zijlsra, & van den Broeck, 2003; van den Bos, Zijlsra, & Spelberg, 2002; Saiegh-Hadded, 2005). Naming speed deficits are mainly assessed by means of tests known as rapid automatized naming (RAN). These tests comprise of a subset of familiar visual symbols from a particular category, such as digits, letters, colors, or simple objects that are presented in a serial array of randomized order, and upon which subjects are required to name the items as accurately and quickly as possible (Denckla, 1972; Denckla & Rudel, 1974; Semrud-Clikerman, Guy, Griffin, & Hynd, 2000; Wolf, Bally, & Morris, 1986, Wolf & Bowers, 1999; Wolf, Bowers, Biddle, 2000).

Although as mentioned earlier support for the predictive value of rapid naming in literacy development has been found, as will be seen, the researching of the literature appears to illustrate that it is important to take in to consideration certain issues when attempting to establish rapid naming as a predictor. The first consideration is related to how rapid naming as a predictor should be perceived; whether it should be perceived within a phonological processing deficit framework or considered as a separate predictor of poor reading ability. The second consideration revolves around what rapid naming as a predictor should entail. For it to act as a predictor, it appears necessary to specify the type of stimuli that will be used when testing for rapid naming (digits, letters, colors, pictures, etc.) and its relative familiarity with the subject (Nation, 2005). And thirdly, how rapid naming is related to the characteristics of a language's orthography.
It should be noted that the role rapid naming has been perceived to play in the prediction of literacy development has been more controversial than the role of phonological processing in the development of literacy. For example, Hammill (2004) in analyzing the combined results of three meta-analysis studies (Hammill & McNutt, 1981; Scarborough, 1998; Swanson, Trainin, Necoechea, & Hammill, 2003) that investigated the degree to which different measures of specific abilities were related to reading, found that non-print abilities such as RAN may have been overemphasized in the past, because they appeared to only moderately correlate with reading. Thus there appears to be a debate on whether RAN should or should not be considered as a predictor of literacy. However, with phonological awareness processing there appears to be a general agreement on its relatedness with reading (see section on phonological differences), the debate was usually on the nature of phonological processing that played at different levels of development and its degree of relatedness to literacy.

Geschwind (1965) was the first to propose a relation between naming deficits and reading disabilities. Denkla (1972) and Denkla & Rudel (1974 & 1976) supported this relation through a series of studies which showed that tasks which measured the speed of retrieval of names of letters, digits, colors, and objects separated individuals with dyslexia from non-dyslexic readers. Naming speed deficit have been found in all ages of poor readers: in school age children (Nation, Marshall, and Snowling, 2001; Swan & Goswami, 1977), in adults (Dietrich & Brady, 2001), and in children at genetic risk of dyslexia (Scarborough, 1990).

Initially, Rapid naming deficits were perceived as part of phonological core deficit in poor readers, where such deficits were explained in terms of accessing phonological codes from memory (Catts, 1989, 1996; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993); whereas, others have perceived naming deficit in poor readers as a general deficit in automized skilled behavior (Nicolson and Fawcett, 1999). It was argued that such a core deficit results in problems in the development of reading, writing, and phonological skills in poor readers and that the impact of this deficit extends beyond
related language skills to include any learned behavior (Nicolson and Fawcett, 1999; Catts, Gillispe, Leonard, Kail, & Miller, 2002). Indeed, some researchers based on their findings have advised that when evaluating reading disabled children it was recommended to not simply use rapid naming speed tasks but to increase the evaluation tool to include memory, attention and phonological awareness; because as it was demonstrated that rapid naming processing was not found to be the strongest contributor to reading but to arithmetic achievement (Ackerman et al., 2001). Whilst others have found that after partialing out phonological awareness and IQ, response time on two non-verbal tasks could not provide an explanation to any unique variance with reading ability (Stringer & Stanovich, 2000). As a result, it was concluded that extending the core deficit of poor reading to include a general deficit in speed of processing was not required. Still others have argued for the rapid naming deficit to be specific to timing in the verbal processing domain without being observable in tasks of nonlinguistic processing (Savage, 2004; Wolf, Bowers, Biddle, 2000). In fact it was noted that some poor readers could show a single deficit in either rapid naming alone or phonological awareness alone, whereas other poor readers could show deficits in both rapid naming as well as phonological awareness (Bowers & Ishaik, 2003; Wolf, Bowers, Biddle, 2000). As a result rapid naming was not perceived as a part of a general phonological processing but instead as providing a unique contribution to literacy development (Catts, Gillispe, Leonard, Kail, & Miller, 2002; Wolf, Bowers, Biddle, 2000; Bowers & Wolf, 1993). To a certain limit, support for rapid naming's unique contribution to reading has been found, in more transparent languages: Italian, Dutch and German (Di Filippo, Brizzolara, Chilosi, De Luca, Judica Pecini, Spinelli, & Zoccolotti, 2005; de-jong & van-der-Leij, 1999; Landerl, 2001). In the Landerl (2001) study with the German speaking third grade dyslexic children, it was found that RAN tasks showed a much stronger relation with measures of reading speed, whilst phoneme tasks were mainly related to reading accuracy. However, as Landerl (2001) pointed out that the two predictors could not be considered as independent because both RAN and phoneme awareness predictors were reliably correlated with each other. Hence, it appears that in a transparent orthography, at least within the German language RAN is related to a particular aspect of reading: rate of
reading speed (Landerl, 2001; Wimmer, 1993). Similarly, Saiegh-Hadded (2005) in using stepwise regression found that the strongest predictor of reading fluency in vowelized Arabic was letter recording speed, where the latter was predicted by rapid naming, memory, and phoneme isolation.

Moreover, some studies have demonstrated that naming of letters and digits (i.e. alphanumeric naming) was more closely related to reading than naming of objects and colors (Schatschneider, Carlson, & Francis, 2002; Wolf, Bally, & Morris, 1986). It appears that performance on alphanumeric naming of simple tasks could be considered as one of the two best predictors of word reading performance in the English language and as the single best predictor in more transparent orthography such as the Dutch, Spanish, Finnish, and German languages (Wolf, Pfeil, Lotz, & Biddle, 1994).

RAN has been studied as a longitudinal predictor in at least five English language studies (Wolf, Bally, & Morris, 1986; Wagnor, Torgesen, Rashotte, Hecht, Barker, Burgess, Donhue, & Garon, 1997; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Uhry, 2002; Simpson & Everatt, 2005; see Table 4.1) and in at least three transparent languages: Spanish, German, and Greek (Guardia, 2003; Wimmer, 1993; Nikolopoulos, Goulandris, Hulme, & Snowling, in press; see Table 4.1). In two of the English studies: Wagnor et al., 1997 and Torgesen, et al., 1997, RAN had been studied up to grades four and five respectively. The measured RAN in both studies consisted of alphanumeric items: digits and letters. Wagnor et al., (1997) study showed that RAN as an alphanumeric predictor in kindergarten could predict literacy in grade two and similarly RAN measurement in grade one could predict literacy in grade three. However, RAN measures in grade two did not appear to predict literacy in grade four. In all cases autoregressive effect of previous learning had been taken in to consideration. On the other hand, in Torgesen, et al., (1997) study alphanumeric RAN measures in each of grades two and three predicted grades four and five scores respectively before autoregressive effect of previous learning had been taken in to consideration. However, once autoregressive effect was taken in to consideration, alphanumeric RAN did not
significantly predict grades four or five literacy scores. Hence, the above studies had demonstrated that when previous learning experiences are taken in to consideration, RAN of alphanumeric items does not appear as a predictor of literacy for the higher primary grades; in particular for grades four and five, in a language with an irregular orthography such as the English Language. However, for lower grades: kindergarten up to grade one, it appears that RAN could act as a predictor (Simpson & Everatt, 2005; Uhry, 2002; Wolf et al., 1986) regardless of whether autoregressive effect is taken in to consideration or not, within the English language. Thus as Wagnor et al., (1997) had pointed out that the role of RAN as a predictor could be regarded as 'time-limited'. Moreover, Allor (2002) who had researched English language based studies that were carried out during the period (1993-1998) found that for RAN measures studied within a year, RAN could not act as a detector of literacy but for longer time periods (e.g. two years), then RAN could act as a predictor of literacy for levels up to grade two.

With regards to the longitudinal studies on RAN in transparent languages, RAN had been studied up to grade five (see Table 4.1). In the German language, RAN numeral in grade two was the main predictor of reading speed differences in grade four (Wimmer, 1993). Moreover, for the Spanish language it has been shown that RAN in kindergarten was the main explicative factor of grade one reading (Guardia, 2003). However, a different pattern of results was found in the study of the Greek language (Nikolopoulos, et al., in press). Alphanumeric RAN in the Greek language was studied up to grade five (Nikolopoulos, et al., in press). In this study, when autoregressive effect of previous learning was taken in to consideration, RAN did not appear as a longitudinal predictor of literacy. Instead, it appeared as a concurrent predictor of reading but not spelling. In fact speech rate was found as the most robust longitudinal predictor for reading and spelling. Therefore, it appears at least form the above studies on RAN in transparent orthographies that when aspects of a language (e.g. reading) consists of a transparent orthographic feature, then RAN numeral could at least be considered as a yardstick for predicting future reading score in the early years of primary schooling. However, in situations when literacy skills have a less transparent orthographic feature (e.g. Greek spelling) then other
<table>
<thead>
<tr>
<th>Language</th>
<th>Age / Grade</th>
<th>RAN measure</th>
<th>Result</th>
<th>Result Non-Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>KG to 2nd.</td>
<td>Color, letter, &amp; number (DEST subtest)</td>
<td>All RAN for KG and RAN (letter) for older ages.</td>
<td>-</td>
</tr>
<tr>
<td>English</td>
<td>KG to 4th.</td>
<td>Alphanumeric</td>
<td>KG to 2nd.</td>
<td>KG to 3rd.</td>
</tr>
<tr>
<td>English</td>
<td>2nd. To 4th. 3rd. to 5th.</td>
<td>Alphanumeric</td>
<td>Before autoregressive effect taken into consideration</td>
<td>After autoregressive effect taken into consideration</td>
</tr>
<tr>
<td>English</td>
<td>KG to 2nd.</td>
<td>Serial rapid naming</td>
<td>After autoregressive effect taken into consideration</td>
<td>-</td>
</tr>
<tr>
<td>English</td>
<td>4.87 to 6.65 years</td>
<td>Color, letter, &amp; number (DEST subtest)</td>
<td>For reading &amp; spelling</td>
<td>-</td>
</tr>
<tr>
<td>German</td>
<td>2nd. To 4th.</td>
<td>Numeral</td>
<td>2nd. To 4th.</td>
<td>-</td>
</tr>
<tr>
<td>Spanish</td>
<td>KG to 1st.</td>
<td>Serial rapid naming</td>
<td>KG to 1st.</td>
<td>-</td>
</tr>
</tbody>
</table>
processing speed measures such as speech rate could be considered as a predictor of literacy.

In addition, three points should be noted. Firstly, results on RAN reading should not be generalized to RAN in spelling, especially after the study on the Greek language (Nikolopoulos, et al., in press), which had shown that when a particular literacy skill relative to another literacy skill of which both are within the same language system but of which each has a different transparency level within its orthographic make up, then results on both skills may not necessarily be similar. Secondly, it must be noted that more studies should be carried out comparing speech rate with RAN across different languages in order to determine whether speech rate could be considered as the main longitudinal predictor for lower and higher primary literacy ability and whether it could be considered as a more important predictor of future literacy than RAN. Thirdly, when a language is transparent but holds a literacy skill that follows an irregular orthographic pattern, then it could be that this particular skill displays a pattern of predictors similar to those produced from languages that are less transparent. In turn, it follows that when considering predictors of literacy, it is not enough to simply observe the overall orthographic structure of a language (transparent versus non-transparent) in order to determine the predictors of future literacy ability; but to necessitate the importance of studying as well the orthographic nature involved in the make-up of a particular skill.

Furthermore, RAN has been studied as a concurrent predictor. A random selection of such studies was collected via electronic search (see Table 4.2). In this search seven studies were collected: two studies were on the English language (Clarke, Hulme, & Snowling, 2005; Bowey, McGuigan, & Ruschena, 2005), two studies were on the Dutch language (van den Bos, Zijlstra, & Spelberg, 2002; van den Bos, Zijlstra, & van den Broeck, 2003), one study was on the French language (Plaza & cohen, 2003), one on the Italian language (Di-Filippo, Brizzolara, Chilosi, De-Luca, Judica, Pecini, Spinelli, & Zoccolotti, 2005), and one study on both the English and Dutch languages (Patel, Snowling, & de Jong, 2004). This brief investigation was carried out in order to help
provide an overview of how effective RAN as a future predictor of literacy when considered as a concurrent predictor relative to when considered as a longitudinal predictor across the different languages.

In the English language RAN as a concurrent predictor has been studied in at least three studies on children up to the age of 11 years (Patel, Snowling, & de Jong, 2004; Clarke, Hulme, & Snowling, 2005; Bowey, McGuigan, & Ruschena, 2005). Results across the three studies were as follows: in Bowey et al., (2005) study, significance was only found for alphanumeric RAN but not for non-alphanumeric RAN as a predictor of literacy. However, in Clarke et al., (2005) study alphanumeric RAN was found significant only for exception word reading. Whilst Patel et al., (2004) study, in using only non-alphanumeric RAN measures, no significant result for RAN as a predictor was reached. Tentatively thus, it could be seen that, at least, in children within the age range of 8 to 11 years alphanumeric RAN appears to be a better predictor than non-alphanumeric RAN as a concurrent predictor which may not necessarily be directed towards all literacy skills within a language of an irregular transparency system (e.g. the English language).

In a less opaque language such as the French language, RAN for pictures, digits, letters were studied on grade one children (Plaza & Cohen, 2003). Significant results were only found for RAN pictures and letters as predictors of reading and spelling. The significant finding for RAN pictures, which is a non-alphanumeric measure of RAN, lead to the argument that RAN should be regarded as independent from phonological processing. Moreover, for a more transparent orthography, such as the Italian language, RAN was studied on children from grades one to six, using RAN colors, objects, and digits (Di-Filippo, et al, 2005). Significant results were found for all RAN measures, across the grades studied, on predicting accuracy and speed of reading but not comprehension. Similar to the French study, it was argued in Di-Filippo, et al, (2005) study that RAN should be perceived as independent from phonological processing. Furthermore, in the Dutch language, from the three studies: van den Bos, et al., (2002); van den Bos, et al., (2003); and Patel et al., (2004), one study collected life-span data across different ages
(van den Bos, et al., 2002). In this study, it was found that alphanumeric RAN measures were superior as predictors than non-alphanumeric items, which increased with age reaching an asymptote at 16 years of age; whereas, non-alphanumeric RAN were found to display an irregular pattern as predictors of literacy. Similarly, the results of van den Bos, et al., (2003) study indicated superiority for alphanumeric RAN relative to non-alphanumeric RAN measures as predictors of word reading speed. On the other hand, significant results for RAN measures as predictors of literacy were not found in the Patel et al. (2004) study. The result in the latter study may be due to the type of RAN measure used (i.e. colors, animals, and objects), all of which could be considered as non-alphanumeric measures of RAN. In turn, it could be seen that at least among the Dutch studies mentioned above, the results are in consistency with each other.

Altogether from the brief research on concurrent predictors, it appears that overall in both transparent and non-transparent languages; there is a superiority of alphanumeric RAN measures for ages up to 11 years over non-alphanumeric RAN as concurrent predictors of literacy. In transparent orthographies, at least within the Dutch language, it appears that this pattern continues through life-span. However, in non-transparent languages, such as the English language, this requires further investigation.

In comparing results of longitudinal versus concurrent predictors of literacy, it could be seen that although results from the two different methods were about similar in showing a superiority of alphanumeric RAN over non-alphanumeric RAN measures at least for young children in lower primary grades from languages with transparent orthographies, longitudinal studies appear to be more beneficial than research on concurrent predictors because of two fold. Firstly, some longitudinal studies have taken into consideration, autoregressive effect of previous learning, and secondly, it has opened up a new avenue of research showing that perhaps speech rate could be considered as an alternative 'all round' predictor of literacy for younger and older age group of children; particularly since it has been shown that it is difficult to improve RAN of letters in beginner readers of the Dutch language (de Jong & Vrielink, 2004).
Table 4.2 - Some studies on rapid automatized naming (RAN) as a concurrent predictor of literacy in transparent and non-transparent languages.

<table>
<thead>
<tr>
<th>Language</th>
<th>Age / Grade</th>
<th>RAN measure</th>
<th>Result Significant</th>
<th>Result Non-Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>English</strong></td>
<td>8 to 11 years</td>
<td>Alphanumeric</td>
<td>For exception word reading</td>
<td></td>
</tr>
<tr>
<td>(Clarke, Hulme, &amp; Snowling, 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>English</strong></td>
<td>4th.</td>
<td>Alphanumeric &amp; Non-Alphanumeric</td>
<td>Alphanumeric in 4th. grade</td>
<td>Non-Alphanumeric</td>
</tr>
<tr>
<td>(Bowey, McGuigan, &amp; Ruschena, 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>French</strong></td>
<td>1st.</td>
<td>Picture, digit, &amp; letter</td>
<td>For letter &amp; picture</td>
<td>-</td>
</tr>
<tr>
<td>(Plaza &amp; Cohen, 2003)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Italian</strong></td>
<td>1st. to 6th.</td>
<td>Colors, objects, &amp; digits</td>
<td>For accuracy &amp; speed of reading</td>
<td>-</td>
</tr>
<tr>
<td>(Di-Filippo, et al, 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dutch</strong></td>
<td>Life span: Grades: 2nd, 4th, 6th, 7th, ages 16 &amp; 64 years</td>
<td>Alphanumeric &amp; Non-Alphanumeric</td>
<td>Alphanumeric increasing with age reaching asymptote at 16 years</td>
<td>-</td>
</tr>
<tr>
<td>(van den Bos, Zijlstra, &amp; Spelberg, 2002)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dutch</strong></td>
<td>Life span: Grades: 2nd, 4th, 6th, 7th, ages 16 &amp; 64 years</td>
<td>Alphanumeric &amp; Non-Alphanumeric</td>
<td>Superiority of Alphanumeric</td>
<td>-</td>
</tr>
<tr>
<td>(van den Bos, Zijlstra, &amp; van den Broeck, 2003)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dutch &amp; English</strong></td>
<td>Young readers: 7-8 years Older readers: 9-11 years</td>
<td>Colors, animals, &amp; objects</td>
<td>-</td>
<td>RAN</td>
</tr>
<tr>
<td>(Patel, Snowling, &amp; de Jong, 2004)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
The results in the literature are considerable, but what is clear is that some form of processing speed deficit exists among some poor readers whether this deficit is of a general nature that includes linguistic and non-linguistic rapid speed processing or a more specific rapid linguistic processing. Part of this controversy over the specifics of rapid processing may lie in the nature and size of samples chosen in the various studies. Usually, samples come from different educational and demographic backgrounds, and from different age groups and intelligence levels. As a result, despite the fact that different studies may have taken the particulars that characterize their sample into consideration, conclusions should be regarded with caution. However, in resorting to neurology which could help give a clearer picture of the role of rapid naming by pinpointing whether performance on rapid naming tasks actually engage specific neural networks that have also been observed in word reading studies. Misra, Katzir, Wolf, & Poldrack (2004), using functional magnetic resonance imaging found that the majority of children and adults with reading difficulties displayed marked difficulties on rapid serial naming measures of letters and objects. In addition, these researchers confirmed that rapid naming tasks employed similar neural network structures that were employed in complex reading tasks, in particular, that rapid serial naming of letters was found to activate the main neural networks that are involved in reading. This in turn, provides support to those studies (Schatzneider, Carlson, & Francis, 2002; Wolf, Bally, & Morris, 1986) that have found supremacy for processing rapid letter naming over processing for rapid object naming, as a predictor of reading.

Overall, whenever RAN is considered as a predictor, it will be seen that from at least the English based studies there appears to be a dispute as to nature of the rapid naming deficit as well as whether such a deficit should be considered as part of phonological processing or not.
Auditory Differences

The importance of auditory processing in normal language acquisition cannot be debated. However, whether it could act as a predictor to particular language problems such as dyslexia remains controversial. As will be seen that results of studies researching auditory processing among poor readers across different languages have not been consistent nor have results within a single language always been consistent.

It must be pointed out that sounds could be analyzed via analyzing their physical characteristics such as frequency, intensity, and temporal features which could be perceived as pitch, loudness, and duration. The American Speech-Language-Hearing Association (1996) maintains that the central auditory processes to be responsible for five behavioral incidents, which could apply to verbal and non-verbal stimuli and which may affect many areas including speech and language. The behavioral incidents listed were localization and lateralization of sound, auditory discrimination, auditory performance with competing acoustic signals, auditory performance with degraded signals, and temporal processing (i.e. temporal resolution, masking, integration, and ordering). In addition, the processing of auditory information is perceived to involve many neurocognitive functions, some of which are specific to the processing of acoustic signals whilst others e.g. attention, memory, and language representation, are not necessarily specific to the processing of acoustic information. In turn, a deficit in auditory processing could be perceived as a weakness in the perception and/or in the cognition following an auditory stimulus input. Moreover, since in the area of reading difficulties a link had been reported between deficits in temporal processing and deficits in phonological skills in reading impaired children (Tallal, Miller, & Fitch, 1999) many studies interested in reading difficulties have focused their effort into researching the temporal aspects of auditory processing.

In the following sections to come, evidence will be given for and against the general auditory processing theory originally proposed by Tallal (1980) from studies carried out in different languages, pin pointing some of the short comings of some of the studies
given and the various manifestations that were provided from the different researches despite having similar conclusive results. Furthermore, this will be succeeded by the proposition of an alternative theory: Amplitude Envelop Onset, proposed by Goswami, Thomson, Richardson, Stainthorp, Hughes, Rosen, & Scott (2002). This theory could be considered as a slightly modified version of the original general auditory processing theory and appears to gain support from different languages and levels of development. Finally, it will be argued that despite the attractiveness of Goswami et al's theory (2002) evidence of a more cross cultural nature is required for a conclusive decision to be made.

A dominant theory is the general auditory processing hypothesis proposed for reading and language impairment (Tallal, 1984; Anderson, Brown, & Tallal, 1993; Fitch, Miller, & Tallal, 1997). According to this theory, which is sometimes known as the rapid temporal or perceptual theory, it is proposed that auditory deficits lie in the neural systems that are responsible for the processing of stimuli with short duration and which appear in rapid succession. Consequently, this deficit was thought to have an affect on language-based skills. More specifically, it is argued that dyslexics are significantly impaired in their ability to discriminate, sequence, or remember brief auditory stimuli that follow one another within a few tens of milliseconds (Tallal, 1980). Since the discrimination of most phonemes, consonants in particular, relies on the ability to perceive frequency changes and voicing onsets that takes place over a brief time span, therefore it was proposed that a deficit in the processing of rapid, transient cues might explain poor phonemic awareness in dyslexics and in turn explain the difficulties dyslexics experience in literacy acquisition. Evidence in support for this theory was provided by studies carried out in languages of less transparent orthographies (English and French) as well as in languages of more transparent orthographies (Hebrew, Finnish, and Belgian). Some such studies on English speaking subjects were Tallal (1980); Reed (1989); Stein & McAnally (1995); Balise (1997); Baldeweg, Richardson, Watkins, Foale, & Gruzelier (1999); and Bell, McCallum, & Cox, (2003) and on French speaking subjects was Rey, DeMartino, Espesser, & Habib's (2002) research. Moreover, some supportive research on the auditory processing theory on subjects speaking more transparent
orthographies such as Hebrew were Cohen-Mimran (2006); Banai & Ahissar (2006); and Moisescu-Yiflach & Pratt (2005) and on languages such as Finnish and Belgian were Hari & Kiesila (1996); and Laasonen, Service, & Virsu (2001) studies carried out on Finnish speaking subjects and Van Ingelghem, Van Wieringen, Wouters, Vandenbussche, Onghena, & Ghesquiere (2001) study carried out Belgian speaking subjects.

With regards to the English based studies, Reed (1989) in attempting to replicate Tallal's (1980) study using speech and non-speech tasks found evidence of poor performance in reading disabled English speaking children (n=23) on temporal order judgment for brief tones and stop consonants. In addition, it was found that those children showed deficits in the perception of words and that they had heavily depended on context for phoneme identification (Reed, 1989). In all, the results were perceived to suggest that some reading disabled children experience perceptual deficit which appear to interfere with phonological processing (Reed, 1989). Similarly, Balise (1997) in examining the relationship between onset frequency and gap duration, found evidence for auditory processing deficit in speech and non-speech sounds that were synthetically produced among English speaking dyslexics (n=30). Where as, Stein & McAnally (1995) found evidence supporting the temporal order judgment theory through using sensitivity to rate and depth of acoustic frequency modulation. Whilst, Baldeweg, et al. (1999) in using an attention-independent auditory brain potential known as the mismatch negativity (MMN) to test non-verbal auditory processing also found support for the general auditory processing theory. In Baldeweg, et al. (1999) study English speaking dyslexics (n=10) relative to controls (n=10) showed MMN potential to changes in tone frequency but not to changes in tone duration, where MMN deficit was also found to correlate with phonological deficit; thus providing evidence for a general auditory processing deficit in dyslexia using only non-verbal stimuli.

The above studies so far mentioned, should be regarded with caution as in many of other studies that will be presented below because of having a small sample size and the absence of a control group with an equivalent reading level ability as the dyslexics. The
former point affects the degree of accepting the analysis of the study and its developmental power. With a small group of say adult dyslexics, it becomes somewhat difficult to generalize the results to dyslexics of younger and/or older age groups. Whereas, the latter point affects the degree to which a developmental causation between deficits in auditory processing and phonological processing can be implied across the different age groups, particularly since the presence of such a reading-level control group helps control for cultural reading experiences.

In addition, some researches have questioned the assumptions of the general temporal processing theory and the evidences provided in support for it (e.g. Studdert-Kennedy & Mody, 1995; Mody, Studdert-Kennedy, & Brady, 1997; Denenberg, 1999; Studdert-Kennedy, Mody, & Brady, 2000; Studdert-Kennedy, 2002). For example, Studdert-Kennedy (2002) criticized some of the studies that have claimed to find evidence for the general auditory processing theory (e.g. Reed, 1989; Stein & McAnally, 1995) in that they lacked having phonetic contrasts as controls for the auditory tasks used, because as Studdert-Kennedy (2002) argued that “a causal role for a particular auditory deficit in defective speech perception can be established only by demonstrating equivalent deficits in perceiving both speech and an acoustically matched non-speech control,” (p. 6, Studdert-Kennedy, 2002). Although as mentioned above some studies did use stimuli controls, their results should be regarded with caution because as Studdert-Kennedy (2002) pointed out, in referring to Reed's (1989) study as an example, that the speech (/ba/ and /da/) and non-speech (tone) stimuli used were not compatible with each other. This was reasoned on the bases that the speech stimuli were "rapidly presented pairs of discrete, complex tones, differing in fundamental frequency (pitch), [whilst non-speech were] rapid continuous sweep of formant transitions, differing in spectral weight (timbre)," (p. 224, Studdert-Kennedy, 2002). Moreover, it was pointed out that significant correlations should not be perceived to reflect a confirmation for a causational relationship between variables (Studdert-Kennedy, 2002). Furthermore, Mody, Studdert-Kennedy, & Brady (1997) noted that some studies had confused between 'perception of rate' with 'rate of perception', in turn leading to misinterpretation of results. It was argued
that perceiving temporal properties such as duration, sequencing, and rhyming of stimuli could be considered to reflect a temporal order decision; whereas, the identification and/or discrimination between briefly presented stimuli could not, simply by virtue of being rapidly realized, be considered to reflect a temporal order judgment. The former type of task was perceived to reflect a 'rate of perception', whilst the latter task was perceived to reflect 'perception of rate' type of task. Overall, the questioning of the general temporal processing theory led certain researchers to propose a 'speech-specific' theory in which poor readers' deficit were perceived to be restricted to the processing of speech stimuli with broad and less defined phonological categories (Studdert-Kennedy & Shankweiler, 1970; Mody, Studdert-Kennedy, & Brady, 1997; 2001).

With regards to the French language, Taylor, Batty, Chaix, & Demonet, (2003) found evidence in a small group of French speaking phonologically dyslexic children with an age range from 8-12 years that showed dyslexics having a slightly lower accuracy performance and a longer reaction time than controls on an auditory discrimination task; thus indicating that at least in the French language, dyslexia appears to be associated with speed as well as with accuracy deficit in discrimination tasks requiring auditory processing. This could provide a suggestion of a typical behavioral feature that could be observed in dyslexics of languages with a less transparent orthographical structure e.g. French. Although such an observation has been mostly associated with reading tasks (Landerl, Wimmer, & Frith, 1997), it appears that it could extend to auditory processing discrimination tasks as well.

It must be noted that Taylor et al. (2003) study provided only partial support to the general auditory processing theory by showing that phonological dyslexics may show auditory temporal deficit but they did not attempt to search for a causation link between phonological deficit and auditory deficit. On the hand, as will be seen below, Rey, et al. (2002) study on French speaking dyslexics found support for the general auditory processing theory. However, their study lacked the inclusion of reading age controls and had a small sample size (10 controls & 13 dyslexics) relative to the large amount of tasks
that were administered (4 phonological processing tasks & 3 event order judgment tasks). Despite such issues Rey et al., (2002) have attempted to go a step further than some of the other researchers by attempting to link auditory perception to the structure of a language’s sound system. In their study, Rey et al., (2002) found evidence for a general auditory temporal deficit among French speaking dyslexic children aged 10-13 years. It was found that phonological deficit was mostly accompanied by a temporal deficit such that the researchers believed that "selecting phonological dyslexics without significant oral language deficit may be quite artificial and misleading," (p. 585, Rey et al., 2002). In addition, significant difference in results between dyslexics and controls were only found for temporal order judgment tasks when stimuli were of consonant clusters (CCV) and not for the simpler syllabic structures (CVCV). Lengthening the consonant duration on event order judgment appeared to improve consonant order judgment in the phonetically dyslexic children. Also, the individual performance of dyslexics on phonological tasks correlated positively with their performance on temporal order judgment tasks only under the condition of consonant clusters (normal or slowed) and not under the simpler syllabic structure condition. In all, the results of their study lead the researchers to conclude that consonant brevity accounted for the poor performance of the dyslexics in the temporal order judgment tasks. Therefore, it was recommended that training phonological dyslexics in slow speech could help improve their performance in literacy tasks e.g. non-word spelling (Rey et al., 2002). It must be noted that as Rey et al., have pointed out that the phonological deficits in dyslexics may in part have resulted from an elementary deficit in the order of short events in which the main deficit could have been due to the brevity of the events rather than on their succession. More importantly, Rey et al., (2002) study tells of the importance of the make up of the orthographical structure of a language and the speed of sounding out its units on the degree of deficit that is expected to be found among dyslexic subjects. Accordingly, it could be hypothesized that the more the consonant structures of a language contain fast changing units of sound, the more likely that a dyslexic speaking such a language will face phonological and literacy difficulties. Such a hypothesis requires cross-cultural comparison studies which, as far as it is known, have not as yet been carried out.
A similar finding was found in Cohen-Mimran (2006) study on Hebrew speaking dyslexics. In the following investigation, behavioral as well as electrophysiological evidence was found showing that Hebrew speaking children experience difficulties in discriminating between pairs of syllables that could be distinguished on the basis of a brief temporal cue (Voice Onset Time), that temporal processing deficit correlated strongly with phonological processing deficits, and that the performance of the poor readers group deteriorated with increasing the rate of stimulus presentation speed. In Cohen-Mimran’s (2006) paper, it was argued that the orthography of a language affected the degree of auditory temporal deficit such that temporal processing deficit was expected to be more related to the consonantal aspect of a language than the vowel aspect particularly since the former aspect usually displayed rapid acoustic changes in speech sounds whereas the latter were usually found to be steadier than consonants (Tallal & Piercy, 1974). Consequently, it was argued that since the Hebrew language is heavily consonantal, therefore the correlation between temporal order processing of consonants and reading related skills was expected to be found. This could be considered an interesting observation given the fact that although Hebrew is usually considered a more transparent language than the French, both of those studies displayed similar findings. In turn, reflecting the importance of the degree at which the consonantal features of a language’s orthography relative to its vowels in affecting the manifestation of dyslexic related auditory and literacy processing abilities; also in such an observation displaying the superiority of orthography over levels of transparency in dyslexia research related to auditory processing.

Furthermore, it appears that the correlation between phonological processing tasks and temporal processing deficit was found to be high in young children (Cohen-Mimran, 2006) relative to adults (Amitay, Ahissar, & Nelken, 2002). This in turn reflected the need for caution in generalizing results of studies taken from an adult sample to those on children and vice versa.
Despite the supportive evidence for the general auditory processing theory, there are equally studies that have failed to find such support (e.g. Mody et al., 1997, Nittouer, 1999, Bishop, Carlyon, Deeks & Bishop, 1999, Marshall, Snowling, & Bailey, 2001, Rosen, 2003, and Heath & Hogbon, 2004 in English speaking subjects; van-Beinum, Schwippert, Been, van Leeuwen, & Kuijpers, 2005, in Dutch speaking subjects; von-Suchodoletz, Berwanger, & Mayer, 2004, in German speaking subjects). However, the different manifestation given in the interpretation of the results within a particular side (either arguing in support of the general auditory processing theory or against it) could have added to the culmination of the controversy with regards to the role auditory processing deficit plays in dyslexia. For example, in Laasonen, Service, & Virsu (2001) study evidence was found for the presence of an auditory processing deficit in Finnish speaking well-educated adult dyslexics. However, the deficit appeared to be related to temporal acuity and not to temporal order of stimuli, thus suggesting that the auditory deficit among at least Finnish speaking dyslexics appeared to be stimulus specific. Simultaneously, correlations between temporal acuity and reading-related tasks were found suggesting an association between temporal acuity and phonological awareness. Whereas, in Moisescu-Yiflach & Pratt (2005) study supportive evidence for the general auditory processing theory was found amongst Hebrew speaking adult dyslexics with high academic achievement. Those subjects differed from controls in the processing of verbal and non-verbal auditory stimuli with temporal and with spectral discriminating cues. In another study (Banai & Ahissar, 2006) carried out only on female Hebrew speaking subjects, it was found that the degree of auditory impairments among female dyslexics studied was dependant on task difficulty rather than stimulus complexity. It was believed that non-speech auditory stimuli were not directly related to reading problems but remained part of the same underlying deficit that contributed to phonological processing deficit and in turn related to poor reading. In addition, auditory processing deficit was not impaired under all conditions because dyslexics were not found to have difficulties in detecting speech in noise. Moreover, it was argued that dyslexic subjects' problem did not lie within the auditory processing per se but was believed to be related to the overall auditory experience which varied depending the on the "stimulus protocol;
and behavioral task" (p. 8., Banai & Ahissar, 2006). Accordingly a neuro-physiological rationalization was given to the findings, explaining the impairment as a problem in the transfer of the auditory experience across hemispheres. Hence, supporting Larsen’s (1989) argument in the way auditory information is transferred and the overall gestalt experience that dyslexics' have a problem in. Similar lines of conclusions were reached at in Meyler & Breznitz (2005) study despite the differences in methodical procedures used in comparison with Banai & Ahissar (2006) research. In examining visual, auditory, and cross-modal temporal patterns, Meyler & Breznitz (2005) found that Hebrew speaking adult dyslexics showed evidence of a general impairment in temporal processing with the greatest impairment being in the processing of visual syllables. In addition, high functioning adults were found to be able to cope with temporal processing. Accordingly, it was proposed that the reason for the ability of the high functioning dyslexics to cope with auditory processing may have been due to the adoption of a strategy that was holistic and orthographic in nature, where the cumulative information from the various sources: modality, stimulus complexity, and linguistic demands, interacted with each other, in turn affecting the influence of temporal processing abilities. As it could be seen that the conclusion reached at by Meyler & Breznitz (2005) was similar to that of Banai & Ahissar (2006) study, but each differed in the manner they argued in support of their point of view. Whereas in another study it was found that Hebrew speaking university students with developmental dyslexia did not significantly differ from controls on a linguistic phonemic identification task (a verbal task) but differed on the non-linguistic rate change (a non-verbal task) thus associating dyslexia with a central auditory processing deficit (Sapir, Maimon, & Eviatar, 2002). It was noticed in the current study that the dyslexics displayed behavior of fatigue after performing the tasks whereas the controls' performance improved across tasks indicating that dyslexics do not necessarily learn from continuous practice. In addition, it was proposed that fatigue which was found to be related to frontal lobe disturbances (Robichon, Levrier, Farnarier, & Habib, 2000) was not directly related to auditory or linguistic processing deficits but instead may have interfered with the dyslexics' performance (Sapir et al., 2002).
As it could be seen just from the supportive evidence provided various explanations were given to auditory deficits. Some studies have perceived it to be stimulus specific (Laasonen, Service, & Virsu, 2001), others to be related to task difficulty rather than stimulus complexity (e.g. Banai & Ahissar, 2006), some perceived it being affected by the consonants of a language (e.g. Rey et al., 2002; Cohen-Mimran, 2006), and still others perceived it to be related to the overall perceptual experience of the stimulus input (e.g. Meyler & Breznitz, 2005). In addition, some studies found a transfer of information taking place through training dyslexics via lengthening the consonant durations (e.g. Rey et al., 2002), whilst others found dyslexics unable to learn from practice and experience fatigue (e.g. Sapir et al., 2002). Hence, altogether making it difficult to form a clear picture of how auditory processing results in phonological and literacy difficulties.

On the other hand, Goswami et al. (2002) study with its neuroconstructivistic approach that based its theory by making use of the cross-cultural evidence found on phonological deficit and dyslexia; in addition to taking a longitudinal approach where children were studied from an early age of four years up to the age of eleven years, helped fill the gap on how auditory processing deficit could result in phonological and literacy difficulties in dyslexic subjects. Goswami et al. (2002) had put forward the theory 'Amplitude Envelope Onset' explaining the nature of auditory deficit in dyslexia. By making use of several findings such as: that phonological awareness was strongly predictive of literacy acquisition across languages (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Hoien, Lundberg, Stanovich, & Bjaalid, 1995; Lundberg, Frost, & Peterson, 1988; Schneider, Kuspert, Roth, Vise, & Marx, 1997); that despite the differences in the phonological structures of the languages being learnt, studies across different languages had produced similar results demonstrating that good phonological awareness of syllables and onsets and rimes was found amongst normally developing preschoolers (Bradley & Bryant, 1978; Siok & Fletcher, 2001; Wimmer, Landerl, & Schneider, 1994; Hoien, Lundberg, Stanovich, & Bjaalid, 1995; Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980); that dyslexics across languages have problems in the phonological representations of words (Goswami, 2000, Snowling, 2000); that
awareness of phonological structures in words is usually measured using rhyme recognition tasks (Bradley & Bryant, 1983); and that rhythm in speech is a feature of the slow amplitude modulation of the waveform (Rosen, 1992) which more or less has been argued to correspond to the amplitude modulation associated with syllables (Goswami et al., 2002); all of which led Goswami et al. (2002) to argue that dyslexics have problems in perceiving the 'beats' in the sounds they hear, which in turn was argued to affect the dyslexics’ phonological representation of words, thus resulting in affecting the dyslexics' ability to read and spell; also, for Goswami et al. (2002) to propose measuring the rhythm aspect in sounds via measuring the rise-time of the amplitude modulation at low rates in a signal (i.e. the suprasegmental aspect of sound).

More specifically, Goswami et al., (2002) found that measuring the detection of amplitude envelop onset helped discriminate between dyslexics and controls; and between young early readers and children of normal literacy development. They then showed that after controlling for individual differences in age, nonverbal IQ, and vocabulary, 25% of the variance in literacy acquisition was accounted for by individual differences sensitivity to the shape of the amplitude modulation; hence showing that the insensitivity of the English speaking dyslexics to the amplitude rise time relative to the controls, could partly account for the dyslexics problems in literacy acquisition. Furthermore, Goswami et al (2002) included two other auditory processing tasks: a rapid frequency discrimination task (RFD) and a temporal order judgment task (TOJ), in addition to the beat perception task; thus allowing for a direct comparison with Tallal's general auditory processing theory. Results indicated that upon correlation of the three auditory processing tasks with phonological and literacy processing tasks, the beat perception task showed evidence of a significantly stronger overall correlation with the various phonological and literacy processing tasks than the other two auditory processing tasks (RFD and TOJ). Moreover, in determining the predictive power of the different auditory processing measures on phonological and literacy processing, it was found that (RFD) did not predict spelling, although it did predict reading of word and non-word and the oddity task. However, the amount that (RDF) predicted literacy (about 10%) was less
than that found for the beat perception processing task (about 25%). The (TOJ) measure was found to be even less sensitive, predicting about 6% of the reading score as well as not showing any significant prediction with spelling (see table 4 in Goswami et al., 2002).

Overall, the appeal in the 'Amplitude Envelop Onset ' theory proposed by Goswami et al. (2002) comes not only from the theoretical argument for the framework they had put forward in their study, but as well from three other factors. One factor involves having found empirical evidence of the superiority of beat perception processing, a type of auditory processing, in predicting literacy and phonological processing relative to other auditory processing tasks (RFD and TOJ). As well as finding that the beat perception task was the only auditory processing task that was able to significantly predict spelling, which supports the finding that the inclusion of spelling tasks in dyslexia assessment is more useful than the inclusion of word reading particularly in languages of transparent orthographies where the mapping from phoneme to grapheme is less consistent than the mapping from grapheme to phoneme (see Goswami et al., 2002). A second factor is that similar findings were reached with French speaking subjects (Muneaux, Ziegler, Truc, Thomson, & Goswami, 2004) upon exact replication of the procedure used in Goswami et al. (2002) study with English speaking subjects. Hence, showing that beat perception is not restricted by the particularities of stress in a language but could generalize to languages with different rhythmic properties (Muneaux et al., 2004). In addition, evidence of beat detection deficits has been reported to be found in Finnish speaking dyslexics (Goswami, 2003). Also, suggestive evidence of a link between syllable processing and mean amplitudes was claimed to be found amongst Spanish speaking poor readers (Alonso-Bua, Diaz, & Ferraces, 2006).

Finally, the third factor is related to the empirical finding for perceptual-centres or 'P-centre' sensitivity to rhymes in the English language, a stress-timed language; as well as in Spanish, a syllable-timed language; and in the Japanese language, among university native speakers (Hoequist, 1983). This suggestive universality of the 'P-centre' (Hoequist,
1983), appears to fit in well with Goswami et al. (2002) argument which referred to other evidences carried out on 'P-centres' (Morton, Marcus, & Frankish, 1976; Gordon, 1987; Vos & Rasch, 1981; Marcus, 1981) associating 'P-centres' with the processing of detecting the beats found in syllables onsets and rhymes of which their accurate detection was argued to be important in phonological representation (Goswami et al., 2002). Altogether, implying that dyslexics' 'P-centres' may be insensitive to syllable onset and rhymes and that such a feature may be found in most languages without necessarily being restricted to the acoustical structure of any particular language. Further research is required for the confirmation of such an observation.

In conclusion, more consistent findings were found for Goswami et al. (2002) theory than for Tallal (1980) auditory processing theory. However, it must be pointed out that the former theory had only recently been put forward relative to that of the latter theory. Therefore, more cross-cultural research is required on the former theory from groups of native speakers from different languages (e.g. Arabic, Hebrew, Greek, German, Danish, etc.). Moreover, an additional informative source on such an issue could be from groups of native speakers sharing a similar language (e.g. English) but belonging to different cultures (e.g. British, American, and Australian).

**Visual differences**

With regards to the role of visual processing in dyslexia, it will be seen that reading disabilities have been mostly associated with low-level visual processing deficits such as visual tracking, visual masking, and visual motion (for a review see Vellutino, Fletcher, Snowling, & Scanlon, 2004). Despite the abundance of studies carried out in this area on English speaking subjects (Staneley, Smith, & Howell, 1983; Getman, 1985; Lovegrove, Martin, & Slaghuis, 1986; Lovegrove, Garzia, & Nicolson, 1990; Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Flemingham & Jakobson, 1995; Hayduck, Bruck, & Cavanagh, 1996; Eden, vanMeter, Rumsey, Maisog, Woods, & Zeffiro, 1996; Everatt, Bradshaw, & Hibbard, 1999; Stein, Richardson, & Fowler, 2000), along with a
number of studies carried out on subject speaking shallower languages such as Italian, German, Spanish, Swedish, Hebrew, or Arabic (e.g. Capece, Acquaviva, De-Marco, Ambrosio, & Bove, 1997; Schulte-Korne, Bartling, Deimel, & Remschmidt, 2004; Martos & Vila, 1990; Ygge, Lennerstrand, Rydberg, Wijecoon, & Pattersson, 1993; Ben-Yehuda, Sackett, Malchi-Ginzberg & Ahissar, 2001; Farrag, Khedr, & Abdel-Naser, 2002, respectively) the findings have not been consistent. Such inconsistencies, as it will be seen, have made it difficult to determine the nature of the visual deficit and its probable connection with dyslexia.

The most dominant theory put forward as an explanation for visual deficit in dyslexia was the magnocellular hypothesis (Lovegrove, Martin, & Slaghuis, 1986; Lovegrove, Garzia, Nicolson, 1990; Stein & Talcott, 1999; Stein, 2001). Briefly, according to this theory it has been proposed that the development of the dyslexic's visual magnocellular system is impaired. This atypical development reflected in the abnormal functioning of the magnocellular system via reduced motion sensitivity, and binocular and visual perceptual instability, was perceived to affect the development of the orthographical skills necessary for the learning to read process. This proposition was based on findings from different areas of research including anatomical: (Livingstone, Rosen, Drislane, & Galaburda, 1991) and psychophysical (Lovegrove, Bowling, Badock, & Blackwood, 1980) work. Anatomically, from post-mortem studies, it was found that the development of the magnocellular layers of the lateral geniculate nucleus in dyslexics were abnormal, whilst the parvocellular layers were normal (Livingstone, Rosen, Drislane, & Galaburda, 1991; Galaburda & Livingstone, 1993). Psychophysically, it was found that some dyslexics had reduced motion sensitivity (Lovegrove, Bowling, Badock, & Blackwood, 1980; Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Flemingham & Jakobson, 1995; Eden, vanMeter, Rumsey, Maisog, Woods, & Zeffiro, 1996), unsteady binocular fixation (Stein & Fowler, 1981; Stein, Richardson, & Fowler, 2000), and poor visual localization particularly on the left side, reflecting left side neglect (Stein & Fowler, 1981; Riddell, Fowler, & Stein, 1990).
Originally, the magnocellular theory was based on studies of English speakers, in which some studies had found support for a magnocellular deficit (e.g. Martin & Lovegrove, 1987; Flemingham & Jakobson, 1995; Cornelissen, Hansen, Gilchrist, Cormack, Essex, & Frankish, 1998; Demb, Boynton, Best, & Heeger, 1998; Hansen, Stein, Orde, Winter, & Talcott, 2001), whilst others did not (e.g. Gross-Glen, Skottun, Glenn, Kush, et al., 1995; Hayduck, Bruck, & Cavanagh, 1996; Johannes, Kussmaul, Munte, & Mangun, 1996; Williams, Stuart, Castles, & McAnally, 2003); and still other researchers found evidence of a magnocellular deficit only amongst some of their dyslexic population (e.g. Borsting, Ridder, Dudeck, Kelly, Matsui, & Motoyama, 1996; Ridder, Borsting, Cooper, McNeel, & Huang, 1997; Slaghuis & Ryan, 1999; Everatt, Bradshaw, & Hibbard, 1999).

With regard to research on the magnocellular-deficit theory, carried out in languages of more regular orthographies, some studies had managed to find support for the theory (e.g. Ben-Yehuda, Sackett, Malchi-Ginzberg & Ahissar, 2001, on Hebrew speaking dyslexic adults; Capece, Acquaviva, De-Marco, Ambrosio, & Bove, 1997, on Italian speaking dyslexic children; Ygge, Lennerstrand, Axelsson, & Rydberg, 1993, on Swedish speaking dyslexic children); whilst others did not manage to find such a support (e.g. Spinelli, Angelelli, De Luca, Di Pace, Judica, & Zoccolotti, 1997, on Italian speaking children; Kronbichler, Hutzler, & Wimmer, 2002 and Hutzler, Kronbichler, Jacobs, & Wimmer, 2006, on German speaking school children; Ygge, Lennerstrand, Rydberg, Wijecoon, & Petessson, 1993, on Swedish speaking dyslexic children; Farrag, Khedr, & Abel-Naser, 2002, on Arabic speaking dyslexic children). In addition, so far as it is known, no studies carried out in languages of regular orthographies were found, reporting a support for the magnocellular-deficit theory amongst only some of their dyslexic population.

From the above, it could be seen that the findings have not displayed a consistent pattern across the different languages: regular and irregular. Perhaps part of the lack of uniformity across findings could be because the different studies have looked into different aspect of the visual magnocellular system, such as contrast sensitivity, eye movements, ocular motor control, etc. using different types of stimuli, mostly non-
linguistic stimuli, at different ranges of frequencies. In other words, there does not appear to be a coherent procedure carried out across the different studies; nor have the various parameters, usually considered associated with the visual magnocellular system, been altogether researched within a single study. For example, within the Swedish dyslexic population, one study tested eye movements and found no support for a magnocellular-deficit theory (Ygge, Lennerstrand, Rydberg, Wijecoon, & Petesson, 1993); whereas another study tested for contrast sensitivity and found support for the theory (Ygge, Lennerstrand, Axelsson, & Rydberg, 1993). In addition, studies have been mostly concerned with searching for a visual deficit; only some have attempted to test for the presence of a direct association between visual processing deficit, if any, and literacy (except for Lovegrove, Slaghuis, Bowling, Nelson, et al., 1986; Cornelissen, Hansen, Gilchrist, Cormack, Essex, & Frankish, 1998; Demb, Boynton, Best, & Heeger, 1998; and Hutzler, Kronbichler, Jacobs, & Wimmer, 2006). Therefore, justice to the role the visual magnocellular theory could provide as an explanation to some of the dyslexic literacy problems becomes difficult to offer.

Despite the inconsistencies in findings some interesting issues have been raised from the different studies, such as the importance of diagnosing dyslexics in to different sub-types, prior to testing; and controlling for the parvocellular system, a competing visual system considered by some researches to function along side the visual magnocellular system (Livingstone & Hubel, 1988). For example, in a German study, Kronbichler, Hutzler, & Wimmer, (2002) found that when grade seven German speaking dyslexics with double deficit impairments, in phonological and rapid naming processes, were assessed on a coherent motion detection task, their performance was similar and sometimes better than those of the controls. The interesting point about this study was that despite the fact that it had employed a similar visual task to that used by the Oxford Group in their study with English speaking dyslexics (Hansen, Stein, Orde, Winter, & Talcott, 2001), each study resulted in different findings. Whilst, the study on the English speaking dyslexics found support for the magnocellular-deficit hypothesis (Hansen, et al, 2001), the study on the German speaking dyslexics did not find such a support (Kronbichler et al., 2002).
Kronbichler et al., (2002) reconciled the differences in findings to the way samples were diagnosed in each of the studies. The diagnosis for the German dyslexics relied on reading time, whereas for the English sample it relied on rate of reading error committed. In turn, it was argued that since the former type of diagnosis was more likely to exclude impulsive subjects than the latter type of diagnosis, therefore the sample in the German study was more likely to have excluded dyslexic cases showing signs of an attention deficit hyperactivity disorder (ADHD), whilst the sample in the English study was more likely to have included such types of dyslexics. Hence, further suggesting that the dyslexic subjects sampled in Kronbichler et al., (2002) study could be perceived as examples of 'true' dyslexics, in which despite showing signs of double deficits in cognitive processes related to literacy, no evidence for a visual magnocellular processing deficit could be found amongst them.

A similar finding was reached by an earlier study carried out on Italian speaking school children tested for contrast sensitivity thresholds (Spinelli, Angelelli, De Luca, Di Pace, Judica, & Zoccolotti, 1997). Although the scoring of the reading measures employed in the study involved speed as well as error rate, the researchers still did not find a visual magnocellular deficit. However, Spinelli et al., (1997) ensured that their subjects fitted the pattern of a particular sub-type of dyslexic grouping known as surface dyslexia, which are usually characterized by having a relatively poor orthographical processing but an intact phonological processing relative to other non-surface dyslexics i.e. phonological dyslexics (for a general review see Coltheart, Masterson, Byng, Prior, & Riddoch, 1983; on Italian language see Job, Sartori, Masterson, & Coltheart, 1984). The latter procedure was carried out because as it was explained in the Spinelli et al., (1997) study that in a language with a regular orthography, the dyslexics that are most likely to be found are of the surface dyslexia sub-type; whereas in a language of a less regular orthography (e.g. English), the dyslexics that are most likely to be found are of the phonological sub-type. Consequently, it could be argued that although the Kronbichler et al., (2002) study did not base the diagnosis of their dyslexic population in terms of sub-types of dyslexia; their German dyslexics were most likely to be of the surface dyslexia sub-type, because of the
orthographical regularity between the grapheme-phoneme correspondences in the German language. In turn, this could imply that the dyslexic samples in both the German and the Italian groups were of similar sub-types and that the magnocellular system responsible for the transient processing appeared to be intact amongst them. However, at closer scrutiny there appears to be a slight contradiction with the findings. More specifically, according to the visual magnocellular theory, the large magno cells are perceived to be responsible for fast task processing, yet dyslexics in both the Italian and the German studies did not display signs of a magnocellular deficit, despite showing signs of a slow processing rate whilst reading. Therefore, further research taking consideration of such a point is required. On the other hand, there is a possibility that the speed of the magncellular processing could be associated to a particular aspect of a language, for example phonology, an aspect of language surface dyslexics have been found to be good on. This area of research requires further investigation.

Moreover, it must be pointed out that the Spinelli, et al., (1997) study is appealing because it went a step further than many of the other studies (e.g. Ben-yehudah, Sackett, Malchi-Ginzberg & Ahissar, 2001; Kronbichler, et al., 2002; Schulte-Korne, Bartling, Deimel, & Remschmidt, 2004). In addition to testing for a magnocellular deficit, they had tested for a deficit within the parvocellular system: a system which is also involved in visual processing, consisting of small cells positioned parallel to the large mango cells (Livingstone, Rosen, Drislane, & Galaburda, 1991), and known to be responsible for sustained high spatial frequency stimuli (Lovegrove, Bowling, Badock, & Blackwood, 1980). The interesting point is that although a magnocellular deficit was not found amongst the Italian speaking dyslexic subjects, a parvocellular deficit was found, reflecting a problem in the processing of stationary stimuli with medium to high spatial frequencies. Such a finding fits in well with the orthographical processing deficit experienced by the Italian surface dyslexics in the study. Furthermore, suggesting that the reading process in some of the transparent languages, such as the Italian language, could be at least associated with the parvocellular system. However, whether sensitivity to
stationary stimuli with medium to high spatial frequencies could act as a predictor for dyslexia in transparent languages requires additional research.

Similarly, Farrag, Khedr, & Abel-Naser, (2002) study on Arabic speaking fourth grade dyslexic children found their dyslexic population performance, on visually evoked potential tasks, to reflect a deficit in the parvocellular system whilst demonstrating normal magnocellular functioning. The dyslexics appeared to have problems in the processing of stimuli at high contrast and high spatial frequencies. In their study, Farrag et al., (2002) argued that their findings went against the main premise of the magnocellular theory in which it was postulated that the magnocellular system whilst active inhibits the function of the parvocellular system that is considered to be responsible for eye-movement fixation and the processing of information on color and fine spatial details in a stimuli (Livingstone & Hubel, 1988). This in turn was perceived to prevent the parvocellular neural activity in one fixation to continue in to the next fixation. Accordingly, it was argued that in dyslexics'; their difficulties appeared to be due to an abnormality in the functioning of the magnocellular system, reflected in it's inability to inhibit the activity of the parvocellular system, thus resulting in an overlap of fixation across sequential processing of information (Lovegrove, Martin, Bowling, Blackwood, Badcock, & Paxton, 1982; Galaburda & Livingstone, 1993). However, as it could be seen that the functioning of the Magnocellular system in the Arabic dyslexics were normal whilst their parvocellular system was not functioning as expected; consequently indicating that the latter system's abnormal functioning was not due to a deficit in the magnocellular system. In fact Farrag et al., (2002) claim that their findings provided support to an earlier study (Burr, Holt, & Ross, 1982) that advocated that the magnocellular system was the target of suppression. A similar argument was discussed in Stein, Talcott, & Walsh (2000) paper in reply to Skottun (2000) strong criticism on the magnocellular theory, noting that by finding out that the magnocellular system did not inhibit the parvocellular cells during saccadic eye-movements did not go against the proposition that the magnocellular system might function abnormally in dyslexics.
Furthermore, the results of Farrag et al. (2002) research have led them to suggest that the deficiency in the visual parvocellular system, reflected an inability to process high frequency high contrast stimuli, could be considered as a predisposing factor in the diagnosis of dyslexics speaking the Arabic language. This proposal appears to fit in well with the way Arabic texts need to be processed during reading. That is, the Arabic texts, read from right to left, require the ability to perceive the fine features discriminating one letter from the next one following it; particularly, since some letters are determined simply from the position and the number of their dots, and the positioning of the vowels (e.g. لیب تاَث)\(^*\). In addition, this proposal appears to fit in well with Share & Levin (1999) suggestion, upon discussing on issues related to the reading process of the Hebrew language, that "visual processing competences ... may be language-specific", (P. 108). Therefore, it could be argued that the way a text needs to be visually processed during reading could depend to a certain extent on particular features in the orthographical make up of a language and that dyslexics might have problems in detecting the fine particularities in the orthography of the language they read. However, in a recent study by Hutzler, Kronbichler, Jacobs, & Wimmer (2006), on German speaking subjects performing a string processing task similar to that required in reading, found that the dyslexics' difficulties were not related to the ability of accurately perceiving letters or to problems in eye-movement control during reading.

To conclude, it appears that at least some dyslexics have visual deficits. However, the exact nature of this deficit remains open to discussion. In particular, whether it could be argued that dyslexics have an abnormality in the visual pathway of the magnocellular system requires further researching. This researching requires taking into consideration the main issues discussed above.

\(^*\) Note the first letter in each of the 3 Arabic words differ in the positioning of their dots (لیب تاَث)\(\) and the positioning of the last vowel (diacritic above/below the last letter).
Lexical Deficit

In search for predictors of dyslexia across languages, it is important at one stage to stop and study the normal functioning of the reading process and how it may help in locating the different areas of processing that may be involved in playing a role in the reading problems' dyslexic subjects appear to experience. Over the years many reading models have been proposed (see chapter 3 for a review). However, it has been claimed that numerous details about skilled reading cannot be rationalized by any model unless it holds a dual-route structural design (lexical and non-lexical routes) within its theorizing. Dual-route models were found to be superior than a one-route model, put forward by Seidenberg & McClelland (1989, 1990), by their ability to explain most of the essential facts related to reading (see Coltheart, Curtis, Atkins, & Haller, 1993).

There have been several reading models with a dual-route design that have been put forward (e.g. Coltheart, 1978; Ellis, 1993; Sadoski & Paivio, 2004). However, in relation to dyslexia, the dual-route model of Coltheart (1978) was used to explain subtypes of developmental dyslexia (Castle & Coltheart, 1993); in addition to being developed into a computational model, known as the Dual Route Cascaded model (DRC), for mimicking the reading aloud behavior of skilled readers (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Therefore, since the concern of the following chapter is the search for predictors of dyslexia, the dual route model, with its lexical and non-lexical routes, that was originally put forward by Coltheart (1978) will be used as a framework within which to locate area/s of processing that may affect in someway dyslexics' reading problems. Moreover, it must be pointed out that the non-lexical (sub-lexical/phonological) processing route has been discussed above, in an earlier section of the current chapter, as a possible predictor of dyslexia; whilst the lexical processing route has not as yet been examined as a possible predictor of dyslexia.

Consequently, the aim of the following section will be to investigate the overall issue of lexical deficits among dyslexics across languages as reported in the literature, in an attempt to find out whether some of the dyslexics' problem may stem from problems in
lexical processing, and whether orthographical transparency of a language plays a role in the way dyslexics experience lexical processing difficulties. Therefore, initially a brief introduction of Coltheart (1978) reading model and its relation to developmental dyslexic reading problems will be given. In addition, the literature on the role lexical processing plays in reading in the different orthographies will be discussed; followed by a considerations of research on subtypes of developmental dyslexia and whether lexical deficits can justify explaining a particular group of dyslexics (i.e. surface dyslexics) reading behavior in the various orthographies that have tackled this issue. The later point is important, because if lexical deficit was found to characterize developmental surface dyslexics as it is claimed (Castle & Coltheart, 1993), then lexical deficit could be used as a predictor of this particular group of dyslexic individuals. It will be seen that the findings have been controversial, with some claiming the deficit that leads to lexical-like problems lies at an earlier stage than the lexical and sub-lexical processing level (e.g. Baraca, Burani, Di Filippo, & Zoccolotti, 2006, on Italian dyslexic speaking sixth graders; Spinelli, De Luca, Di Filippo, Mancini, Martelli, & Zoccolotti, 2005, on Italian speaking dyslexics of sixth, seven, and eighth grades); whilst other researches have failed to find clear cut distinctions between different subtypes of developmental dyslexia in the way the lexical/sub-lexical routes are used (e.g. Gonzalez & Santana, 2002, on third grade Spanish speaking dyslexic children; Zabell & Everatt, 2002, on English speaking adult dyslexics; Genrad, Mousty, Content, Alegria, Leybaert, & Morais, 1998, on French speaking dyslexics).

Coltheart (1978) advocated a dual-route model for reading aloud. It was proposed that the system by which skilled readers read entails the engagement of at least two different procedures: the sublexical procedure and the lexical procedure. The former route involves reading via processing stimuli using the grapheme-phoneme conversion rules of a particular language, in which the processing is perceived as slow and effortful. It was proposed to be used in words that do not have any mental representation in the lexicon, in which it is perceived to be used to process words (novel) and pseudowords/non-words. Whereas, reading via the latter route entails the retrieval of the phonological form of a
particular orthographic stimulus from the mental lexicon, in which the processing of stimuli is considered to be fast and preset. This route was perceived to be used for the processing of regular and irregular/exception words. Exception words were not perceived to be processed via the sublexical procedure because their orthographical structures do not follow the usual grapheme-phoneme conversion pattern. Therefore, in reading a skilled reader was expected to be able to make use of both the procedures: lexical and sublexical.

The framework of the dual route model was applied to the English language and developed into a computational model for the reading aloud behavior observed in data gathered from human subjects speaking that language (Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart, Langdon, & Haller, 1996; Coltheart & Rastle, 1994; Coltheart, Woolams, Kinoshita & Perry, 1999; Rastle & Coltheart, 1998; 1999a; 1999b). This computational model was named: the dual route cascaded model (DRC) and was programmed to behave in the same manner as in the human reading aloud behavior. The architecture of the English DRC model has been illustrated in figure 4.1 below.

Briefly, the DRC model consists of two sections: the lexical and nonlexical routes. The lexical route consists of the 'orthographic level' which contains the 'visual feature detectors' where each unit is perceived to represent a letter; the 'letter units' where each letter is perceived to represent a single letter of the alphabet; and the 'orthographic lexicon' where each unit is perceived to represent a word. The 'orthographic level' is connected to the 'phoneme level' via either a 'semantic system' or via the 'phonological output lexicon'. It must be pointed out that it has been noticed that in the DRC model, the latter connection (i.e. the lexical route from the 'orthographic level' to the 'phoneme level' via the 'phonological output lexicon') has been mostly studied and researched relative to the former connection. In addition, it is assumed in the model that the interactive activation of the model requires the application of two principles. The first principle applies to the interactive application between levels, where activation is perceived to
Figure 4.1 - The dual route cascaded model (DRC) of reading aloud adapted from Coltheart, Rastle, Parry, Langdon, & Ziegler (1993) showing the architecture of the English DRC. Arrows (---) indicate excitatory connections. Lines with filled circular ends (---) indicate inhibition connections.
spread in a bidirectional manner between levels, mutually activating each other. An example of this is the excitatory activation between the 'orthographic input lexicon' and the 'phonological output lexicon'. The second principle revolves around units from the same level which are expected to mutually inhibit one another. An example of this is the mutual inhibition between the different processing units within the 'orthographic level' (e.g. 'letter identification' unit and 'orthographic input lexicon' unit). However, the nonlexical route's main concern was perceived to be related with phonological assembly which involves the conversion of a single letter or a group of letters into a single phoneme using the grapheme-phoneme conversion rule (GPC rules). This operation is perceived to take place in a serial manner, where each phoneme is processed separately before being assembled together. In addition, it is assumed that letter information becomes progressively available with time in the nonlexical route after a constant number of cycles, such that after a constant number of cycles a letter is expected to be assembled into a phoneme. The dynamics of the DRC model and further details on the model can be found in other of the Coltheart papers referred to above.

Confirmation of certain aspects of the proposed model has been found in the literature. For example, it has been found that the processing in the lexical routes occurs in parallel across letters, whereas in the sublexical route, it occurs in a left-to-right serial order across letters (Rastle & Coltheart, 1999a; 1999b; Coltheart, Woolams, Kinoshita & Perry, 1999). In addition, research has confirmed that children attain their GPC rules and rime units from their reading experiences (Stuart, Masterson, Dixon, & Quinlan, 1999). Also, evidence was found supporting the view that the processing of orthography and phonology occurs within the reading procedures and not at an earlier stage (Rastle & Coltheart, 1999a). Moreover, results of research on the DRC model has shown that it could be successfully applied to the German language in reading German monosyllabic words and in simulating loan word effects (Ziegler, Perry, & Coltheart, 2000). Furthermore, the DRC model was applied to the French language, where it was found that the DRC model in its original version (English) required a slight modification in the assumption of the processing speed of the sublexical route. This involved allowing the
sublexical processing to commence simultaneously with that of the lexical route rather than being slightly delayed (as in the original version) so that the model was successful in reflecting findings on the regularity effects of words in the French language (Ziegler, Perry, & Coltheart, 2003). That is, in the French language, which has a more regular spelling to sound correspondence and less irregular words than the English language, it was found that regardless of word frequency rates (high/low) the reading aloud of irregular words was slower than that of regular words (Ziegler, Perry, & Coltheart, 2003; Content, 1991). However, this regularity effect differs from findings in the English language, where the reading aloud of low frequency irregular words was found to be slower than that for high frequency irregular words (e.g. Andrew, 1982; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Paap & Noel, 1991). Therefore, by slightly adjusting for the speed of processing in the sublexical route of the French model, the differences in findings between both orthographies was accommodated for within the general framework of the DRC model (Ziegler, Perry, & Coltheart, 2003). In turn, such a step had lead to the conclusion that at least with the DRC model, an adjustment is required along the speed dimension of processing when being applied to more regular languages (Ziegler, Perry, & Coltheart, 2003); implying that the orthography of a language may have an effect on the speed of sublexical processing allowing it, either to be similar or different to that of the speed of the lexical route.

Evidence of use of lexical processing have been found in transparent orthographies such as Arabic (Taouk & Coltheart, 2004), and Italian (Barry & de Bastiani, 1997; Tabossi & Laghi, 1992); and in less transparent orthographies such as English (Ellis & Hooper, 2001). Moreover, other studies appear to imply that in transparent orthographies, such as the Italian language, word reading is dependent on the route from the orthographic input lexicon directly to the phonological output lexicon (Bates, Burani, D'Amico, & Barca, 2001). Lexical access was argued to be involved because word frequency effects were found in the absence of semantic effects (see Bates, Burani, D'Amico, & Barca, 2001; Burani, Dovetto, Spuntarelli, & Thornton, 1999). However, it could further be argued from the Orthographic Depth Hypothesis (Katz & Frost, 1992; Frost, 1994) point of view
that dependence on the lexical route in reading may be weaker for subjects in shallow orthographies (e.g. Serbo-Croatian, Spanish, and Italian) than for subjects from more deep orthographies (e.g. Hebrew and English). This suggestion is only a tentative one and requires further researching. It was based on the idea that the relative reliance of the 'assembled' phonology as opposed to the 'stored' phonology is a function of the orthography of a language (Katz & Frost, 1992). In a language with a deep orthography (the mapping between grapheme and phoneme is not always consistent) such as in the unpointed Hebrew text, readers have been shown to mainly use the orthographical-lexical route, whereas in a shallow orthography such as the Serbo-Croatian language, readers have been found to depend on the phonological processing (Frost, Katz, & Bentin, 1987; Shimron, 1993; Feldman & Turvey, 1983). Therefore, as mastery of phonological processing in shallow orthographies have been found to be established earlier in a readers' life relative to mastery of phonological processing of readers from deep orthographies (Juul & Sigurdsson, 2005), and as readers of deep orthographies display a higher dependence on lexical-orthographical processing relative to those readers from shallow orthographies (Frost, Katz, & Bentin, 1987), in turn, it would only be logical to argue that, at least in the early years of learning to read, readers from deep orthographies would be expected to be more in need of use of the lexical route relative to the nonlexical route than readers from shallow orthographies, whose use of the lexical route may therefore be weaker than readers from deep orthographies.

In fact, Oney, Peter, and Katz (1997) had researched and discussed this point in terms of a ‘cost-effective’ manner. They argued that the advantages would be less for readers from a transparent orthography like Turkish, with a clear grapheme-phoneme conversion rules relative to other less transparent languages (e.g. English) to adopt a visual-orthographic route of processing because the route to phonological processing has minimal cost associated with it; whereas, an opposite argument was given for readers from less transparent orthographies. This argument was supported in their study on Turkish and English readers from second grade, fifth grade, and adults using words as stimuli and non words as primers, in which it was found that Turkish readers stayed longer using the
phonological procedure than English readers (Oney, Peter, and Katz, 1997). However, it was mentioned that further researching in this area was required using non words as stimuli (Oney, Peter, and Katz, 1997).

On the other hand, how early children from the different types of orthographies adopt a lexical strategy in their literacy development remains open for researching. Zoccolotti, De Luca, Di Pace, Gasperini, Judica, and Spinelli (2005) found that at least in a shallow orthography such as the Italian language, there was suggestive evidence that they adopt a lexical approach fairly early in their literacy learning (at about second grade). This appears to contradict earlier arguments on the expectation that a reader from a language of a shallow orthography to remain longer using the phonological processing procedure. However, such results could be reconciled by arguing that adoption of lexical strategy maybe dependent on the type of tasks used. For a rhyme task such as in the Oney, Peter, and Katz (1997) study, it would be best for readers of a transparent orthography to adopt a phonological procedure in their response, relative to readers from less transparent orthographies, whose use of a similar strategy would be expected to be costly for them. However, on a vocal reaction time type of task on words of various lengths, such as in the Zoccolotti, De Luca, Di Pace, Gasperini, Judica, and Spinelli (2005) study, it would be better for readers of a transparent orthography to adopt a lexical strategy (if available) than remain using a phonological procedure in their processing; because theoretically accessing whole words from the mental lexicon would be expected to be faster than carrying out serial grapheme-phoneme conversion of words of various lengths. Therefore, it could be argued that although lexical processing might be available to readers of shallow orthographies, it is used only when needed. In turn, this would imply that readers from both orthographies: shallow and deep are capable of lexical processing from an early age but whether the presence of lexical processing could be used to forecast proficient reading requires further investigation.

The study of dyslexia can contribute important information on the role of lexical processing in reading. Castle and Coltheart (1993) after reviewing and evaluating
evidences on the reading processes of developmental dyslexics found that there were two
types of developmental dyslexics: surface and phonological, analogous to those found in
the acquired dyslexic population. In their paper, the authors found that developmental
dyslexics acquire both lexical and sublexical processes in reading but for some reason
one process did not appear to be operating as efficiently as the other; in turn, producing
either of the subtypes: surface or phonological. Surface dyslexics appeared to show a
deficit in lexical processing through applying the regularization rule of the traditional
grapheme-phoneme conversion to the reading of irregular words. Whereas, phonological
dyslexics appeared to show evidence of deficit in the sublexical processing route by
being unable to read non-words despite intact ability to the reading of regular and
irregular words. As a result, Castle and Coltheart (1993) proposed that developmental
surface dyslexia is characterized by a processing deficit in the lexical route relative to that
in the sublexical route; and developmental phonological dyslexia is characterized by
displaying the reverse pattern of processing to those of surface dyslexics.

Since the concern at hand revolves around the role of lexical deficit as a predictor of
dyslexia, therefore, it could be argued that lexical deficit as defined by Castle and
Coltheart (1993) could be used as a predictor of surface dyslexia, a subtype of dyslexia.
Furthermore, it is important to note that lexical deficit was not perceived in ‘absolute’
terms but rather in a ‘relative’ term with regards to the degree of efficiency of both
procedures within an individual (Castle and Coltheart, 1993). According to Castle and
Coltheart (1993) study, surface developmental dyslexics were characterized by having
deficits in both reading routes but more so in the lexical route than the sublexical route;
consequently, the spared sublexical route was expected to be used during reading. Studies
on Italian surface dyslexic children found that their eye-movement pattern reflected the
use of the sublexical procedure in reading text (De Luca, Di Pace, Judica, Spinelli, &
Zoccolotti, 1999) and lists of words and pseudowords (De Luca, Borrelli, Judica,
Spinelli, & Zoccolotti, 2002). More specifically, the dyslexics’ read text in short and
frequent saccades that were pursued by long fixation where word length was affected by
the numbers of saccades. The longer the word, the more were the number of saccades;
accompanied with a greater number of fixations in the dyslexics than in the controls (De Luca, Di Pace, Judica, Spinelli, & Zoccolotti, 1999). Similarly, surface dyslexics processed words in the same manner they processed pseudowords, where the number of saccades depended on stimulus length; the longer the stimulus, the greater were the number of saccades, while saccade amplitude remained small and constant (De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002). However, the controls processed words differently from the way they processed pseudowords. The former stimuli were processed such that they reflected a saccade amplitude increase with word length, while not reflecting a similar change in the number of saccades. On the other hand, controls processed the latter stimuli such that the number of saccades depended on the length of the pseudoword (De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002). Hence, as it could be seen that the visual deficits' of the dyslexics appear to correspond to the way surface dyslexics (as described above) process stimuli during reading; that is in a serial phonological way reflecting the use of the sublexical procedure in the reading of words as well as nonwords. In turn, it could be argued that such a visual deficit could be used as an indicator of a lexical deficit in this subtype of dyslexics. However, De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, (2002) have noted in their discussion that further research was required to support their findings that the reported visual deficits could be used to characterize the way surface dyslexics read; because as it was argued that there was the possibility that the dyslexics' visual processing pattern may not necessarily be restricted to only linguistic stimuli but to "any small closely space stimuli" (p. 625, De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002). Furthermore, it must be pointed out that although the findings in the De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, (2002) study appeared to imply that the visual deficits' of the developmental surface dyslexics appeared to be associated with lexical deficits, the question that remains to be determined is the direction of this association; that is, of whether a dyslexic's lexical deficit had resulted in the reported visual deficits or whether a dyslexic's visual deficit had resulted in the lexical deficit. In another words, it is not clear whether the actual deficit is at the procedural levels of processing or at another processing level.
On the other hand, evidences from other studies have suggested that the dyslexics' deficits reflected problems that appeared to lie at an earlier level of processing than that proposed by Castle and Coltheart (1993). In particular, it has been found that dyslexics' deficits appeared to lie at the perceptual level of processing as opposed to being at the lexical/sublexical level of processing (Barca, Burani, Di Filippo, & Zoccolotti, 2006; Spinelli, De Luca, Di Filippo, Mancini, Martelli, & Zoccolotti, 2005; Spinelli, De Luca, Judica, & Zoccolotti, 2002). For example, Barca, Burani, Di Filippo, & Zoccolotti, (2006) found that the pattern of results on word frequency and grapheme contextuality outcomes did not provide an explanation of the reading deficiency in terms of how surface dyslexics are usually defined (Castle & Coltheart, 1993). Surface dyslexics are usually characterized by showing an inefficient lexical processing relative to sublexical processing, with an over reliance on the latter processing procedural route in their analysis of text (Castle & Coltheart, 1993). In contrast, the Barca, Burani, Di Filippo, & Zoccolotti, (2006) study found that the lexical procedure was used by the Italian dyslexic children in their study, which had displayed a processing pattern similar to those of younger expert readers. In addition, the absence of a contextuality effect for high frequency words was taken as evidence that the sublexical processing route was not necessarily used for all types of stimuli; thus refuting the idea of an over reliance of the sublexical procedure in the dyslexic children's reading. Altogether, the results of the Barca, Burani, Di Filippo, & Zoccolotti, (2006) study appeared to imply that their Italian dyslexic children exhibited a speed processing deficit, which had provided a better framework for defining them than the expected definition of surface dyslexia. In turn, such a finding had lead the researcher to suggest that dyslexics from a transparent orthography such as the Italians language appeared to have problems at the perceptual level of analysis rather than at the lexical procedural level.

In another study, a similar finding was reached. Spinelli, De Luca, Di Filippo, Mancini, Martelli, & Zoccolotti, (2005) found two types of dyslexics (A&B). Type 'A' which had employed a parallel processing mode on stimuli of up to four-letter words only and not any larger; whereas type 'B' employed sequential processing on stimuli of any length.
However, upon closer examination, it was found that the reading procedures were not sufficient for the discrimination of the two types of dyslexics. Instead, the speed of processing was found to be a better measure in explaining the differences in performances between both groups of dyslexics. Consequently, Spinelli, De Luca, Di Filippo, Mancini, Martelli, & Zoccolotti, (2005) argued that their results reflected that at least their Italian dyslexics' deficits did not appear to lie at the procedural-linguistic level of analysis but at an earlier perceptual level of processing, without specifying the exact nature of the perceptual mechanism; rather it was only pointed out that further research was required for the definition of such a mechanism. A possible definition of this mechanism was provided in the Spinelli, De Luca, Judica, & Zoccolotti, (2002) study, where it was found that the dyslexics' deficit did not necessarily stem from stimuli being linguistic or non-linguistic, nor from being processed at the procedural level of processing; rather their Italian dyslexics' deficit appeared to reflect a perceptual deficit. In particular, it was found that the Italian dyslexics were slower and more sensitive to the neighboring stimuli than the controls, and when the crowding effects were reduced through a moderate increase in inter-letter spacing, the dyslexics produced faster vocal reaction timing; whilst the controls did not show any improvements in their performance. Thus, it could be argued that the perceptual mechanism in dyslexics, at least from transparent orthographies such as the Italian language, could be associated in some way with the way stimuli are presented, regardless of being linguistic or not; with a suggestion that the 'crowding effect' could be perceived as one possible explanation for the perceptual deficit reported to be found in dyslexic children (Spinelli, De Luca, Judica, & Zoccolotti, 2002). Further researching is required to confirm such a finding and whether there may be other mechanisms also involved.

Alternatively, there are findings from other psychological studies (Zabell & Everatt, 2002; Gonzalez & Santana, 2002; Sprenger-Charolles, Cole, Lacert, & Serniclaes, 2000; Cstnick, 1998) and a neuro-imaging study (Wydell, Vuorinen, Helenius, & Salmelin, 2003) that appear to cast doubt on the sub-typing pattern proposed by Castle and Coltheart (1993). For example, in Zabell & Everatt (2002) study on a group of English
speaking dyslexic adults, it was found that although it was possible to allocate the
dyslexic population into either surface or phonological sub-typing as described by Castle
and Coltheart (1993), subsequent analysis on measures of lexical access, phonological
processing, and word recognition revealed that there were hardly any differences between
both groups, above all on measures of phonological skills. Thus, it was concluded that the
sub-typing procedure as defined by Castle and Coltheart (1993) was not considered as an
effective and practical procedure for the diagnosis of the dyslexic population (Zabell &
Everatt, 2002).

A similar finding was also evident in studies carried out on Spanish and French dyslexic
children (Gonzalez & Santana, 2002; Sprenger-Charolles, Cole, Lacert, & Serniclaes,
2000). Despite the fact that both studies employed the regression based procedure as used
by Castle and Coltheart (1993) as a means to determine the two sub-types of dyslexics,
both studies failed to find the adequacy in the use of such a procedure for distinguishing
between surface and phonological dyslexics. In particular, the results of the Spanish
dyslexics on measures of phonological ability and the analysis of their errors had failed to
confirm the allotment of the dyslexic sample into the two proposed sub-types of
dyslexics: surface and phonological (Gonzalez & Santana, 2002); in addition, the results
of the French dyslexics had showed that there were no differences in the deficits of
phonological awareness processing and the deficits in the phonological short-term
memory ability between both sub-types of dyslexic children (Sprenger-Charolles, Cole,
Lacert, & Serniclaes, 2000). Therefore, it appears that in transparent and less transparent
languages, surface and phonological dyslexics appear very similar on phonological
processing deficits. In fact, in a single cross-cultural study that compared dyslexics from
a transparent orthography (German) with dyslexics from a less transparent orthography
(English) found that despite the differences in the transparency levels of the orthography
employed, both dyslexic populations exhibited more similar findings than there were
differences (Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Korne, 2003). It was found that
shared similarities between the two dyslexic populations were in the areas of reading
displaying deficits in speed of processing and in the ability to read non-words relative to
words; as well as showing slow serial phonological processing. In addition, both populations demonstrated that they were able to process large orthographic units, thus indicating the capability of lexical processing (Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Korne, 2003). This fits in well with the neuro-imaging study that failed to find different cortical areas involved in the processing of words and non-words (Wydell, Vuorinen, Helenius, & Salmelin, 2003); and with Paulesu, Demonet, Fazio, McCrory, Chanoine, Brunswick, et al (2001) study, in using positron emission tomography scans found that there were common cortical areas in the left hemisphere that were involved in reading and that were shared by dyslexics from England, France, and Italy.

On the other hand, Cstnick (1998) found in her study on English speaking dyslexic children that there were more different patterns of developmental dyslexics than the proposed surface and phonological dyslexics. The analysis of results in Cstnick (1998) study revealed that there were about 36.7% of the dyslexic cases that could not be explained by the dual-route model of Castle and Coltheart (1993). Within this unspecified grouping there were dyslexics that displayed problems in lexical processing but with different patterns than that suggested by the dual-route theory (see table 10, Cstnick, 1998).

To summarize, therefore the search for lexical deficits as predictors of dyslexia has resulted in findings that were varied and controversial across orthographies. Findings were not necessarily consistent across orthographies with similar levels of transparencies. As it could be seen from the above discussion that the role lexical deficit play as a predictor of dyslexia or even as a predictor of a certain sub-group of dyslexics (surface), has not been as clear as the role phonological processing deficit or as the role speed of processing deficit, both had played when considered as predictors of dyslexia. In most of the studies reported above whether carried out on dyslexic populations or even on proficient readers, phonological processing or speed of processing were some how involved; regardless of the absence or presence of lexical processing. On the other hand, it does appear that lexical processing is somehow involved in the reading of languages.
from different levels of orthography; although how much damage its absence is expected to have on the process of reading requires further researching. In addition, whether the degree of lexical processing's relevancy to reading could be considered as that proposed in the dual route theory of reading (Coltheart, 1978; Castle & Coltheart, 1993) requires further investigation. It is important for the dual-route reading model to be able to accommodate for the contradictory findings reported above, in order to be able to validate its feasibility for use in the sub-typing of the different reading disorders. In turn, such a step may help spell out precisely the role lexical processing plays in reading and dyslexia, at least better than currently possible.

Morphological deficit

Morphological processing deficit as a predictor of dyslexia has not been researched thoroughly across languages as has the phenomenon of phonological processing deficit. In the light of what is available, it will be seen that morphological processing plays a secondary role in normal literacy development; more so in some languages than others. Consequently, in order to determine the degree of morphological processing deficit in poor readers, it will be necessary to clarify its role in normal developmental literacy systems; followed by what research has been able to find as regards to the degree of morphological deficit amongst some of the poor readers studied and the impact morphological processing deficit has on their acquisition of literacy skills.

Morphological processing involves the understanding of the patterns of word formation and the rules they follow. The importance of morphological processing in literacy acquisition has been found in languages from different orthographies. Evidences from various studies carried out in different languages have shown that normally developing children were capable from a somewhat early age to make certain use of morphology in their spelling development (e.g. Treiman, Cassar, & Zukowski, 1994, on English speaking children; Pacton, Fayol, & Perruchet, 2002, on French speaking children; Chliounaki & Bryant, 2002, on Greek speaking children). In addition, studies have
demonstrated that although phonology was found to be a compelling predictor of reading, morphological skill was also found to play a role in reading as well amongst French speaking children (Plaza, 2003); amongst English speaking children (McBride-Chang, Wagner, Muse, Chow, & Shu, 2005); and Hebrew speaking children (Levin, Ravid, & Rapaport, 1999). It must be pointed out that although the predictive power of morphological skills such as morphological structure awareness and/or morpheme identification have been found to be small relative to phonological skills, morphological processes were capable independent of phonological processes to explain for literacy knowledge (Decan, & Kirby, 2004; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005). For example, in McBride-Chang, Wagner, Muse, Chow, & Shu (2005) study, it was found that about 48% of vocabulary knowledge was predicted by phonological skills whilst about 10% of vocabulary knowledge was predicted by morphological skills alone. In fact, it was found that morphological awareness was capable to significantly play a role, at least, in the reading development of English speaking children, even after a gap of three years when the measure was originally taken and even after controlling for phonological awareness and verbal and non-verbal intelligence (Decan, & Kirby, 2004). Moreover, it appears that in reading the development of morphological structures have an affect on all readers in the same way (at least as it was found amongst Hebrew speaking subjects in Ravid & Schiff, 2004 study); and that in spelling morphological awareness appeared to develop in an apparent developmental prototype (at least as it was found amongst English speaking subjects upon researching the spelling of morpheme designating past tense in Nunes, Bryant, & Bindman, 1997 study). In particular, Nunes, Bryant, & Bindman, (1997) noted that at first children's choice of spelling pattern was carried out with little consideration to the morphological aspects of language, where children appeared to use the morphological patterns in an inappropriate manner generalizing the grammatical pattern to inappropriate words (e.g. sofed for soft); followed by confining such generalization to the correct grammatical group (e.g. keped for kept); and Lastly, the children eventually appeared to be able to restrict the grammatical pattern to the right categories of word (i.e. regular verbs).
In addition, it appears that experience in reading, at least amongst the Hebrew speaking readers and the English children that had been researched in Ravid & Schiff (2004), and Nunes, Bryant, & Olsson (2003) studies respectively, assisted in the development of morphological awareness in reading; and improved children’s use of morphological rules in spelling (Nunes, Bryant, & Olsson, 2003). Furthermore, Bryant, Nunes, & Aidinis (1999) had found with their English sample that their attainment of morphological strategies was not achieved in a single step; instead it had developed over a two year period; a period that began from the time those children had started to read and write. Such a development was claimed to be similar across languages (Bryant, Nunes, & Aidinis, 1999).

Therefore, as it could be seen that although the findings reported above have been derived from languages of different orthographical levels; overall, it appears that some form of morphological processing is involved in the normal literacy acquisition of children, which appears to be considered independent of phonological processing. However, the degree of involvement of morphological processing in literacy acquisition may vary depending on the structure of the particular language. Bentin & Frost (1995) have suggested that morphological analysis was necessary for readers of the Hebrew language because it helped in the activation of meaning in morphologically complex words; that is after phonological representation had taken place. Similarly, Abu Rabia (2002) upon reviewing past studies concluded that evidences appeared to point that amongst Arab readers, morphological analysis was necessary for the performance on reading comprehension tasks more so than for the performance on reading aloud tasks.

With regards to the role of morphology in the representation of words in the mental lexicon it was proposed that the characteristics of the language morphology was expected to affect the way words were stored (Frost, Foster, & Deutsch, 1997). This proposition was derived from research performed on Hebrew speakers where it was found that lexical access to words were better facilitated by other words sharing the same root rather than a facilitation that was based on word patterns (Frost, Foster, & Deutsch,
A similar finding was expected to be reached upon studying the Arabic language, particularly since the Arabic language is very similar to that of the Hebrew language; both of which share the same Semitic origin and are known as heavily morphological in their linguistic structure. However, Abu Rabia and Awwad (2004) upon studying the Arabic language did not find that morphological analysis had any influence on word recognition as was found amongst the Hebrew speakers in Frost, Foster, & Deutsch, (1997) research. Instead words were found to be stored in the mental lexicon in their whole shapes (Abu Rabia and Awwad, 2004). On the other hand such a finding on the Arabic language should be treated with caution because as Abu Rabia and Awwad (2004) had pointed out that unlike in the Frost, Foster, & Deutsch, (1997) study their study was based on high frequency words which may have had a different way of being represented than new or low frequency words. In turn, it was proposed that morphological decomposition was expected to be resorted to only with new and/or low frequency words (Abu Rabia and Awwad, 2004). This proposition appears to be supported by another study that was carried out on Arabic speakers using complex Arabic words (Boudelaa & Marslen-Wilson, 2005), where it was found that “morphological effects, including root and word pattern effects, (took) precedence over orthographic and semantic effects, because morphological structure offer(ed) a more salient and consistent domain of analysis and processing in lexical access.” (p. 232; Boudelaa & Marslen-Wilson, 2005).

Whereas, in the English language, which has a different morphological structure than that of the Arabic language, it had been found that complex English words were perceived/analyzed on the basis of both their morphological and orthographical properties more so than their semantic properties (Rastle, Davis, & New, 2004). Hence, as it could be seen that in both languages, morphological processing played a role in literacy, in which its integration with other areas of knowledge (i.e. semantic and/or orthographical processing) varied across languages with differing levels of morphological make-up.

Turning to the role of morphological processing in individuals with developmental dyslexia, it has been found that their impairment is not only restricted to phonological deficit but, in addition, extended to morphological awareness deficit (Abu Rabia & Taha,
2004, on Arabic speaking dyslexic children; Arnbak & Elbro, 2000, on Danish speaking
dyslexic children; Ben-Dror, Bentin & Frost, 1995, on Hebrew speaking dyslexic
children; Bourassa, Treiman, & Kessler, 2006, on English speaking children; Carlise,
1987, on French speaking learning disabled children; Joanisse, Manis, Keating,
Seidenberg, 2000, on English speaking dyslexic children; Schiff & Raveh, in press, on
Hebrew speaking adult dyslexics).

Moreover, children who eventually experience reading difficulties have been shown to
initially demonstrate an advantage, in contrast to younger children of the same reading
level, on grammatical awareness skills in spelling; however, within a year this advantage
had been shown to disappear and the performance of the children with reading difficulties
was not found to be any better than that of their reading level controls (Bryant, Nunes,
and Bindman, 1998). It was argued that the poor readers’ difficulty with letter-sound
correspondences was the reason for them losing their advantage in grammatical
awareness skills (Bryant, Nunes, and Bindman, 1998). Hence, according to Bryant,
Nunes, and Bindman (1998), it appears that development of morphological awareness
processes may be somewhat dependent on proper development of phonological
processing skills. A similar suggestion was reached by Casalis, Cole, & Sopo (2004)
upon studying French speaking dyslexic children, where it was suggested that
“morphological awareness cannot be developed entirely independently of reading
experience and/or phonological skills” (p. 114; Casalis, Cole, & Sopo, 2004).

Furthermore, Bourassa, Treiman, & Kessler (2006) found similarities in the way
morphologically complex words (such as waiting and needed) were spelt, in both older
children with dyslexia and younger normally developing spelling-level matched children.
However, both groups’ use of morphology was perceived as ‘fragile’ because they were
not capable of taking full advantage of the information that had been available to them.
Although, eventually by ten years of age normally developing spellers become capable of
acquiring such a morphological skill in spelling (Treiman & Cassar, 1996) dyslexics of
similar age groups remain unable to perform such a task (Bourassa, Treiman, & Kessler, 2006).

In another study, Abu Rabia & Taha (2004), upon investigating the error patterns of Arabic speaking dyslexic children, age-matched controls, and reading-level matched controls in reading and spelling of the Arabic language found that the most frequent error shared by all three groups were morphological errors. However, there was a significant difference in the number of morphological errors between the dyslexics and the age-matched controls, where the dyslexics had produced more of such errors than the age-matched controls. On the other hand, there were no significant differences in the number of morphological errors between the dyslexic group and the reading-level match children. In fact, both the reading-level and the dyslexic groups displayed similar error pattern profiles. Moreover, after a detailed analysis of the error patterns that were produced by the dyslexic sample and the two controlled samples under study from a phonological, morphological, and semantic perspectives, Abu Rabia & Taha (2004) concluded that the error profiles reflected a developmental lag due to the disposition of the Arabic orthography which is characterized by diglossia, morphology, and phonology (in particular in relation to the voweling system). In turn, it was recommended that those aspects of the Arabic language should be emphasized from an early stage in the learning to read and write processes in order to reduce the heavy cognitive loads that those aspects that characterize the Arabic orthography have on the development of literacy skills. It must be noted that diglossia refers to the phenomenon when the spoken language differs in phonology, grammar, morphology, and syntax from that of the written form (see Abu Rabia, Share, & Mansour, 2003).

Therefore, as it could be seen from Abu Rabia & Taha (2004) study that although the dyslexics showed signs of morphological difficulties, those difficulties were also shared by the younger normally developing readers. In turn, it becomes difficult to argue that the dyslexics’ morphological deficits is an aspect inherent in being dyslexic nor could morphological deficit be used as an indictor of dyslexia because it could simply reflect a
developmental lag, which could with proper morphological training become of use to dyslexic readers as has been found in other studies on the Danish language (Arnbak & Elbro, 2000; Elbro & Arnbak, 1996). Although the two languages Arabic and Danish vary in orthography, such an aspect as training dyslexics in morphology should be researched further in the Arabic language in order to form a better picture of the Arabic dyslexic profile. This call for a clearer assessment of dyslexia in the Arabic language has been addressed in Elbeheri, Everatt, Reid, & alMannai (2006) study.

Training in morphological awareness has been found, at least amongst Danish speaking dyslexic children, to improve performance in reading and spelling of morphologically complex words (Arnbak & Elbro, 2000; Elbro & Arnbak, 1996). In turn, this suggests that dyslexics are capable of morphological processing to a certain extent; however, the exact nature of such a processing remains to be determined.

Another interesting point to note is that in alphabetical languages, vowels are part of the morphological structure of a word. In most languages (e.g. English, French, and Spanish) it is not considered as an option; vowels are placed within the string of sequence that makes up a particular word. However, in Semitic languages such as Arabic and Hebrew, vowels are optional and most texts addressed to older readers drop the vowels in their writing up of the text. Thus, from this aspect of morphology, Semitic languages are unique and in turn it would be interesting to find out its impact on dyslexic individuals and the possibility of being considered as a predictor of dyslexia in those group of languages.

Abu Rabia (1997a) in studying the effect of vowels and context in the Arabic language across both skilled and poor readers from grade ten, found that regardless of the type of text that was read (vowelized/non-vowelized newspaper articles or vowelized/non-vowelized narrative texts) both the poor readers as well as the skilled readers benefited from the addition of vowels in texts. Whereas, in another study on Hebrew undergraduate readers and dyslexics, pointed texts (i.e. vowelized texts) were found to place a heavier
burden on the dyslexic individuals than non-pointed texts, indicating that the dyslexics could not make use of the morphological cue that was available to them (Schiff & Ravid, 2004). In addition, overall the normal readers’ performance was found to be better than that of the dyslexics under both conditions: pointed and non-pointed words (Schiff & Ravid, 2004). Hence, as it could be seen that the findings from both the studies of Abu Rabia (1997a) and Schiff & Ravid (2004) on the Arabic and Hebrew languages respectively were contradictory. However, those findings could be reconciled by the fact that although both languages stem from the same Semitic origin, to a certain extent, they differ morphologically. The Arabic language is rich with homographic words (i.e. words that look alike but carry different meanings), whereas this phenomenon is not common in the Hebrew language (Abu Rabia, 1997a). Consequently, greater importance would be expected to be placed on the vowels in the Arabic language in order to help disambiguate meanings of words with similar consonantal make-up, whilst there appears to be less of such a need for vowels to the Hebrew reader; thus explaining the differences in the findings of Abu Rabia (1997a) and Schiff & Ravid (2004) studies. On the other hand, such reconciliation should be treated with caution because although the general topic under investigation was similar in both of the studies, the sampled populations (in terms of age and diagnosis) and the tasks used were not compatible enough with each other for a direct between studies comparison to be carried out.

Overall, as it could be seen that while morphological processing is important in normal literacy acquisition and appears to be of secondary importance in relation to phonological processing, it is difficult for it to be considered as a predictor of dyslexia at this stage. More cross-cultural studies are needed to confirm whether morphological processing depends on phonological processing and whether this could be the case in orthographies of different morphological levels. In addition, studies should attempt to investigate the effect of training in morphological aspects of a language on dyslexics’ literacy development by researching the nature and extent of the dyslexics’ capabilities in literacy skills as a result of such a training; with the aim of seeking out the degree such a training
could have in forming a better image of the capabilities of individual dyslexics across various orthographies.
CHAPTER 5

An Introduction to Potential Predictors of Literacy in Bahrain:
Study Rationale and Methodology
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Introduction and Study Rationale
In the Kingdom of Bahrain, work in the field of dyslexia may be considered as still in its infancy. The central control of the educational process by the ‘Ministry of Education’ has been seen to be advantageous in enabling the progress of education among the ‘normal’ population and making it available to everybody. Unfortunately progress has been relatively slower for those students whose learning difficulties stem from a specific cognitive (or hidden) disability, such as dyslexia, than for those students suffering from a more general mental and/or physical disability. Hence, the absence of an apparent physical disability among the former group of students may have contributed to the slow progress in terms of recognition and support for those with dyslexia.

No standardised assessment tool for the screening of dyslexia per se is available. For many years dyslexic children have been treated in the same way as those with more general learning disabilities. The diagnosis of learning difficulties is academically oriented and relies heavily on student achievement. If a student’s academic performance in either Arabic and/or Mathematics reaches a level below the minimum ‘Adequacy Requirement’ for his/her grade level as has been set by the Directorate of Curriculum of Education, then the student is put on a special education program. This is available to students of grades one, two and three. Further support for students at higher grades is not available, except recently in the private sector.

In the past few years, two private institutions: Dar-al-ma’rifa which offers the “Davis Dyslexia Correction” program and the Bahrain Institute for Special Education which is directed by Dr. AlZeera have become available for the assessment and aid of dyslexic
children. However, the assessment tools that are used are imported from overseas: The United States of America and the Kingdom of Jordan respectively. Therefore, there is an essential need for tackling the issue of dyslexia with a new perspective: one that takes into consideration the language and the culture of that group of children. Accordingly the research reported as part of this thesis was designed with this general aim in mind.

The following study attempted to investigate the underlying patterns of cognitive factors displayed by monolingual poor Arab readers, within the Bahraini culture. However, with the lack of an assessment tool that would help to define what a Bahraini dyslexic would actually constitute, it was thought best to search inside the literature for predictors of dyslexia within the alphabetical languages and thus investigate whether those predictors could act as yardsticks to normal literacy acquisition of the Arabic language amongst young school children from Bahrain. Once predictors to early Arabic literacy acquisition within the Bahraini culture have been identified, those predictors could then be used in forming the framework for characterising a Bahraini poor reader. This should inform further research in the development and future standardisation of procedures to reliably assess children for literacy and literacy-related deficits consistent with our current understanding of dyslexia in alphabetic orthographies.

Moreover, the following research work was constructed within an ‘information processing’ perspective (Silver, 1993), which is often used in work on dyslexia (Snowling, 2000). The basic premise is that the dyslexic individual has a dysfunction somewhere in the processing of written information that leads to deficits that may hinder educational achievement (see Smythe & Everatt, 2000, 2002). In addition, the main theories of cognitive-based reading disabilities have been those associated with phonological processing. However, such processing forms part of general language processing. Hence, dyslexia has been seen as part of a range of specific disabilities characterized under the label of language impairment (see Stackhouse & Wells, 1997). This perspective leads to the view that dyslexia may be language related and that the underlying deficits associated with specific literacy deficits may vary according to
language or script (Everatt et al., 2002). Furthermore, research on literacy difficulties in languages other than English has been limited (Miles & Miles, 1996). In the particular context that has been the focus of the current research the structure of the Arabic language is characteristically and linguistically different than that of the English language (see chapter 2 for details on the Arabic language). The two languages have different script systems as well as varying in their sound to symbol consistency. For example, whereas in general the Arabic language is regarded as a transparent language (at least in the initial years of acquisition), the English language is perceived as an opaque language (Miles & Miles, 1996). Such variations in transparency have been argued to be very important in influencing the processing of written words (Katz & Frost, 1992). Therefore, research is necessary to determine whether the Arabic language shows such specific language effect on the development of literacy and the factors leading to poor reading/writing and dyslexia.

Accordingly, the findings of the English studies were used to determine the starting point for tackling the issue under study. A list of the difficulties experienced by dyslexics as reported in the literature (see introductory chapters) was compiled. However, it must be noted that the list was compiled in the initial stages of the research, at a period of time when research in the field of dyslexia was not as rich as it is today. Therefore, some more recent findings that may have been reviewed in the literature may have not had the opportunity to have been considered in the compiling of the difficulty lists. Based on this analysis, the difficulties experienced by dyslexics can be classified into twelve categories of learning task – of course, this is not necessarily a consensus viewpoint, but it does provide a starting point on which to develop procedures for distinguishing dyslexics from non-dyslexics. Those were as follows:

1. Reading tasks.
A defining characteristic is that dyslexics face greater difficulties than their peers in learning to read. It has been suggested that dyslexics learn to read words 'by sight' rather than by phonological recoding (Seymour & Evans, 1994). There is good evidence that
dyslexic children exhibit non-word reading deficits (van Ijzendoorn & Bus, 1994), and that, regardless of developments in reading skills, dyslexics show little improvement in the readings of such non-words (Snowling, 1980; 1981). These findings have been taken as evidence that dyslexics face particular problems decoding visual symbols into their corresponding phonological form (Rack et al., 1992).

2. Spelling tasks.
Dyslexics have been shown to experience difficulties in the spelling of words (Bruck, 1988; Bruck, 1990; Bruck & Treiman, 1990; Kibel & Miles, 1994; Snowling, 1994) which is consistent with the general word-level literacy deficits commonly used as a defining characteristic of dyslexia. In fact, spelling deficits may be harder to remediate and may show longer-lasting negative effects on literacy development/education than reading problems (Everatt & Brannan, 1996).

3. Phonological awareness; e.g., ‘oddity tasks’.
Dyslexics have been found to exhibit difficulties in identifying the odd-sound out in a sequence of words such as ‘nod-red-fed-bed’ (Bradley & Bryant, 1978). The difficulty in such tasks has been argued to lie in the processing of phonological information.

4. Phonological manipulation; e.g., ‘spoonerism task’.
Dyslexics experienced difficulties in manipulating word parts (Perin, 1983; Landerl, Wimmer & Frith, 1997). Again, the processing of phonological information has been implicated, but such manipulation tasks may be seen as more complex than relatively simple awareness tasks such as the ‘odd-one-out’ task described previously. These more complex phonological tasks may, therefore, be more appropriate for testing older, more experienced participants.

5. Phonological memory; e.g., non-sense word repetition tasks.
Dyslexics have been found to score poorly on phonological memory tasks (Brady, Shankweiler & Mann, 1983; Gathercole & Bradley, 1989; Gathercole, Hitch, Service, &
Martin, 1997; Snowling, 1981; Snowling et. al., 1986). This difficulty may be due to problems within phonological short-term memory (or working memory), but equally may be related to dyslexics experiencing problems in the process of setting up new phonological representation of word forms through the use of segments of known words and/or through experiencing difficulties in the production process.

6. Auditory processing; such as ‘speech gating’ tasks.

It was found that dyslexics required more acoustic input of the onset of a word than age-matched controls in order to recognize familiar words from sparse neighborhoods (Metsala, 1997). Although, some studies using such tasks have yielded null results (Elliot et. al. 1990; Griffiths, 1999, cited in Snowling, 2000). Explanations of the equivocal nature of the findings have considered whether top-down representations of the stimuli can be used to compensate for the underlying phonological weaknesses experienced by dyslexics (Salasso & Pisoni, 1985).

7. Speeded auditory processing; such as ‘temporal ordering’ tasks.

Mixed results have been found in tasks that required dyslexics to make decisions about rapidly presented auditory stimuli (Tallal & Piercy, 1973; Tallal, 1980; Heath et. al., 1999). Such studies have used such temporal ordering tasks in an attempt to uncover basic auditory processing deficits that may explain dyslexics’ selective difficulties in representing phonological forms in memory. However, the difficulties identified could be related to problems in the dyslexics’ working memory in terms of their sequencing and/or their storing of information.

8. Articulation; e.g., ‘vowel articulation’ tasks.

Dyslexics exhibited difficulties in fine-grained measures of speech production (i.e. an acoustic output – Stirling & Miles, 1988). Findings have suggested that the deficit in dyslexia was more apparent in tasks that taped onto speech production than in those tasks that taped onto speech perceptual processes (Hulme & Snowling, 1992).
9. Naming; e.g., ‘confrontation naming’ tasks.
Dyslexics experienced difficulties in naming simple pictures on demand (Olfield & Wingfield, 1965; Spring & Capps, 1974). This could be due to a problem in accessing and/or production of names of familiar figures. Performances on such tasks are determined in terms of the number of errors made.

10. Speeded naming; e.g., ‘rapid automatized naming’ tasks.
Dyslexics experienced difficulty in naming familiar, well-specified phonological forms, e.g. colors or pictures of familiar objects (Spring & Capps, 1974; Wolf, 1991). This could be due to a problem in the speed of accessing and/or the outputting of names of familiar items. Unlike confrontation-naming, task performance here is determined in terms of the time taken to respond to a familiar item.

11. Automatic versus controlled processing; e.g., ‘Stroop interference’ tasks.
Dyslexics have been found to experience greater stroop interference than non-dyslexics of the same chronological age (Everatt et. al., 1997). It was suggested that the dyslexics did not appear to lack the automatic process per se in reading, as it had been previously put forward (Mac Leod, 1991) but that they appeared to lack the control over this automatic process.

12. Visual processing; e.g., motion perception tasks.
Compared to non-dyslexic peers, dyslexics have been found to show reduced sensitivity to movement (Raymond and Sorensen, 1998). It was explained that this finding did not reflect an inability to detect motion as such but rather an abnormality in the perceptual integration of motion information. This finding supports an earlier MRI study that showed a lack of activation amongst dyslexics in area V5 when perceiving moving stimuli (Eden et. al., 1996). However, other studies have showed that this deficit appeared at a much earlier stage of visual analysis: in the striate cortex or area V1 (Cornelissen et. al., 1995; Cornelissen et. al.,1997).
These tasks have been analyzed within Silver’s information processing model (1993). Silver’s model is comprised of four components: input, integration, storage, and output. The input refers to how the information from the sense organs enters the brain. The integration component refers to interpreting and processing the information. The storage refers to storing the information for later retrieval, and the output refers to expressing the information through language or muscular activity.

The task descriptors above suggest that the processing areas which appeared to reflect most difficulties amongst dyslexics were mostly in the storage and the integration areas, particularly since the difficulties in the output may be due to difficulties at an earlier level of processing. Moreover, not all the twelve areas of difficulty were considered suitable for the current research, either because they tapped processing areas beyond the cognitive level of the group of subjects under study (e.g. phonological manipulation), or the tasks required technical expertise that was beyond the researcher’s scope (e.g. speech gating and visual processing). Furthermore, it was found that three of the tasks (e.g. non-sense word repetitions, rapid automatized naming, and confrontation naming) could be easily accommodated within other tasks (such as the phoneme task, Stroop task, and digit span task respectively*). Accordingly, based on this, a set of six tasks were developed to tap onto to some of the learning difficulties experienced by dyslexics as researched from the literature above. This step was taken as result of the absence of any set of standardized tests for the screening of cognitive deficits in dyslexia, within the Kingdom of Bahrain. The tests developed were the following:

1. The reading task (words and non-words).
2. The stroop task (Includes within it a measure for rapid naming).
3. The temporal ordering task.

* As employed in the current research.
4. The phoneme task (words and non-words).
5. The rhyme task (words and non-words).
6. The spelling task (words and non-words).

Furthermore, five sub-tests from the WISC-III (Bahraini version - 1998), which has been standardized for children aged 6-16 years, were used. These sub-tests were chosen due to their previous use in the research with reading disabled children (Bannatynne, 1968; 1971). The chosen sub-tests were as follows:
1. Digit span (sequential stimuli processing).
2. Coding (sequential stimuli processing).
3. Block design (spatial ability, visual-motor coordination).
4. Picture completion (spatial ability).
5. Picture arrangement (sequential spatial processing).

These tasks were selected to provide data on the cognitive factors associated with Bahraini readers' literacy levels. Specifically, the research focused on children in the first three grades of primary schooling and followed-up a sub-set of this sample one year later. The findings derived from analyses of the cross-sectional and longitudinal data were discussed initially within the framework of the expected predictors of the normal developmental process of early Arabic literacy acquisition, followed by a general discussion of the results within the framework of the expected predictors of poor reading/dyslexia in the Arabic language. In all, this work is anticipated to inform theories about the relationship between language and literacy as well as the development of assessment tools in the educational system in Bahrain.

**Research Aims**

The aims of the current research were firstly, to determine predictors of early Arabic literacy at least as perceived within the Bahraini culture studied from a cross-sectional as well as a longitudinal perspective; secondly, to determine a framework of the expected
predictors of poor reading/dyslexia in the Arabic language, at least as indicated from the normally developed reading process of the Bahraini sample studied; and finally, to provide an overall discussion of findings generating inputs towards practical understanding of handling pedagogical early literacy related issues.

Research Questions and Hypotheses

The current study addressed the nature of the Bahraini children’s Arabic literacy skills by considering:

(i) Whether phonological awareness predicts more variability in early Arabic literacy than the other predictor measures used in the study. As found in the literature, it is expected that phonological skills will have a stronger weight than the other predictors in determining early Arabic literacy acquisition; however, the type of phonological predictor may vary across languages, particularly if they vary in orthographic transparency.

(ii) Given that Arabic in its early stage of acquisition incorporates a relatively transparent orthography, the second issue addressed by this research is whether the same underlying cognitive processes that have been found to predict variance in alphabetical transparent orthographies also influences the level and acquisition of early Arabic literacy.

These considerations were addressed from a cross-sectional methodological approach and a longitudinal one; with the former approach being addressed and discussed in chapter six and the latter approach being addressed and discussed in chapter seven.

Research Sample

There were two samples: one for the pilot study and another for the main formal research.
The sample size in the pilot study consisted of 21 subjects of both the sexes from the first and third grades of two government primary schools, one for boys and one for girls, in the Kingdom of Bahrain. The school children in the sample were randomly chosen and consisted of ten children from grade one and eleven children from grade three.

The sample size in the main study consisted of 171 school children of both sexes randomly chosen from the first three grades of four government primary schools. Two schools were only for boys and two were only for girls. There were 64 subjects from grade one, 55 subjects from grade two, and 52 subjects from grade three; with an overall total of 84 boys and 87 girls (see Table 6.1 for details of the size of the sample by grade and sex).

In the follow-up study, one year later, the size of the sample consisted of 116 students from the original 171 Bahraini school children. These 116 students were in grades one and two in the first year of the study and were followed on one year later, when they had moved up to grades two and three respectively. In the longitudinal study, the size of the second grade sample was 62 children and the size of the third grade sample was 54 children; with a total of 54 boys and 62 girls (see Table 7.1 for details of the size of the sample by grade and sex).

A point to note is that the pilot testing was carried out in schools that were not included in the study of the formal research. Additionally, the Ministry of Education in the Kingdom of Bahrain centrally controls the educational system, providing education in the government schools segregated between the sexes with the language of instruction, particularly in the first three primary grades, being Arabic. The schools selected were from typical areas in the Kingdom of Bahrain with a cross section of socioeconomic status (SES) families. Children enter a school based on catchment area, rather than other reasons and, therefore, the school samples were representative of typical SES levels found in the Kingdom of Bahrain. Government schools were targeted specifically
because they are not biased towards any particular SES group, and are characterized with a more balanced SES cross-section in comparison to the private education sector.

Measuring Instrument and General Procedures

Eleven tasks were used in the study: the Stroop task, picture arrangement, digit span, temporal order, coding, block design, picture completion, phoneme (word and non-word), rhyme (word and non-word), reading (word and non-word) and the spelling (word and non-word) tasks. Five of the tasks in the instruments (picture arrangement, digit span, coding, block design, and picture completion) were taken from the Bahraini version of the WISC III (1998)*. The six remaining tasks (the stroop task, temporal order, phoneme, rhyme, reading and the spelling tasks) were personally prepared. The construction of these six tasks was based on theoretical frameworks and previous research, with the results of the pilot study being used to make minor modifications on those tasks.

Specifically, in the non-word reading measure the items (non-words) were re-arranged in levels of difficulty; with the item list starting from the least to the most difficult. Moreover, in the temporal order and rhyme (word and non-word) tasks, the numbers of items were reduced and the order of the remaining items re-arranged based on levels of difficulty. Overall, the results of the analyses of the pilot testing indicated that the developmental trends of all the measures were within the appropriate range of the age group tested.

* Written permission for use of the five sub-set tests of the WISC (Bahraini version- 1998) was granted from the Psychological Cooperation, at Harcourt Assessment Company, San Antonio, Texas (see appendix).
Although the five sub-tests that were taken from the WISC III (1998) were taken from an intellectual assessment tool, they were not used to test the children’s intelligence. Instead each of the sub-tests was treated separately. The coding task was used to assess the speed of processing of stimuli within a task that required hand-eye coordination and the production of written items.

The block design, picture completion and picture arrangement tasks were used to assess non-verbal skills amongst the children by requiring the processing and production of visual/spatial arrangements as well as the recognition and comprehension of common objects and situations based on visual presentations of those objects or pictures that made up a story line.

The digit span test was used to assess the child’s capacity to store sequences of phonological information in short term-memory. Forward digit span, backward digit span, and the aggregate digit span of forward and backward produced from the administration of the digit span task, were analyzed separately to allow assessments of (i) simple storage efficiency, often associated with the phonological loop system of working memory, (ii) storage with manipulation, which has been seen to include executive functioning provided by the central executive of the working memory system, and (iii) the typical measure used in dyslexia practice (i.e., the combination of forward and backward span scores).

In addition to the phonological memory score provided by the digit span measure, phonological processing skills were assessed in the rhyme and the phoneme tasks, which were used to assess phonological awareness, and the Stroop task procedures which included a task for measuring rapid automatized naming of familiar stimuli (color blocks) and hence an assessment of the efficient access from memory of known phonological forms.

The reading and spelling tasks were used as assessments of literacy levels within the
cohort tested. Measures for words and non-words were used to assess the ability to process letter strings that varied in potential familiarity within the cohort, as well as letter strings (i.e., non-words) that would be unfamiliar to the children. The processing of non-word items, therefore, provides an assessment of literacy skills related to the decoding of letter strings and phoneme sequences, which may be necessary to support the early stages of literacy acquisition.

As a first step in the preparation of the materials, a computer program was developed to allow the random generation of Arabic words associated with grade levels 1-4. This was carried out by accumulating four lists of words for the first to the fourth grades. The words were taken from the reading texts of two different syllabuses: one syllabus is used by two private schools and the other syllabus is used in the government schools. The four lists of words were entered into the computer program which randomly selected words for use in the phoneme, rhyme, reading and spelling tasks.

Items for the temporal order task were prepared in a sound proof studio in order to ensure the clearness of the sound of the tones and to ensure that the levels of the two chosen tones (one high and one low) were the same within a trial and across the trials.

An instruction manual, a record form, and the necessary materials for the tasks were prepared (see Appendix). Each prepared measure had detailed instructions on how to implement each of the prepared measure, including quoted speeches on what to say through out the testing sessions and how to handle different situations that may arise. This step was taken to control for the possibility of any experimenter bias from occurring. These materials were used to train the test administrators. The phonological awareness tests (phoneme and rhyme) as well as the literacy tasks (reading and spelling) were tape recorded, so as to ensure accurate recordings of the children's responses. Overall, each child had required approximately one and a half-hour to complete the instrument. To avoid boredom and fatigue, the instrument was administered over a two-day period, lasting about 45 minutes each day.
Permission letters for the administration of the instrument on the school children tested were granted from the University of Bahrain and the Directorate of Primary Education at the Ministry of Education (see Appendix). Also, at the end of the testing period, all the schools who had participated in the research were sent thank you notes for their cooperation during the period of study.

**Description of the five Tasks Taken from the WISC III (1998) – Bahraini Version.**

For an English language description of the materials used in the five tasks that were taken from the WISC III (1998), as well as the procedural administration for each of those tasks, one could be referred to Kaufman & Lichtenberger (2000); particularly since the Arabic/Bahraini version is based on the English version and that the items within the chosen sub-tests could be perceived as of the universal type and not considered anchored to any language. The WISC III (1998) Arabic/Bahraini version contains within its kit a booklet with a description of all the sub-tests, a description of how to administer each of those sub-tests, and instructions on how to record and interpret a child’s performance. The kit contains the materials needed for each sub-test with the necessary record forms and a booklet of standardized table for each sub-test.

**Description of the Six Tasks Personally Prepared**

1. **The stroop task**

The current research was carried out according to the assumption that dyslexics’ lack the control over the automatic reading process.

1a. **Materials**

The materials for the stroop task consisted of:
- A time watch.
- A record sheet.
- Five A4 size cards in which:
Card#1 consisted of four rectangular color patches: yellow, blue, red, and green aligned in the center of the card, one after the other respectively and under each patch the name of the color was printed in black ink.

Card#2 consisted of 40 color words (yellow, blue, red, and green) randomly selected and printed in black ink.

Card#3 consisted of 40 color (yellow, blue, red, and green) rectangular patches randomly selected and printed.

Card#4 consisted of 40 color words printed in congruous colors; e.g., the word yellow in yellow ink.

Card#5 consisted of 40 color words printed in incongruous colors; e.g., the word yellow in red ink. The choice of color word (yellow, blue, red, and green) and color were randomly selected.

In addition, Cards # 2, 3, 4, and 5 were prepared in a 4X10 matrix, so that there were four words or color patches in each row.

It should be noted that the choice of the card size, the quantity and types of color, and the number of stimuli on a card were based on the materials used in previous Stroop tests (e.g. Everatt et al., 1997).

1b. Procedure

The procedure for the stroop task consisted of the following steps:

1. Presented card #1 to the subject to ensure that they knew each color and color word.

2. Presented card #2 (word – reading condition). Recorded the time in seconds to complete reading the color words on the card and the time needed to correct errors (this latter step was cancelled after the administration of the pilot study).

3. Presented card #3 (color – naming). Recorded the time in seconds to complete naming all the colored rectangular patches on the card and the time needed to correct errors (this latter step was cancelled after the administration of the pilot study).
4. Presented card #4 (color – naming with congruous word). Recorded the time in seconds to complete naming all the colors in the card and the time needed to correct errors (this latter step was cancelled after the administration of the pilot study).
5. Presented card #5 (color – naming with incongruous word). Recorded the time in seconds to complete naming all the colors in the card and the time needed to correct errors (this latter step was cancelled after the administration of the pilot study).

1c. Measured Variable
The measured variables in the main study of the Stroop task were the Stroop word interference measure and the rapid naming measure.

The Stroop word interference measure for each child tested was calculated in seconds by subtracting the recorded timing of presenting card #3 from the recorded timing of presenting of card #5.

The rapid naming measure for each child tested was found by recording the time in seconds taken to read card #3.

2. Temporal Ordering Task
The temporal ordering task is perceived to measure recognition and integration of sequential auditory stimuli in short-term memory.

2a. Materials
The materials for the temporal ordering task consisted of:
- A CD prepared in a sound proof studio, taped on it 12 different chain-pairs of tones making up 12 trials.
- A CD player
- A record sheet
Initially, the current task consisted of two ‘example’ trials and fourteen ‘test’ trials. However, after the administration of the pilot study the ‘test’ trials were reduced to ten trials. Each trial consisted of two different/similar chains of tones. Each tone-chain consisted of a series of high and low tones arranged in a particular manner. One high tone and one low tone were used, which were each artificially produced, in a recording studio. Those two tones were then used to produce chains of different combination and of different length of tone chains for each of the trials. The length of a single tone chain across the various trials ranged from a minimum of about 3.55 seconds to a maximum length of about 8.02 seconds. The pattern of tones set for each trial could be found in Table 5.1. Each trial had its own particular pattern of paired tone chains, ranged in levels of difficulty from least to most difficult as the trials progressed.

2b. Procedure
At the start of the task, the researcher explained to the subject what was required of him/her. This involved the subject listening to two chain-tones, followed by being asked to decide whether the two chain-tones that were heard were similar or not.

Following the initial instructions to the requirements of the task, the testing began with the two ‘example’ trials, in which the subject had two chances at the task within a trial.

More specifically, if, at a particular ‘example’ trials (i.e. trial 1 &/or trial 2), the subject failed to respond correctly on the first attempt, the researcher allowed the subject to listen to the pair of chain-tones a second time. As the researcher played the two chains of tones the second time, s/he pointed out the high and low tones as they were heard. Then the researcher posed the question of whether the two chain-tones were similar or not. Once it was clear that the subject had understood the requirements of the task, the researcher began the ‘test’ trials with the subject.

In the ‘test’ trials the subject had only one chance to listening to the pair of tone chains. Once both chains were presented, the child was asked to give a response to whether the
Table 5.1 - The chain of tone patterns as heard by the subject across the different trials of the temporal order task, with the subject's expected response and method of scoring.

<table>
<thead>
<tr>
<th>Trials</th>
<th>Heard Tone Pattern</th>
<th>Expected Response</th>
<th>Score (1 or 0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example Trial 1</strong></td>
<td>+ space +</td>
<td>Similar</td>
<td>A score of 1 is given to the subject only if the correct response is produced on the first time round.</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Example-Trial 2</strong></td>
<td>+ space - -</td>
<td>Not Similar</td>
<td>A score of 1 is given to the subject only if the correct response is produced on the first time round.</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 3</strong></td>
<td>+ space + space +</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space + space +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>+ space - space +</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 4</strong></td>
<td>+ space - -</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>+ space - -</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 5</strong></td>
<td>+ space - - space +</td>
<td>Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space - - space +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>+ - space - - space+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 6</strong></td>
<td>+ + space - - space+</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ + space - - space+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>+ - space - - space+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 7</strong></td>
<td>+ space - - - space+</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>+ space - - - space+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - space - - space+</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 8</strong></td>
<td>- - space + space -</td>
<td>Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>- - space + space -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - space + space -</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test - Trial 9</strong></td>
<td>- - - +</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test -Trial 10</strong></td>
<td>- - - +</td>
<td>Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test -Trial 11</strong></td>
<td>- - - +</td>
<td>Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test -Trial 12</strong></td>
<td>- - - +</td>
<td>Not Similar</td>
<td>No second chance is given</td>
</tr>
<tr>
<td>1st. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd. Tone Chain</td>
<td>- - - +</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ = A high tone;  - = A low tone; space = A two seconds interval
pair of chain tones were similar or not. Following the subject's response, s/he was moved onto the next 'test' trial. The procedure in the 'test' trials continued in the same manner, until the subject had been taken through all of the 'test' trials.

2c. Measured Variable
The measured variable in the temporal order task was the total number of correct responses produced by the subject from the 'example' as well as the 'test' trials. However, in the 'example' trials where the subject is given two opportunities at attempting a trial, the score of only the first opportunity is recorded and not the second.

3. The Phoneme Task.
The Phoneme task could be considered as an add-phoneme manipulative type of activity measuring phonological awareness at the level of the phoneme.

3a. Materials
The test materials used were:
- List A: a list of 28 words.
- List B: a list of 28 non-words.
- A Record Form for every subject.

The list of words (List A) consisted of twenty-eight, five letter words randomly chosen from the primary level Arabic textbooks of first, second and third grade government and private syllabuses. The word list included words that ended with phonemes (letter-sounds) which covered the whole range of the Arabic consonant phonemes. However, it must be noted that there were two phonemes: ﺕ ﺞ that were only found to come at the end of a 'five-letter' word once in all the textbooks. As a result those two words were the ones used in the list of words (List A). Since the Arabic language has twenty-eight consonant phonemes, therefore no item in list A ended with the same phoneme.
Similarly, the list of non-words (List B) consisted of twenty-eight made up words. Those non-words had no meaningful value and each non-word was composed from parts of two randomly chosen words that were put together to give a ‘nonsense’ word. Usually, the beginning part of the randomly selected word was combined with the ending part of the second randomly selected word in order to form a non-word. In addition, two criteria were met before the non-word was included in list B. The first was that the ‘made-up’ item was a nonsense word and the second was that the total number of letters within an item equalled five. Furthermore, the list of non-words ended with phonemes that covered the whole range of the Arabic consonant phonemes.

3b. Procedure
The Phoneme task was administered to each subject individually. It consisted of two parts: Part I (administration of List A) and Part II (administration of List B). Both parts were administered orally and the subject was not allowed to see any of the written lists. Letter sounds were used throughout the procedure. At the start of each part of the procedure, the subject was given a practice test. Each practice test consisted of two examples. This helped familiarize the subject with the requirements of the task.

In Part I the experimenter orally presented each incomplete word on List A, one at a time. Each incomplete word was followed by its final phoneme. The subject’s task was to put the two sounds together in order to give a complete word. The child’s response was marked on the record form. Each correctly pronounced word on List A was ticked on the record form and was counted as a single point. The maximum score a subject could receive on List A was 28 points.

After completing List A, List B was administered. The procedure for List B was similar to that of List A. The only exception was in the type of items that were used in List B which were 28 non-words. As with List A, the Maximum score a subject could receive on List B was 28 points.
3c. Measured Variable

The measured variables in the Phoneme task were the total number of correct pronunciations given to the tested items on List A, producing a ‘word phoneme’ score and the total number of correct pronunciations given to the tested items on List B, producing a ‘non-word phoneme’ score.

4. The Rhyme Task

The Rhyme task could be considered as an odd-sound out manipulative type of activity measuring phonological awareness at the level of the syllable.

4a. Materials

The test materials used were:

- List A: a list of 20 word triads. (Reduced from the 28 strings of three words used in the pilot work)
- List B: a list of 20 non-word triads. (Reduced from the 28 strings of three non-words used in the pilot work)
- A Record Form for every subject.

List A of the Rhyme task was made up of twenty strings of three words. In each word triad, two of the three words rhymed with each other. One of the rhyming words was randomly chosen from the Primary level Arabic Reading text books of the first, second and third grade government and private school syllabuses’ in the Kingdom of Bahrain. The second rhyming word was chosen on the basis that it rhymed with the first randomly chosen word. On the other hand, the third word was chosen on the basis that it sounded slightly different from the other two words within a single string of words.

In addition, the position of the target stimuli (the odd sounding word) within a string randomly varied across the list of tested items. Care was taken to ensure that the number
of letters in a word was equal across each triad of words. The number of letters making up the words in a triad ranged from three letters per word to seven letters per word.

List B of the Rhyme Task was similar to List A, with the exception that it was made up of non-words rather than words. The non-words were created from normal words chosen from the same Arabic Reading syllabuses of the first, second and third grades mentioned above. Two of the non-words were produced such that when pronounced correctly they rhymed. The third non-word in a triad was produced so that when pronounced correctly it did not rhyme with the other two non-words.

4b. Procedure

The Rhyme task was administered to each subject individually. It consisted of two parts: Part I (administration of List A) and Part II (administration of List B). Both parts were administered orally and the subject was not allowed to see any of the written lists. At the start of each part of the procedure, the subject was given a practice test. Each practice test consisted of two examples. This helped familiarize the subject with the requirements of the task.

In Part I the experimenter orally presented each of the three-word strings on List A, one at a time. The subject’s task was to listen to the three words and choose the one that did not rhyme with the other two words. The subject’s response was marked on the record form. In the case where the subject was able to recognize and orally produce the target word, a tick for that particular string of words was given. The maximum score that a child could receive in this task was 20 points.

After completing List A, List B was administered. The procedure for List B was similar to that of List A. The only exception was in the type of items that were used in List B which were 20 strings of three groups of non-words. As with List A, the maximum score that a child could receive on List B was 20 points.
4c. Measured Variable
The measured variables in the Rhyme task were the total number of correct items on List A, producing a ‘word rhyme’ score, and the total number of correct items on List B, producing a ‘non-word rhyme’ score.

5. The Reading Task
The reading task could be considered as a measure of literacy, involving the ability to translate visual symbols represented by strings of grapheme stimuli (known and unknown) into an output comprising a string of phonemes.

5a. Materials
The task consisted of:
- List A: Forty words written on an A4 size white card. The words were displayed on an array of 4X10. Each two rows corresponded to words randomly taken from a particular grade level. The order of the levels began with words from the first grade and continued to words from the fourth grade.
- List B: Ten nonsense words written on an A4 size white card. The non-words were displayed on an array of 2X5.
- A stop watch.
- A record form for each subject individually

5b. Procedure
The reading task was administered to each subject individually. Each subject was first asked to read List A, followed by List B. The instructions for List A and List B were given separately. All subjects started by reading List A from the start and were left to continue reading the words until they reached their own grade level; then they were stopped upon making five consecutive reading mistakes. It must be noted that unlike List A, all the subjects had to read all the non-words in List B.
The total reading time, the words/non-word reached at every thirty seconds, and the number of correct responses were recorded.

5c. Measured Variable
The reading variables used in the current study comprised of the total number of words read correctly from List A; and the total number of non-words read correctly from List B.

6. The Spelling Task
The spelling task could be considered as a measure of literacy, involving the ability to translate auditory stimuli represented by strings of phoneme stimuli (known and unknown) into visual symbols represented by strings of graphemes.

6a. Materials
The task consisted of:
- List A: Forty words written on an A4 size white card. The words were displayed on an array of 4X10. Each two rows corresponded to words randomly taken from a particular grade level, which had began from the first grade and continued up to the fourth grade. It must be noted that none of the words used in the reading task were used in the spelling task.
- List B: Ten nonsense words written on an A4 size white card. The non-words were displayed on an array of 2X5. It must be noted that none of the nonsense words used in the reading task were used in the spelling task.
- A4 lined blank piece of paper with the subject name on it.
- A sharpened pencil without a rubber
- A record form for each subject individually
6b. Procedure

The spelling task was administered last and it was administered to a whole group of subjects. Once a group of subjects had finished all the other tasks, they were gathered together and were given a spelling task.

Each subject was handed an A4 lined blank piece of paper with their names on it and a sharpened pencil without a rubber. List A was administered first followed by List B. The instructions for each list were given separately. Each word/non-word was read twice and the subject was given time to write the words/non-words as they were dictated. Once all the words in List A were dictated, the subjects were instructed to turn the paper and were instructed on the second part of the spelling task (List B).

6c. Measured Variable

The spelling variables used in the current study comprised of the total number of words spelt correctly from List A; and the total number of non-words spelt correctly from List B.
CHAPTER 6

Results on the Bahraini Sample at Time One:
A Cross-Sectional Analysis
Chapter 6

Results on the Bahraini Sample at Time One:
A cross-sectional Analysis

Introduction
The current study was carried out on Bahraini school children of both sexes during the year 2003 (referred to as T1). The rationale for the choice of measures used in the research, detailed information on the participants, full description of the chosen measures and the methodological and procedural outline have been provided in the previous chapter (chapter 5). As a reminder of the current research, only a brief outline of the participants and measures used will be given below.

The aim of the following chapter (Chapter 6) is to specify the research questions and hypotheses, present the results, and discuss the findings within the particulars of the culture, its orthography, and past literary findings.

Research Questions and Hypotheses
The current study investigated the role played by the variables discussed in the previous chapter as potential predictors of early Arabic literacy acquisition. The research was conducted from the perspectives of an information processing model and within the findings of cross-cultural research on transparent and non-transparent alphabetical languages.

The study addressed the nature of the Bahraini children’s Arabic skills by considering:
(i) Whether the degree of effect of phonological awareness predictors are relatively stronger than the effects of the other predictors on the acquisition of early Arabic literacy. As found in the literature, it is expected that phonological awareness skills will predict more variability in early Arabic literacy acquisition than the other predictors.
(ii) Whether the underlying cognitive processes common to alphabetical transparent orthographies also influence the acquisition of Arabic literacy. Given the transparency of the Arabic language with its Semitic root, it is expected that visio-spatial ability, memory processing, and decoding skills will play a role in Arabic literacy acquisition.

For the testing of both the above hypotheses, first a correlation between all predictors will be carried out to look for associations between the potential predictors. These will be followed by regression analyses, controlling for age, sex, school, and grade, to investigate the relative strength of the prediction provided by each variable. Analyses will be performed on grade 1 to 3 Bahraini school children.

Briefly, the size of sample in the following study was 171 Bahrain students of both sexes randomly chosen from the first three grades of four primary monolingual government schools of which two of the schools were only for boys and the other two schools were only for girls. Table 6.1 provides details of the size of the sample by grade and sex.

Table 6.1 – Size of the Bahraini sample at time one (T1) by sex and grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>34</td>
<td>30</td>
<td>64</td>
</tr>
<tr>
<td>Two</td>
<td>20</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>Three</td>
<td>30</td>
<td>22</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>87</td>
<td>171</td>
</tr>
</tbody>
</table>
With regards to the measures, seventeen measures were used in the study (see Table 6.1.1). Four of them were measures of literacy and provided the dependent variables. Those measures of literacy were single word reading, single non-word reading, single word spelling, and single non-word spelling. Word and non-word reading tasks assessed the decoding (from grapheme to phoneme) of known and novel letter strings respectively. In contrast, word and non-word spelling assessed the ability to decode from phoneme to grapheme, with known and novel letter strings again being used.

The remaining 13 measures provided the independent variables in the study. These were: the add phoneme tasks for words and non-words, the odd sound out tasks for words and non-words, the forward and backward digit span tasks, a temporal ordering task, a picture arrangement task, a picture completion task, the block design measure, the coding measure, rapid naming and the Stroop task. Of the thirteen measures, four tested for phonological awareness processing (add phoneme for word and non-word and odd sound out for words and non-words). The odd sound out tasks measured rhyme awareness for known and novel letter strings; whereas the add phoneme tasks measured the ability to manipulate phonological forms at the level of the phoneme, again using known and novel letter strings. Digit span tasks measured phonological short-term memory. Forward digit span assessed simple short-term storage, whilst backward digit span assessed storage and manipulation of the same phonological stimuli in working memory. The temporal auditory task measured recognition and integration of sequential auditory stimuli in short-term memory. The rapid naming task assessed the automaticity in retrieval of linguistic information on known stimuli. The picture completion task measured the ability to recognize missing information based on general knowledge accessed from long-term memory. The picture arrangement task measured reasoning and visual planning skills. The Stroop task measured the extent to which word reading is an automatic process. Block design was used as a visuo-spatial measure of non-verbal production. Coding was used as a measure of speed of processing.
Table 6.1.1 – A list of measures used at TI with a brief description of the assessed process for each measure.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Assessed Process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent Variables:</strong></td>
<td>Literacy</td>
</tr>
<tr>
<td>Single word reading</td>
<td>Literacy</td>
</tr>
<tr>
<td>Single non-word reading</td>
<td>Literacy</td>
</tr>
<tr>
<td>Single word spelling</td>
<td>Literacy</td>
</tr>
<tr>
<td>Single non-word spelling.</td>
<td>Literacy</td>
</tr>
<tr>
<td><strong>Dependent Variables:</strong></td>
<td></td>
</tr>
<tr>
<td>Add phoneme for word</td>
<td>Phonological awareness processing (at the level of the phoneme).</td>
</tr>
<tr>
<td>Add phoneme for non-word.</td>
<td>Phonological awareness processing (at the level of the phoneme).</td>
</tr>
<tr>
<td>Odd sound out for word</td>
<td>Phonological awareness processing (at the level of the rhyme).</td>
</tr>
<tr>
<td>Odd sound out for non-word.</td>
<td>Phonological awareness processing (at the level of the rhyme).</td>
</tr>
<tr>
<td>Forward digit span – from WISC</td>
<td>Simple short-term phonological storage.</td>
</tr>
<tr>
<td>Backward digit span – from WISC</td>
<td>Storage and manipulation of phonological stimuli in working memory.</td>
</tr>
<tr>
<td>Temporal auditory task</td>
<td>Recognition and integration of sequential auditory stimuli in short-term memory.</td>
</tr>
<tr>
<td>Rapid naming</td>
<td>Automaticity in retrieval of linguistic information on known stimuli.</td>
</tr>
<tr>
<td>Picture completion – from WISC</td>
<td>Recognition of missing information based on general knowledge accessed from long-term memory.</td>
</tr>
<tr>
<td>Picture Arrangement - from WISC</td>
<td>Reasoning and visual planning skills.</td>
</tr>
<tr>
<td>Stroop task</td>
<td>Extent to which word reading is an automatic process.</td>
</tr>
<tr>
<td>Block design - from WISC</td>
<td>A visuo-spatial measure of non-verbal production</td>
</tr>
<tr>
<td>Coding - from WISC</td>
<td>Speed of processing.</td>
</tr>
</tbody>
</table>
Results

Description of the Arabic literacy Skills amongst Bahraini School Children*

Table 6.2 presents the means and standard deviations on words and non-words for reading and spelling in Arabic across the first three grades of four primary schools in Bahrain. Means for reading and spelling showed evidence of improvements across the grades with, overall, the improvement for spelling being better than that for reading. With regards to the variability in scores for reading and spelling of non-words, there were indications of floor effects for grade one which was to be expected given that in this grade students may not have the strategies, or experience, to decode novel letter strings effectively. Similarly, the variability within the scores for reading and spelling of words suggested a skewed distribution for grade 1 data, again indicative of a lack of experience/skill amongst some children. Moreover, the variability within each of the literacy scores between grades two and three were about the same.

Description of the Independent Variables amongst Bahraini School Children

Table 6.3 presents the mean and standard deviations on the following variables: the phoneme scores (word and non-word), the rhyme scores (word and non-word), digit span scores (forward, backwards, and combined), temporal order score, rapid naming score, Stroop word interference score, picture completion score, picture arrangement score, coding score, and block design score.

Overall, with the exception of the coding measure, the children’s mean scores improved from grade 1 to grade 3. However, the children’s coding scores reflected a drop in performance level across grades. With regards to the standard deviations of the

* It must be noted that where potential outliers were identified, these were removed and the relevant analyses were repeated. However, these procedures made little difference to the results of the analyses. Therefore, the following descriptions of the analyses will include all of the children tested.
Table 6.2 – Mean, standard deviations, and minimum and maximum scores by grade of the Arabic literacy (reading and spelling) measures at T1, with the results of one-way analyses of variance assessing the effects of grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Single Word Reading</th>
<th>Single Non-Word Reading</th>
<th>Single Word Spelling</th>
<th>Single Non-Word Spelling</th>
</tr>
</thead>
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<td></td>
</tr>
<tr>
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<td>1.34</td>
<td>7.47</td>
<td>1.48</td>
</tr>
<tr>
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<td>1.58</td>
<td>6.55</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Max.</td>
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<td>6.00</td>
<td>26.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Two</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>13.11</td>
<td>2.53</td>
<td>15.51</td>
<td>2.40</td>
</tr>
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<td>9.27</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Max.</td>
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<td>32.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Three</td>
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<td></td>
</tr>
<tr>
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</tr>
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<tr>
<td>Max.</td>
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</table>

<table>
<thead>
<tr>
<th>ANOVA</th>
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<th>Df</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2 and 168</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

independent variables, they reflected a reasonable level of individual variability within each of the measures tested across the three grades. In addition, there was little evidence of floor or ceiling effects for any of the measures.

Finally, within the phonological awareness measures, the children’s mean performances on the word tasks (phoneme and rhyme) were better than their mean performances on the non-word tasks (phoneme and rhyme). With regard to the standard deviation of the phonological awareness measures, it could be seen that within the phoneme tasks there was greater variability in the children scores in the first and second grades than in the third grade, which could reflect that the children’s phonological awareness ability may have become somewhat similar by third grade particularly for the phoneme word task.
Table 6.3 – Means, standard deviations, and minimum and maximum scores, together with the number of cases, by grade for the independent variables at T1, and the results of one-way analyses of variance investigating the effects of grade. (Anova results in bold are significant at the 0.05 level.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>One</td>
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<td>64</td>
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<td>55</td>
<td>55</td>
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<td>3.00</td>
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<td>8.00</td>
<td>5.00</td>
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</tr>
<tr>
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ANOVA F-value

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<td>2 and 168</td>
<td>2 and 168</td>
<td>2 and 168</td>
<td>2 and 168</td>
<td>2 and 168</td>
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</table>
Table 6.3 continued – Means, standard deviations, and minimum and maximum scores, together with the number of cases, by grade for the independent variables at T1, and the results of one-way analyses of variance investigating the effects of grade. (Anova results in bold are significant at the .05 level).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Rapid Naming (Color Blocks)</th>
<th>Stroop Word Interference</th>
<th>Picture Completion</th>
<th>Picture Arrangement</th>
<th>Coding (Standardized Score)</th>
<th>Block Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
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<td>54.57</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>25.01</td>
<td>4.08</td>
<td>4.93</td>
<td>3.48</td>
</tr>
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<td>57.77</td>
<td>12.37</td>
<td>14.50</td>
<td>8.88</td>
</tr>
<tr>
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<td>52</td>
<td>52</td>
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</tr>
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<td>2 and 168</td>
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<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.163</td>
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</tbody>
</table>
Developmental Patterns in Learning to Read and Write in Arabic at T1

One-way analyses of variance (ANOVA) were performed on the scores of the literacy measures produced by grades 1, 2, and 3, in order to assess whether the Arabic Bahraini children’s literacy ability had significantly improved with increasing years of schooling. These can be found in Table 6.2, and indicate that significant grade effects were found for word and non-word reading, and for word and non-word spelling. The mean scores of the children in each of the grades (Table 6.2) indicate that scores on the literacy tasks had improved over the years of schooling.

Similar one-way analyses of variances were performed on the remaining measures (presented in Table 6.3). With the exception of the non-word rhyme, the coding, and the word interference measures, which did not show significant effects, the remaining measures (word rhyme, word and non-word phoneme, forward digit span, backward digit span, forward and backward digit span, temporal order, rapid naming, picture completion, picture arrangement, and block design) showed evidence of significant changes in the children’s performances across the grades, with the mean scores reflecting an increase in performances from grade 1 to grade 3.

Association Strengths between Arabic literacy Measures and Potential Predictors

Table 6.4.1 presents Pearson correlation coefficients used to calculate the degree of relationship between the literacy measures: single word reading, single non-word reading, single word spelling, and single non-word spelling. These coefficients indicate that all the literacy measures were strongly and significantly associated with each other.

Pearson correlation coefficients were then calculated to estimate the degree of relationship between the Arabic literacy measures (word reading, non-word reading, word spelling, and non-word spelling) and each of the potential predictor measures (word phoneme, non-word phoneme, word rhyme, non-word rhyme, forward digit span,
backward digit span, forward and backward digit span, temporal order, rapid naming, Stroop word interference, picture completion, picture arrangement, coding, and block design). As can be seen from Table 6.4.2, apart from the Stroop interference and the coding measures, the potential predictors were significantly associated with each of the reading and spelling measures; mostly at the 0.01 level in a two-tailed test.

Table 6.4.1 – Pearson correlations, assessing the interrelationship between the Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) at T1.

<table>
<thead>
<tr>
<th>Potential Predictors</th>
<th>Whole</th>
<th>Cohort</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Word Reading</td>
<td>NW Reading</td>
</tr>
<tr>
<td>Word Reading</td>
<td>.794**</td>
<td>.796**</td>
</tr>
<tr>
<td>Non-Word Reading</td>
<td>.794**</td>
<td></td>
</tr>
<tr>
<td>Word Spelling</td>
<td>.796**</td>
<td>.706**</td>
</tr>
<tr>
<td>Non-Word Spelling</td>
<td>.709**</td>
<td>.633**</td>
</tr>
</tbody>
</table>

**correlations significant at the 0.01 level (2-tailed), NW= Non-Word.

With regards to the potential phonological awareness predictors (word phoneme, non-word phoneme, word rhyme, non-word rhyme), all showed positive and reasonable associations with each of the literacy measures; although overall higher associations were found with word reading and spelling than with non-word reading and spelling. In addition, the literacy measures appeared to be more strongly associated with word rhyme and non-word phoneme than with word phoneme and non-word rhyme.

Apart for rapid naming, all the remaining potential predictor variables (forward digit span, backward digit span, forward and backward digit span, temporal order, picture completion, picture arrangement, and block design) that showed significant associations with the various literacy measures reflected associations that were positively related with each other. Consistent with faster times reflecting better performance, rapid naming scores were negatively associated with each of the literacy measures.
Table 6.4.2—Pearson correlations between Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) and each of the potential predictor measures used in the study at T1.

<table>
<thead>
<tr>
<th>Potential Predictors</th>
<th>Whole Cohort</th>
<th>Whole Cohort</th>
<th>Whole Cohort</th>
<th>Whole Cohort</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Word Reading</td>
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<td>NW Spelling</td>
</tr>
<tr>
<td>Phoneme-Word Add</td>
<td>.420**</td>
<td>.371**</td>
<td>.458**</td>
<td>.375**</td>
</tr>
<tr>
<td>Phoneme-NW Add</td>
<td>.455**</td>
<td>.427**</td>
<td>.513**</td>
<td>.410**</td>
</tr>
<tr>
<td>Rhyme-Word Odd Sound</td>
<td>.478**</td>
<td>.410**</td>
<td>.546**</td>
<td>.465**</td>
</tr>
<tr>
<td>Rhyme-NW Odd Sound</td>
<td>.406**</td>
<td>.356**</td>
<td>.436**</td>
<td>.380**</td>
</tr>
<tr>
<td>Digit Span- Forward</td>
<td>.215**</td>
<td>.153*</td>
<td>.242**</td>
<td>.169*</td>
</tr>
<tr>
<td>Digit Span- Backward</td>
<td>.386**</td>
<td>.313**</td>
<td>.445**</td>
<td>.443**</td>
</tr>
<tr>
<td>Digit Span- (F &amp; B)</td>
<td>.410**</td>
<td>.313**</td>
<td>.454**</td>
<td>.402**</td>
</tr>
<tr>
<td>Temporal Order</td>
<td>.342**</td>
<td>.259**</td>
<td>.392**</td>
<td>.351**</td>
</tr>
<tr>
<td>Rapid Naming</td>
<td>-.416**</td>
<td>-.374**</td>
<td>-.455**</td>
<td>-.420**</td>
</tr>
<tr>
<td>Stroop Word Interference</td>
<td>-.006</td>
<td>-.021</td>
<td>.085</td>
<td>.044</td>
</tr>
<tr>
<td>Picture Completion</td>
<td>.385**</td>
<td>.313**</td>
<td>.335**</td>
<td>.250**</td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td>.340**</td>
<td>.355**</td>
<td>.313**</td>
<td>.298**</td>
</tr>
<tr>
<td>Coding (standardized)</td>
<td>-.011</td>
<td>-.024</td>
<td>-.055</td>
<td>-.024</td>
</tr>
<tr>
<td>Block Design</td>
<td>.382**</td>
<td>.372**</td>
<td>.347**</td>
<td>.298**</td>
</tr>
</tbody>
</table>

*correlations significant at the 0.05 level (2-tailed), ** correlations significant at the 0.01 level (2-tailed).
NW = Non-Word, (F & B) = Forwards and Backwards.

Finally, Pearson correlations were calculated between the literacy measures (word reading, non-word reading, word spelling, and non-word spelling) and each of the potential predictor measures (word phoneme, non-word phoneme, word rhyme, non-word rhyme, forward digit span, backward digit span, forward and backward digit span, temporal order, rapid naming, Stroop word interference, picture completion, picture arrangement, coding, and block design) used in the study, for each of the three grades separately. The results of the analysis were presented in Table 6.4.3.
Table 6.4.3 –Pearson correlations between Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) and each of the potential predictor measures used in the study at T1, for each of the grades one, two, and three.

<table>
<thead>
<tr>
<th>Potential Predictors</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word Reading</td>
<td>NW Reading</td>
<td>Word Spelling</td>
</tr>
<tr>
<td>Phoneme-Word Add</td>
<td>.286*</td>
<td>.278*</td>
<td>.362*</td>
</tr>
<tr>
<td>Phoneme-NW Add</td>
<td>.298*</td>
<td>.312*</td>
<td>.420**</td>
</tr>
<tr>
<td>Rhyme-Word Odd Sound</td>
<td>.337**</td>
<td>.286*</td>
<td>.397**</td>
</tr>
<tr>
<td>Rhyme-NW Odd Sound</td>
<td>.400**</td>
<td>.265*</td>
<td>.474**</td>
</tr>
<tr>
<td>Digit Span-Forward</td>
<td>.123</td>
<td>.135</td>
<td>.089</td>
</tr>
<tr>
<td>Digit Span-Backward</td>
<td>.194</td>
<td>.269*</td>
<td>.330**</td>
</tr>
<tr>
<td>Digit Span-(F &amp; B)</td>
<td>.193</td>
<td>.239</td>
<td>.232</td>
</tr>
<tr>
<td>Temporal Order</td>
<td>.340**</td>
<td>.379**</td>
<td>.336**</td>
</tr>
<tr>
<td>Rapid Naming</td>
<td>-.468**</td>
<td>-.431**</td>
<td>-.387**</td>
</tr>
<tr>
<td>Stroop Word</td>
<td>.237</td>
<td>.241</td>
<td>.285*</td>
</tr>
<tr>
<td>Interference</td>
<td>.182</td>
<td>.223</td>
<td>.229</td>
</tr>
<tr>
<td>Completion</td>
<td>.205</td>
<td>.369**</td>
<td>.211</td>
</tr>
<tr>
<td>Picture Arrangement</td>
<td>.094</td>
<td>-.001</td>
<td>.053</td>
</tr>
<tr>
<td>Coding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Standardized)</td>
<td>.095</td>
<td>.195</td>
<td>.123</td>
</tr>
</tbody>
</table>

*correlations significant at the 0.05 level (2-tailed), **correlations significant at the 0.01 level (2-tailed), NW= Non-Word, (F & B)= Forwards and Backwards.
These correlations indicated that, with the exception of word phoneme in grade three, the phonological awareness measures in each of the grades 1, 2 and 3 at T1 showed positive and significant associations with each of the Arabic literacy measures. Overall, the associations between the literacy measures and the phonological awareness predictors that reached significant levels in the first grade usually showed an increase in the relationship by second grade, with a slight reduction in the degree of relationship been found by grade 3*.

However, with regards to the associations between the other potential cognitive measures and the literacy measures at T1; the number of significant associations, at either the 0.01 level or the 0.05 level in two-tailed tests, were mostly found in grade one, followed by grade two, and lastly by grade three.

In grade 1, significant associations were found between the different literacy measures and backward digit span, temporal order, rapid naming, Stroop word interference, and picture arrangement; with some of those measures showing more significant associations with the different literacy measures than others. For example, rapid naming was found to be significantly associated with all the literacy measures; temporal order with only three of those measures; Stroop word interference with only two, and picture arrangement with only one of the literacy measures (non-word reading).

On the other hand, in grade 2, significant associations with the different literacy measures were found for forward and backward digit span, temporal order, rapid naming, picture completion, picture arrangement, and block design; with some of those measures

* The insignificant associations between word phoneme and the literacy measures of grade three appear as a surprise; in particular because no such finding were found in the cross-sectional study of the year 2004 (see chapter seven), nor did the grade three data contain any obvious outliers that could have affected the correlations. Consequently, such a finding would be treated as anomalous and would not be discussed any further.
showing more significant associations with the different literacy measures than others. For example, temporal order was found to be significantly associated with all the literacy measures; block design with only three of those measures; picture arrangement with only two; and rapid naming and picture completion, each significantly associated with only one of the literacy measures (word spelling).

Finally, in grade 3, the literacy measures were significantly associated with backward digit span, forward and backward digit span, rapid naming, and picture completion; with some of those measures showing more significant associations with the different literacy measures than others. For example, backward digit span was significantly associated with all of the literacy measures; forward and backward digit span and rapid naming, each were significantly associated with the same three literacy measures; and lastly picture completion was significantly associated with only one of the literacy measures (word reading).

The majority of the significant associations mentioned above were positive; i.e., better scores related to higher literacy levels. The exception was rapid naming, which showed a negative relationship with the different literacy measures; i.e., faster times related to better literacy levels. In addition, particularly in grades 1 and 2, the phonological awareness measures generally produced larger relationship values with the different literacy measures than the other measures.

Predictors of Arabic Literacy Skills at T1

Stepwise regression analyses were performed for each of the Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) of the Bahraini school children from the first three primary grades, after controlling for sex, age, school, and grade. Results of the analyses were presented in Table 6.5.
The demographic variables accounted for about 25% of the variability in word reading; for 13% of the variability in non-word reading; for about 33% of the variability in word spelling; and for 23% in non-word spelling.

For word reading, non-word rhyme was the best predictor of variability overall, explaining about 12% of the test scores. Word rhyme explained a further 4%, indicating that rhyme measures could explain about 16% of the variability in word reading scores. In addition, to the rhyme measures, block design and backward digit span each explained a further 3% and about 2% of the variability respectively.

For non-word reading, word rhyme was the best predictor of variability overall, explaining about 10% of the test scores. Block design explained a further of about 7% of the variability; followed by non-word rhyme and picture arrangement of which each explained about 3% and about 2% of the variability respectively. Again, as it could be seen, that the rhyme measures were capable of explaining about 13% of the variability in non-word reading scores.

For word spelling, word rhyme was the best predictor of variability overall, explaining 14% of the test scores. Non-word rhyme and backward digit span, each further explained 4% and 2% of the variability in the spelling scores, respectively. Altogether, the rhyme measures were capable of explaining about 18% of the variability in the spelling scores.

For non-word spelling, non-word rhyme was the best predictor of variability overall, explaining 10% of the test scores. This was followed by backward digit span and word rhyme, of which each respectively, explained a further of about 5% and of about 3% of the variability in the spelling scores. Thus, as it could be seen that rhyme measures were again able to explain about 13% of the variability in the non-word spelling scores.
Table 6.5 – Regression Analyses performed on each of the Arabic literacy measures: word reading, non-word reading, word spelling, and non-word spelling at T1.

<table>
<thead>
<tr>
<th>Variable Entered</th>
<th>Predictor</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>R Square Change</th>
<th>Significant F Change</th>
<th>Standardized Beta Coefficients Final Model</th>
</tr>
</thead>
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<tr>
<td><strong>WORD READING</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Block 1. Enter</td>
<td>Sex</td>
<td>.245</td>
<td>.227</td>
<td>&lt;0.001</td>
<td>.191</td>
<td>-.109, .051, .335</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 2. Tests - Stepwise</td>
<td>NW Rhyme</td>
<td>.360</td>
<td>.341</td>
<td>.115</td>
<td>&lt;0.001</td>
<td>.208</td>
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<td></td>
<td>Word Grade</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Rhyme</td>
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<td>.040</td>
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<td>.200</td>
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<tr>
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<td>Block Design</td>
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<td>.405</td>
<td>.030</td>
<td>&lt;0.001</td>
<td>.197</td>
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<tr>
<td></td>
<td>Backward Digit Span</td>
<td>.445</td>
<td>.417</td>
<td>.015</td>
<td>&lt;0.001</td>
<td>.139</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>.113</td>
<td>&lt;0.001</td>
<td>.249</td>
<td>-.032, .054, .089</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td></td>
<td></td>
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<td></td>
<td>School</td>
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<td>Grade</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 2. Tests - Stepwise</td>
<td>Word Rhyme</td>
<td>.229</td>
<td>.205</td>
<td>.095</td>
<td>&lt;0.001</td>
<td>.181</td>
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<td>Block Design</td>
<td>.296</td>
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<td>.067</td>
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<td>NW Rhyme</td>
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<td>.026</td>
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<td></td>
<td>Picture Arrangement</td>
<td>.346</td>
<td>.313</td>
<td>.024</td>
<td>&lt;0.001</td>
<td>.183</td>
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<td><strong>WORD SPELLING</strong></td>
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<td></td>
<td></td>
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<tr>
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<td>.304</td>
<td>.048, .153, .302</td>
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<td>Age</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>School</td>
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<td>Grade</td>
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<td></td>
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<tr>
<td>Block 2. Tests - Stepwise</td>
<td>Word Rhyme</td>
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<td>.212</td>
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<td>.511</td>
<td>.023</td>
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<td>.170</td>
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<td></td>
</tr>
<tr>
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<td>.212</td>
<td>&lt;0.001</td>
<td>.043</td>
<td>-.043, -.150, .336</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 2. Tests - Stepwise</td>
<td>NW Rhyme</td>
<td>.334</td>
<td>.314</td>
<td>.103</td>
<td>&lt;0.001</td>
<td>.201</td>
</tr>
<tr>
<td></td>
<td>Backward Digit Span</td>
<td>.381</td>
<td>.358</td>
<td>.047</td>
<td>&lt;0.001</td>
<td>.210</td>
</tr>
<tr>
<td></td>
<td>Word Rhyme</td>
<td>.408</td>
<td>.383</td>
<td>.027</td>
<td>&lt;0.001</td>
<td>.199</td>
</tr>
</tbody>
</table>

NW=Non-Word.
Therefore, from the results of the regression analyses that were performed on the scores of the reading and spelling tasks, the best predictor was either one of the rhyme measures (word or non-word). For a skill that involved decoding a known string of graphemes into phonemes, or for a skill that involved decoding novel strings of phonemes into graphemes, the non-word rhyme measure was perceived, in each of those skills, to act as a good predictor; along side secondary predictors such as word rhyme and backward digit span. Also, for the former skill, block design appeared additionally to act as a secondary predictor for it.

On the other hand, for a skill that involved decoding a novel string of graphemes into phonemes, or for a skill that involved decoding known strings of phonemes into graphemes, word rhyme measure was perceived in each of those skills, to act as a good predictor; along side secondary predictors such as non-word rhyme. Also, for the former skill, block design and picture arrangement appeared additionally to act as secondary predictors; whilst for the latter skill, backward digit span appeared as well to act as a secondary predictor.

Finally, it must be noted that the results of the regression analyses reported above on the different literacy measures supported the findings of the correlation analysis (see Table 6.4.2).

**Discussion**

The present study addressed the nature of the Bahraini children’s Arabic literacy skills by considering two issues. The first concern was whether the phonological awareness measures were better predictors of the acquisition of early Arabic literacy levels than the other predictors. The second concern was whether the underlying cognitive processes that have been argued to predict literacy learning in transparent orthographies are also predictive of the acquisition of Arabic literacy.
In this discussion, phonological processing refers to the processing associated with the sound system of a language, and phonological awareness is considered as only one aspect of the whole array of phonological processing involved in language related tasks. The literature reviewed in chapter 4 suggests that phonological processing plays a part in rapid naming, verbal short-term memory, as well as phoneme and rhyme related measures. However, phonological awareness is typically seen as measured by assessing the individual’s ability to recognize sounds within words and, consistent with previous research, is measured by rhyme and phoneme tasks in this study (Bradley & Brayant, 1983; Catts, Wilcox, Wood-Jackson, Larrivee, & Scott, 1997).

Therefore, with regards to the first concern, based on the evidence in the literature, it was expected that the phonological awareness measures would be a good predictor of early Arabic literacy acquisition. This expectation was confirmed. The regression analyses for the whole cohort (Table 6.5) indicated that for each of the reading (word and non-word) and spelling (word and non-word) measures, the phonological awareness tasks accounted for more variability in the early Arabic literacy scores than any other predictor measure. Such findings for an association between phonological awareness skills and literacy are consistent with those of Abu Rabia, Share, and Mansour (2003) on the Arabic language.

However, Arabic in the early years of schooling is introduced to children in its vowelized form. This suggests that the current findings should be considered as relevant to Arabic as a transparent orthography. Studies of other languages with transparent and less transparent orthographies have also identified relationships between phonological processing and literacy (e.g. Wimmer, Landerl & Schneider, 1994, on the German language; Jimenez-Gonzalez & Juan, 1997, on the Spanish language; Lukatela & Turvey, 1995, on the Serbo-Croatian language; de Jong & van der Leij, 1999, and Patel, Snowling & de Jong, 2004, on the Dutch language; Bentin & Leshem 1993, and Kozminsky & Kozminsky 1993/94, on the Hebrew language; Sprenger-Charolles, Siegel, & Bechennec, 1997, on the French language; Giannouli & Harris, 1997, on the Greek language; and Bradley & Bryant, 1985; and Lundberg, Frost, & Petersen, 1988 on the English
language). However, in some transparent alphabetical languages, such as the German language, the duration of the effect of phonological awareness processing as a predictor of literacy appears to be somewhat time limited. It has been argued that the orthography of the German language with its one to one correspondence between its graphemes and phonemes has enabled the German children to grasp phonological awareness at an earlier stage of the reading development than children from less transparent orthographies, such as the English language (Wimmer & Goswami, 1994; Frith, Wimmer, & Landerl, 1998). Thus, within a few months of instruction at school entry, it has been shown that German children’s reading reflected no indications of problems in phonological awareness sensitivity, in which their performance was almost accurate on non-word measures of reading and spelling. Rather than phonological awareness, other domains of phonological processing such as phonological memory and rapid automatized naming (RAN) were found better associated with German literacy acquisition (Wimmer, 1993; Wimmer, Mayringer, & Landerl, 1998). Accordingly, despite the fact that both the vowelized Arabic language and the German language are orthographically transparent, they do not appear to display similar patterns of phonological awareness processing involvement in the process of literacy development. Specifically, German children by the end of grade one with their almost accurate reading and spelling of non-words (Wimmer, Mayringer, & Landerl, 1998), appear by the end of grade one to reach an asymptote with regards to phonological awareness involvement in literacy; whereas in the data reported in the present thesis on vowelized Arabic, phonological awareness continued to vary across children and was found to be a predictor of Arabic literacy for children up to grade three. Altogether, it could hence be argued that although phonological awareness is perceived as a predictor of literacy, its duration (potency) as a predictor varies across languages even within those languages of a similar orthographical transparency level.

A further interesting, but potentially divergent finding from those predicted by the literature in this study is that although two types of phonological awareness measures (rhyme and phoneme) were used, only the rhyme measure appeared as a significant predictor of early Arabic literacy. This seems inconsistent with those theories that argue
for phoneme tasks to be better predictors of English literacy than rhyme tasks (Muter et al., 1998; Simpson & Everatt, 2005), but more consistent with those models that propose the rime (or syllable) as a basis on which early literacy may develop (Goswami, 2000). However, these latter models also argue for different effects based on the regularity of the script, with more transparent scripts providing the basis to progress to phoneme-level representations of language faster than less transparent scripts. In the case of Arabic, therefore, it would seem likely that children should have progressed to phoneme-level representations over the age ranges tested in this study, which would argue for better literacy skills being related to better phoneme awareness.

Moreover, in the phoneme measure of the present study, the child in each trial was required to listen to two sounds: the first was the sound of a word/non-word lacking its last phoneme, and the second was the sound of the last phoneme of the same word/non-word that was used in the trial. The child was then required to attempt to produce the whole word/non-word. Therefore, proper pronunciation of the word/non-word in the phoneme task entailed the child having an understanding how to manipulate sound units. On the other hand, in the rhyme measure the child was required to listen to three strings of words/non-words and reproduce the word/non-word which did not rhyme with the other two items in the string. Scrutinizing the two types of phonological awareness measures, it could be seen that each measure tapped different levels of phonological awareness processing. The level that tapped the rhyme task appears to be similar to what has been defined as implicit phonological awareness, requiring the ability to be aware of sounds at the level of the syllable or sub-syllable (Harris & Giannouli, 1999). Whereas, the level of phonological awareness processing that tapped the phoneme task in the current study appears to involve explicit phonological awareness, which has been defined as involving the ability to identify and manipulate sound units at the level of the phoneme (Harris & Giannouli, 1999). The current data is consistent with grades 1, 2, and 3 children developing awareness at the level of implicit phonological awareness (i.e. the rhyme/syllable) but awareness at the explicit phonological awareness (i.e. the phoneme level) has been less influential. On the other hand, although the Bahraini early Arabic
literacy measures were mostly predicted by tasks that involved implicit phonological awareness as opposed to explicit phonological awareness; with the vowelized Arabic language being considered as a regular orthography, such a finding appears at opposition to Harris & Giannouli (1999) conclusion, where they “argued that implicit phonological awareness appeared to be a predictor of early reading success for irregular but not regular orthographies” (p. 67).

In addition to phonological awareness, other underlying cognitive processes were found to play a role in the early acquisition of Arabic literacy. In particular, block design was found to be a predictor of reading and backward digit span a predictor of spelling. These effects may reflect the different cognitive processes operating in these different literacy tasks. It may be that for reading Arabic, precise visual-spatial processing is required to differentiate orthographic symbols that require a recognition of the spatial relationships between lines and dots, together with a realization that a letter will change shape depending on the letters around it due to the cursive nature of the script. In spelling, the ability to store sounds in short-term memory, and manipulate sequential events, may be important due to the complex morphemic structure of the Arabic language that may advantage the stripping of multi-morphemic words down to their root and using morphemic patterns to support accurate spelling. These findings appear to support other studies on the Arabic and Hebrew languages in which cognitive processes such as visual processing and working memory have been stressed to be important in literacy acquisition in languages of Semitic origin (Abu Rabia, Share, & Mansour, 2003; alMannai & Everatt, 2005; Meyler & Breznitz, 1998; Share & Levin, 1999); and not in others such as the English language (Ellis & Large, 1987; 1988), which has a different morphological configuration to that of Semitic languages. Such potential effects are worthy of future research.

There are many studies that have provided support for rapid naming being predictive of literacy development in transparent orthographies such as Greek, Spanish, Italian, German, Dutch, and Arabic (Nikolopoulos, Goulandris, Hulme, & Snowling, in press;
Guardia, 2003; Di Filippo, Brizzolara, Chilosi, De Luca, Judica Pecini, Spinelli, & Zoccolotti, 2005; Wimmer, 1993; Landerl & Wimmer, 2000; Aarnoutse, van Leeuwe, & Verhoeven, 2005; de-Jong & Vrielink, 2004; van den Bos, Zijlsra, & van den Broeck, 2003; van den Bos, Zijlsra, & Spelberg, 2002; Saiegh-Haddad, 2005), as well as in less transparent orthographies (for reviews see, Bowers & Ishaik, 2003; Semrud-Clikerman, Guy, Griffin, & Hynd, 2000; Wolf, Bowers, Biddle, 2000). However, rapid naming was less predictive of literacy in the present study. Consideration of the correlations between the different literacy measures and rapid naming for each of the three grades separately (Table 6.4.3) suggests that only in the first grade was rapid naming significantly associated with the different literacy measures. This argues for rapid naming being a potential predictor of Arabic literacy in the very early stages of development (see also al-Mannai & Everratt, 2005). In addition, it has sometimes been found that non-alphanumeric rapid naming measures appeared associated with the reading level of young beginning readers (Simpson & Everatt, 2005; Wolf, Bally, & Morris, 1986), whereas alphanumeric rapid naming measures have sometimes been found to be associated with reading only in older readers (van den Bos, et al., 2002; Wolf, Bally, & Morris, 1986). It may be that the use of alphanumeric items in the rapid naming task increases the relationship with literacy for grade 2 and 3 children in the present study.

A final point to note was that, overall, spelling appeared to be an easier task to perform than reading. It was found that although grade one children had been newly introduced to literacy, they had not showed any floor effects for single word spelling, whereas floor effects were found in the reading of words (see Table 6.2). In turn, this appears to suggest that at least within the Arabic sample studied, the decoding from phoneme to grapheme may have been easier to perform than the decoding from grapheme to phoneme. Although such an observation is speculative (since the reading and spelling tasks may have varied in level of difficulty for the cohort), it is an issue that perhaps should be attended to in future analyses on literacy research, particularly given the different secondary predictors found for reading and spelling. Such a speculation may be consistent with the fact that Arabic reading, with its text containing some letters from
which their sounds are discriminated on the bases of the number of dots and their position above or below the letters as well as having short vowels placed either above and/or below the letters, incurs heavy demands on visual spatial processing (Abu Rabia, 2001); whereas in spelling, theoretically, there may be less demand on visuo-spatial processing abilities. One prediction that this leads to is the possibility of reading text without short vowel markers being easier than when vowel markers are included, despite this leading to a much more opaque orthography.

In conclusion, the cross-sectional study on the predictors of early Arabic literacy of the Bahraini school children at T1 has provided support for phonological awareness processing as being the main predictor of reading as well as spelling in the early years of Arabic literacy learning, although awareness at the level of the rhyme seems more predictive than that at the phoneme level of representation. In addition, visuo-spatial processing and working memory were also found to be predictive of early Arabic literacy, whereas speed of processing measures (i.e., rapid naming) seem more likely predictive of very early literacy level.
CHAPTER 7

Results on the Bahraini Sample at Time Two: Cross-Sectional Followed by Longitudinal Analyses
Chapter 7

Results on the Bahraini Sample at Time Two:
A Cross-Sectional Analysis Followed by a Longitudinal One

Introduction
The current study was carried out on Bahraini school children of both sexes during the year 2004 (T2). The aim was to follow up students from the previous year and repeat a subset of the measures of the previous year in order to find out whether variables at T1 can predict literacy skills at T2. However, before reporting the results of this research, a cross-sectional overview will be given on the results of the study carried out at time 2.

Research Questions and Hypotheses
The longitudinal study continued to test the hypotheses addressed in the study at T1. In addition, this study wanted to find out what the gains of the literacy in Arabic would be like one year after initial testing. Of particular interest was the question of whether the same cognitive factors that predicted literacy development at T1 would predict Arabic literacy at T2.

The analyses in the following research were similar to those carried out on the data at T1 of the study. This involved descriptive analyses of all measures used at T2, followed by the calculation of correlation coefficients to determine the level of relationship between the measures used at T2. The correlation analyses were conducted initially on the whole cohort at T2 and then each of grades 2 and 3 separately. Lastly, a series of regression analyses were performed on the data, following a similar procedure to that used in the previous chapter and controlling for the age, sex, school, and grade of the children in the data set. Initial regression analyses entailed finding concurrent predictors of early Arabic literacy at T2. Subsequent analyses focused on predictors of early Arabic literacy from measurement scores obtained one year earlier, at T1 of the study.
Briefly, the size of the sample at T2 of the study comprised 116 students from the original 171 Bahraini school children that were examined at T1 of the study. These 116 students were in grades 1 and 2 at T1 (ie, the previous year of testing) and were re-tested at T2, one year later when they had moved up a grade. Table 7.1 provides details of the size of the sample by sex and grade.

Table 7.1 – Size of the Bahraini sample at time two (T2) by sex and grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td>34</td>
<td>28</td>
<td>62</td>
</tr>
<tr>
<td>Three</td>
<td>20</td>
<td>34</td>
<td>54</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>62</td>
<td>116</td>
</tr>
</tbody>
</table>

With regards to the measures, fewer tests were used in the research at T2 than at T1 of the study. Out of the original seventeen measures used, only fourteen measures were re-administered at T2 of the study. As in the study at T1, children’s Arabic literacy skills were assessed using four measures: single word reading, single non-word reading, single word spelling, and single non-word spelling. The remaining ten measures used in the study at T2 were: add phoneme tasks for words and non-words; odd sound out tasks for words and non-words; forward and backward digit span tasks; a temporal ordering task; rapid naming; a stroop test; and block design. The three measures that were taken out of the study at T2 were the coding, the picture arrangement, and picture completion tasks. This reduction in tasks was undertaken to avoid over-testing the children in the study. Therefore, rather than using three measures of visuo-spatial ability, only the Block Design measure was used at T2, since this was the measure most likely to be predictive of literacy levels based on the analyses at T1. The coding task was removed due to the
difficulties reported at T1 related to the standardized scores of the task, which were necessary because the coding task involved administering different test-form for different age groups. Basically, data from T1 suggested that the standardization of the Bahraini version of WISC may be questionable (see also discussions in Elbeheri, Everatt, Reid & alMannai, 2006). For this purpose raw scores were used in the analysis of the results obtained at T1, and will continue to be used in the analyses conducted in this chapter.

Results

Description of the Arabic literacy Skills amongst Bahraini School Children at T2
Table 7.2 presents the means and standard deviations on words and non-words for reading and spelling in Arabic across grades two and three of four primary schools in Bahrain at T2. Overall, as it can be seen that the means and standard deviations of the literacy measures increased from grade two to grade three, reflecting improvement in performance and variation in scores. Moreover, the means on the spelling measures of both word and non-word appeared slightly higher than means on the reading measures for both word and non-word respectively across both grades.

Description of the Independent Variables amongst Bahraini School Children at T2
Table 7.3 presents the means, standard deviations, minimum and maximum scores, and the number of cases on the phoneme measures (word and non-word add phoneme), rhyme measures (word and non-word odd sound out), digit span (forward, backward, and together forward and backward), temporal order, rapid naming, word interference, and block design in Arabic across grades two and three of four primary schools in Bahrain at T2.

Means scores for all the variables (with the exception of rapid naming and word interference) increased from grades 2 to 3. For rapid naming and word interference, the means decreased across the two grades. Overall, these results provide an indication of an improvement in performance for children moving up from grade 2 to 3.
Table 7.2 – Mean, standard deviations, minimum and maximum scores by grade of the Arabic literacy (reading and spelling) measures at T2, with the results of one-way analyses of variance assessing the effects of grade. (bolding is used to indicate significant effects between grades at the 0.05 level).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Single Word Reading</th>
<th>Single Non-Word Reading</th>
<th>Single Word Spelling</th>
<th>Single Non-Word Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>12.27</td>
<td>2.29</td>
<td>15.98</td>
<td>2.84</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>9.75</td>
<td>2.05</td>
<td>9.53</td>
<td>2.41</td>
</tr>
<tr>
<td>Min.</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Max.</td>
<td>36.00</td>
<td>7.00</td>
<td>33.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>17.28</td>
<td>3.06</td>
<td>19.52</td>
<td>3.96</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>10.93</td>
<td>2.40</td>
<td>10.21</td>
<td>2.68</td>
</tr>
<tr>
<td>Min.</td>
<td>1.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Max.</td>
<td>36.00</td>
<td>8.00</td>
<td>34.00</td>
<td>9.00</td>
</tr>
<tr>
<td>ANOVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>6.79</td>
<td>3.43</td>
<td>3.72</td>
<td>5.67</td>
</tr>
<tr>
<td>Df</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
</tr>
<tr>
<td>P</td>
<td>.010</td>
<td>.067</td>
<td>.056</td>
<td>.019</td>
</tr>
</tbody>
</table>

Developmental Patterns in Learning to Read and Write in Arabic at T2

One-way analyses of variance (ANOVA) were performed on the literacy measures in order to assess whether at T2 the grade three children’s Arabic literacy scores were different from those of the grade two children (these analyses can be found in Table 7.2). Significant between grades effects were found for single word reading and for single non-word spelling which suggests that at T2, the grade three children’s performance on those literacy measures were significantly better than the performance’s of the grade two children. For single word spelling and single non-word reading, despite the fact that the mean scores were in the direction of the grade three children being better than the grade two children at T2, the results of the one-way analysis of variance on those literacy measures were just non-significant.
Table 7.3 – Means, standard deviations, and minimum and maximum scores, together with the number of cases, by grade for the independent variables at T2, and the results of one-way analyses of variance investigating the effects of grade. (Anova results in bold are significant at the 0.05 level).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Two</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>18.00</td>
<td>13.37</td>
<td>8.06</td>
<td>4.56</td>
<td>6.10</td>
<td>2.97</td>
<td>9.06</td>
</tr>
<tr>
<td>N</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>5.38</td>
<td>6.44</td>
<td>2.49</td>
<td>2.19</td>
<td>1.38</td>
<td>1.10</td>
<td>1.75</td>
</tr>
<tr>
<td>Min.</td>
<td>2.00</td>
<td>0.00</td>
<td>4.00</td>
<td>0.00</td>
<td>3.00</td>
<td>0.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Max.</td>
<td>26.00</td>
<td>25.00</td>
<td>14.00</td>
<td>12.00</td>
<td>10.00</td>
<td>5.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>20.61</td>
<td>15.24</td>
<td>9.35</td>
<td>5.24</td>
<td>6.26</td>
<td>3.41</td>
<td>9.67</td>
</tr>
<tr>
<td>N</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>4.53</td>
<td>6.10</td>
<td>3.42</td>
<td>2.83</td>
<td>1.18</td>
<td>1.22</td>
<td>1.81</td>
</tr>
<tr>
<td>Min.</td>
<td>2.00</td>
<td>0.00</td>
<td>3.00</td>
<td>1.00</td>
<td>4.00</td>
<td>2.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Max.</td>
<td>28.00</td>
<td>26.00</td>
<td>19.00</td>
<td>14.00</td>
<td>9.00</td>
<td>8.00</td>
<td>17.00</td>
</tr>
<tr>
<td>ANOVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>7.86</td>
<td>2.56</td>
<td>5.46</td>
<td>2.10</td>
<td>.46</td>
<td>4.16</td>
<td>3.30</td>
</tr>
<tr>
<td>Df</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
</tr>
<tr>
<td>P</td>
<td>.006</td>
<td>.113</td>
<td>.021</td>
<td>.150</td>
<td>.500</td>
<td>.044</td>
<td>.072</td>
</tr>
</tbody>
</table>
Table 7.3 continued – Means, standard deviations, and minimum and maximum scores, together with the number of cases, by grade for the independent variables at T2, and the results of one-way analyses of variance investigating the effects of grade. (Anova results in bold are significant at the 0.05 level).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Temporal Order</th>
<th>Rapid Naming (Color Blocks)</th>
<th>Stroop Word Interference</th>
<th>Block Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.00</td>
<td>44.85</td>
<td>51.89</td>
<td>10.44</td>
</tr>
<tr>
<td>N</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>1.28</td>
<td>16.37</td>
<td>16.29</td>
<td>7.12</td>
</tr>
<tr>
<td>Min.</td>
<td>5.00</td>
<td>27.44</td>
<td>23.83</td>
<td>0.00</td>
</tr>
<tr>
<td>Max.</td>
<td>10.00</td>
<td>138.20</td>
<td>88.07</td>
<td>30.00</td>
</tr>
<tr>
<td>Three</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>8.30</td>
<td>37.00</td>
<td>46.61</td>
<td>17.80</td>
</tr>
<tr>
<td>N</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>1.71</td>
<td>7.94</td>
<td>18.13</td>
<td>9.22</td>
</tr>
<tr>
<td>Min.</td>
<td>4.00</td>
<td>25.05</td>
<td>21.46</td>
<td>4.00</td>
</tr>
<tr>
<td>Max.</td>
<td>12.00</td>
<td>67.28</td>
<td>99.24</td>
<td>39</td>
</tr>
<tr>
<td>ANOVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>1.13</td>
<td>10.29</td>
<td>2.73</td>
<td>23.47</td>
</tr>
<tr>
<td>Df</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
<td>1 and 114</td>
</tr>
<tr>
<td>P</td>
<td>.290</td>
<td>.002</td>
<td>.101</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Similar one-way analyses of variances were performed on the remaining measures (see Table 7.3). Five of the measures (word phoneme, word rhyme, backward digit span, rapid naming, and block design) showed significant effects of grade; reflecting differences in performance at T2 between second and third grades. The remaining measures (non-word for rhyme and phoneme, forward digit span, forward and backward digit span, temporal order, and Stroop word interference) at T2 did not show significant effects across grades, despite the fact that the mean scores on these latter measures reflected better performances of children in the third compared to the second grade.

**Association Strengths between Arabic literacy Measures and Potential Predictors**

Table 7.4.1 presents the results of calculations of Pearson correlation coefficients, carried out amongst the T2 literacy measures of single word reading, single non-word reading, single word spelling, and single non-word spelling. These indicate that all the literacy measures were positively, strongly, and significantly associated with each other at the 0.01 level in a two-tailed test.

<table>
<thead>
<tr>
<th>Potential Predictors</th>
<th>Whole Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word Reading</td>
</tr>
<tr>
<td>Word Reading</td>
<td>.822**</td>
</tr>
<tr>
<td>Non-Word Reading</td>
<td>.822**</td>
</tr>
<tr>
<td>Word Spelling</td>
<td>.777**</td>
</tr>
<tr>
<td>Non-Word Spelling</td>
<td>.708**</td>
</tr>
</tbody>
</table>

** correlations significant at the 0.01 level (2-tailed), NW= Non-Word.

Table 7.4.2 presents the results of calculations of Pearson correlation coefficients indicating the degree of association between the Arabic literacy measures (word reading, non-word reading, word spelling, and non-word spelling) and each of the potential predictor measures used in the study at T2 (word phoneme, non-word phoneme, word rhyme, non-word rhyme, forward digit span, backward digit span, forward and backward
digit span, temporal order, rapid naming, Stroop word interference, and block design), for
the whole cohort. These calculations indicate that, apart from forward digit span and the
temporal order measure, the predictor variables were significantly associated with each of
the reading and spelling measures; mostly at the 0.01 level in a two-tailed test. In the
majority of cases, these correlations were positive (higher scores related to better
literacy), but in the cases of the rapid naming and interference measures, the relationships
were negative, suggesting better reading and spelling scores were associated with faster
naming times and less interference.

With regards to the phonological awareness predictors (word phoneme, non-word
phoneme, word rhyme, non-word rhyme) at T2, all showed positive and significant
associations with each of the literacy measures. These correlations were, in the main,
larger than those between the literacy measures and any of the other potential predictor
variables, with the only other correlation reaching the value of \( r = 0.4 \) or more being that
between the Block Design measure and the Non-word reading measure.

Table 7.4.2 – *Pearson correlations between Arabic literacy measures (word reading,
non-word reading, word spelling and non-word spelling) and each of the potential
predictor measures used in the study at T2.*

<table>
<thead>
<tr>
<th>Potential Predictors</th>
<th>Whole Cohort</th>
<th>Word Reading</th>
<th>NW Reading</th>
<th>Word Spelling</th>
<th>NW Spelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoneme-Word Add</td>
<td>.439**</td>
<td>.385**</td>
<td>.502**</td>
<td>.460**</td>
<td></td>
</tr>
<tr>
<td>Phoneme-NW Add</td>
<td>.462**</td>
<td>.428**</td>
<td>.533**</td>
<td>.476**</td>
<td></td>
</tr>
<tr>
<td>Rhyme-Word Odd Sound</td>
<td>.499**</td>
<td>.373**</td>
<td>.474**</td>
<td>.527**</td>
<td></td>
</tr>
<tr>
<td>Rhyme-NW Odd Sound</td>
<td>.568**</td>
<td>.511**</td>
<td>.510**</td>
<td>.476**</td>
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<td>-.209*</td>
<td>-.341**</td>
<td>-.348**</td>
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<tr>
<td>Stroop Word Interference</td>
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<td>-.270**</td>
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<td>.312**</td>
<td>.433**</td>
<td>.355**</td>
<td>.335**</td>
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</tbody>
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*Correlations significant at the 0.05 level (2-tailed), ** correlations significant at the 0.01 level (2-tailed).
NW = Non-Word, (F & B) = Forwards and Backwards.
Pearson correlations coefficients were also calculated between the literacy measures (word reading, non-word reading, word spelling, and non-word spelling) and each of the potential predictor measures (word phoneme, non-word phoneme, word rhyme, non-word rhyme, forward digit span, backward digit span, forward and backward digit span, temporal order, rapid naming, Stroop word interference, and block design) used in the study at T2, for each of the two grades separately. The results of these calculations can be found in Table 7.4.3, which suggests that for both grade 2 and 3 data, correlations between literacy and phonological awareness were mainly significant and all were positive. The only association amongst the phonological measures that had not reached significance was that between word rhyme and non-word reading in grade two.

In contrast, associations between literacy scores and the other potential predictor measures were less consistently significant across grades. In grade two, significant associations were found amongst rapid naming, forward and backward digit span, backward digit span, forward digit span, and block design, with some of those measures showing more significant associations with the different literacy measures than others. Rapid naming, and forward and backward digit span were found to be significantly associated with all the literacy measures, whereas backward digit span, forward digit span, and block design were found associated with only some of the literacy measures. On the other hand, in grade three significant associations were found amongst block design, Stroop word interference, temporal order, and backward digit span, with block design and Stroop word interference being significantly associated with all the literacy measures, but temporal order and backward digit span being associated with only one of the literacy measures (non-word spelling).

Overall, the phonological awareness measures appeared to reflect stronger significant relationship with the different literacy measures than the other measures across both grades two and three.
Table 7.4.3 – Pearson correlations between Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) and each of the potential predictor measures used in the study at T2, for each of the grades two and three.

<table>
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<tr>
<th>Potential Predictors</th>
<th>Grade 2</th>
<th>Grade 3</th>
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<td>NW Reading</td>
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<td>Phoneme-NW Add</td>
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<td>.452**</td>
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<td>Rhyme-Word Odd Sound</td>
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<td>Rhyme-NW Odd Sound</td>
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<td>.574**</td>
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<td>Block Design</td>
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</table>

*correlations significant at the 0.05 level (2-tailed), ** correlations significant at the 0.01 level (2-tailed), NW= Non-Word, (F & B)= Forwards and Backwards.
Predictors of Arabic Literacy Skills at T2

Stepwise regression analyses were performed for each of the Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) of the Bahraini primary school children from grades two and three at T2, after controlling for sex, age, school, and grade. Results of the analyses were presented in Table 7.5.

The demographic variables accounted for 16% of the variability in word reading; for 7% of the variability in non-word reading; for 12% of the variability in word spelling; and for 10% in non-word spelling. Apart from non-word reading, these were significant at the 0.05 level.

For word reading, non-word rhyme was the best of the predictor variables, explaining about 25% of the variability in test scores. Word phoneme and word rhyme explained a further 6% and 3% of the variability respectively. This analysis suggested that Arabic single word reading was primarily related to measures of phonological awareness, which explained about 34% of variability in scores.

For non-word reading, non-word rhyme was the best predictor of variability overall, explaining about 22% of the variability in test scores. Block design explained a further 9% of the variability, followed by word phoneme, which explained about 3% of the variability. The phonological awareness measures were capable of explaining about 25% of the variability in the non-word reading scores.

For word spelling, non-word phoneme was the best predictor of variability overall, explaining 24% of the variability in test scores. Word rhyme and non-word rhyme explained a further 8% and 3% respectively. The word phoneme measure added a further 3% to the explanation of variability provided by the analysis. Thus, altogether, the phonological awareness measures were capable of explaining about 38% of the variability in the spelling scores; and as with the single word scores, the phonological measures were the only predictors to emerge from the analysis of the single word spelling
<table>
<thead>
<tr>
<th>Variable Entered</th>
<th>Predictor</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>R Square Change</th>
<th>Significant F</th>
<th>Beta Coefficients</th>
<th>Standardized</th>
<th>Final Model</th>
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<td>NW Phoneme</td>
<td>NW Rhyme</td>
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<td>NW Phoneme</td>
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<td>NW Rhyme</td>
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<td>.407</td>
<td>.080</td>
<td>.000</td>
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<td>.028</td>
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</table>

NW=Non-Word.
scores. However, it should be mentioned that the non-word phoneme measure was removed as a predictor in the final model of the regression analysis.

For non-word spelling, word rhyme was the best predictor of variability overall, explaining about 26% of the variability in test scores. This was followed by word phoneme and non-word rhyme, which explained respectively a further 7% and 3% of the variability in the non-word spelling scores. Again, the phonological awareness measures were the only predictors to emerge from the analysis of the single non-word spelling scores, explaining in all a total of 36% of the variability in the Bahraini children’s non-word spelling.

Therefore, from the results of the regression analyses that were performed on the scores of the reading and spelling tasks, the phonological awareness measures were found to be the primary predictors of literacy in this study. The only non-phonological predictor was block design which was found to explain a portion of the variability in the non-word reading scores. In particular, non-word rhyme was found to be a primary predictor and word phoneme as a secondary predictor in both the word and non-word reading measures.

The results suggest that being able to process an unfamiliar string of phonemes, as well as to be aware of how familiar sound units are combined, are skills that are related to better levels of novel or known letter string decoding and pronunciation. In addition, some level of visual spatial ability appears to be involved in the decoding of novel strings of graphemes into phonemes. For word spelling, the non-word phoneme task appeared as the main predictor, implicating the importance of being able to combine unfamiliar sound units in a pattern that would follow the structure of the sound system of the language concerned in a skill that entails decoding known strings of phonemes into graphemes. Whereas, for non-word spelling, word rhyme was found to be the major predictor of its scores; in turn associating the ability of discriminating familiar strings of phonemes with the ability of decoding novel strings of phonemes into graphemes.
Finally, it must be noted that the results of the regression analyses reported above on the different literacy measures supported the findings of the correlation analysis (see Table 7.4.2 and Table 7.4.3).

Predictors of Arabic Literacy Skills at T2 from Independent Variables at T1
Stepwise regression analyses were performed on each of the Arabic literacy measures (word reading, non-word reading, word spelling and non-word spelling) of the Bahraini primary school children from grades 2 and 3 at T2, with the non-literacy measures (word phoneme, non-word phoneme, word rhyme, non-word rhyme, forward digit span, backward digit span, forward and backward digit span, temporal order, rapid naming, word interference measure, and block design) of the same children tested one year earlier at T1, when they were in grades 1 and 2 respectively, acting as independent variables after controlling for sex, age, school, and grade. Results of the analyses were presented in Table 7.6.

The demographic variables accounted for 16% of the variability in word reading; for 7% of the variability in non-word reading; for 12% of the variability in word spelling; and for 10% in non-word spelling. Apart from for non-word reading, the analyses involving just these control variables were significant at the 0.05 level.

For word reading, word phoneme was the best predictor of variability overall, explaining 12% of the test scores. Non-word rhyme and temporal order explained a further 5% and 3% of the variability respectively. Overall, 17% of the variability in the Bahraini children’s single word reading scores was predicted from the phonological awareness measures.

For non-word reading, block design was the best predictor of variability overall, explaining about 14% of the variability in test scores. Non-word phoneme accounted for a further 6% of the variability in the single non-word reading scores.
Table 7.6 – Regression Analyses performed on each of the Arabic literacy measures at T2, with the non-literacy measures at T1 acting as the independent variables.

<table>
<thead>
<tr>
<th>Variable Entered</th>
<th>Predictor</th>
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<th>R Square Change</th>
<th>Significant F Change</th>
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<td>.357</td>
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<td>.000</td>
<td>.211</td>
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</table>

NW=Non-Word.
For word spelling, word rhyme was the best predictor of variability overall, explaining 15% of the variability in test scores. Temporal order and word phoneme explained a further 5% and 3% of the variability in the spelling scores, respectively. Thus, altogether, the phonological awareness measures were capable of explaining about 18% of the variability in the single word spelling scores.

For non-word spelling, word rhyme was the best predictor of variability overall, explaining about 20% of the variability in test scores. This was followed by temporal order and backward digit span, which explained a further 4% and 3% of the variability in the non-word spelling scores. In addition, 3% more of the variability in the test scores was explained by the addition of the non-word phoneme scores. The phonological awareness measures accounted for about 23% of the variability in the Bahraini children’s performance on the single non-word spelling test.

Overall, with the exception of the non-word reading measure, these longitudinal regression analyses confirmed the cross-sectional data in identifying phonological awareness measures as the main predictors of literacy used in this study. The phonological awareness measures were also found to play a role in non-word reading, though not as the main predictor.

These results may be consistent with the skills required to perform the literacy measures. For reading, which entailed the decoding of strings of graphemes into phonemes, a phonological task that relied on the ability to assemble sound units together was found to be given higher weight than one that relied on sound discrimination ability. Whereas, in spelling, which involved the decoding of strings of sound units into graphemes, an opposite pattern emerged such that more weight was given to a phonological task that relied on sound discrimination as opposed to one that focused on sound assembly.

Finally, with regards to the other predictor measures, only three (temporal order, block design, and backward digit span) were entered into the regression analyses of early
Arabic literacy. The temporal order measure was entered into the analyses of three out of
the four different literacy measures, whereas block design and backward digit span
appeared as predictors only in the non-word reading and non-word spelling analyses
respectively.

Discussion
The present study at T2 investigated the nature of the Bahraini children’s Arabic literacy
skills from a cross-sectional perspective and a longitudinal one. As at T1, the study
assessed whether the phonological awareness measures were relatively stronger
predictors of Arabic literacy than the other potential predictor variables, and whether the
initial acquisition of Arabic literacy was predicted by similar underlying cognitive
processes as those which have been proposed as predictors of literacy acquisition in other
transparent orthographies.

From a cross-sectional perspective, the first concern was confirmed. The phonological
awareness measures were found to be the main predictors of variability in the children’s
performance on each of the four literacy tasks (word reading, non-word reading, word
spelling, and non-word spelling). In fact, all the predictors identified in the stepwise
procedures involving word reading, word spelling and non-word spelling were
phonological awareness measures. Only in non-word reading acquisition was another
predictor (block design) included in the regression equation. These findings argue for
phonological awareness to be related to higher levels of Arabic literacy in second and
third grade Bahraini school children.

The longitudinal data were used to assess whether early phonological awareness skills
were predictive of Arabic literacy acquisition one year later. The analyses of these data
confirmed the conclusions of cross-sectional data. With the exception of non-word
reading, each of the remaining literacy measures at T2, were mainly predicted by
phonological awareness measured at T1. Overall, these findings suggest that the reading
and spelling levels of grades 2 and 3 Bahraini school children could be predicted, to a certain extent, one year earlier from their phonological awareness skills.

Therefore, whether considered from a cross-sectional perspective or a longitudinal one, the evidence is consistent with the view that an awareness of sounds within words (phonological awareness) contributes to, or supports, the acquisition of early Arabic literacy. This conclusion supports that derived from the cross-sectional analyses of T1 data; although the findings at T1 and T2 were not identical. At T1, the rhyme measures were the main predictors of literacy, whereas the T2 analyses revealed the non-word phoneme measure as the primary predictor (following the entry of control variables) of spelling. Similarly, phoneme awareness measures were more likely to be identified as a predictor by the T2 regression analyses than the corresponding analyses at T1. One possible explanation returns to a point discussed in the last chapter, which considered the level of phonological representation developing from rime/syllable-based to phoneme-based. Such an observation fits well with the view that explicit phonemic awareness (the ability to identify and manipulate sound units at the phoneme level of analysis) appeared to develop after a child had learned to read (Harris & Giannouli, 1999). As the phoneme measures used in the current study had tapped what has been understood as explicit phonemic awareness, and as it was found to predict literacy only in the studies that had excluded grade one children (cross-sectional study at T2 and longitudinal study at T2), therefore it could be argued that the findings of the current study appear suggestive towards supporting Harris & Giannouli (1999) proposal that explicit phonemic awareness processes seems to emerge after the early stages of learning to read. Moreover, such a finding seems compatible with Goswami’s (1999a) proposal that the development of phoneme-based recognition occurs after instruction in reading had begun, and with Ziegler & Goswami’s (2005) proposal that an awareness of within-word sounds that are larger than the phoneme develops prior to phoneme awareness, regardless of the regularity of the orthography of the language. Furthermore, the finding of both rhyme- and phoneme-based measures predicting literacy amongst second and third grade Bahraini school children, whilst the literacy scores of grade 1 children were predicted
primarily by rhyme measures seems to match Anthony & Lonigan’s (2004) view that sensitivity to the different phonological measures should not be perceived as a ‘sequential progression’ or as ‘temporally discrete’ but as a ‘quasi-parallel’ progression (see p.52, Anthony & Lonigan, 2004), such that younger children are sensitive to larger linguistic units whereas older children are sensitive to both larger and smaller linguistic units producing some overlap in the developmental progression rather than the sensitivity to the different linguistic units being discrete and independent from one age group of cohorts to another. However, further research is necessary here as the findings of the correlational analyses do not seem to support these speculations. Correlations between rhyme tasks and literacy at T2 seem to grow between grades 2 and 3, which is not consistent with the view that rhyme-based tasks are becoming less important. Also, regression analyses performed at T1 which exclude grade 1 children do not show a change in literacy prediction from rhyme to phoneme tasks. At T1, rhyme tasks still remained good predictors of literacy levels across all the grades (as can be seen from Table 6.4.3). And, indeed, rhyme tasks were still a good predictor of Arabic literacy in the T2 analyses. This suggests an alternative interpretation that phonological processing at a unit of sound larger than the phoneme (e.g., rime or syllable based) may be as useful for the acquisition of Arabic literacy as phoneme-based awareness has been argued to be useful for the development of English literacy.

A second difference between the analyses at T1 and T2 was the involvement of the temporal processing tasks as a predictor of future literacy levels. Some level of efficient short-term memory integration and processing of auditory information may be involved in the early stages of the development of Arabic reading and spelling processes, which may also be consistent with involvement of the backward digit span measure as another longitudinal predictor, this time of non-word spelling. These data may be consistent with past findings for short-term memory of verbal material to be related to reading ability (Abu Rabia, 1995; Daneman, Carpenter, & Just, 1982; Jorm, Share, Maclean, & Russell, 1984; Meyler & Breznitz, 1998). On the other hand, it should be noted that although Meyler & Breznitz (1998) found that verbal short-term memory in kindergarten to be
significantly associated with later decoding ability, a visual short-term memory measure was found to be a better longitudinal predictor than the verbal short-term memory measure. Since the current study did not measure visual short-term memory, this is an area that future research on Arabic literacy may consider further. Moreover, the finding of the temporal order measure as a longitudinal predictor of reading and spelling appears consistent with Tallal's (1980) perceptual theory associating the role of auditory perception skill to literacy development (see also Simpson & Everatt, 2005, for data on English literacy).

To conclude, the main finding of this study was that, when compared against the predictor measures included in this study and following the controlling of age, sex, grade and school, the phonological awareness measures were found to be the primary predictors of early Arabic literacy among these Bahraini Arabic speaking school children. The findings argue for the importance of tasks measuring an awareness of within-word sounds larger than the phoneme when attempting to predict Arabic children’s literacy skills, and for the additional involvement of measures of short-term auditory memory and visuo-spatial processing in Arabic literacy learning.
CHAPTER 8

General Discussion and Conclusions
Chapter 8

General Discussion and Conclusions

Introduction
The general discussion chapter’s goals are to provide (i) an overview of the main findings from the cross-sectional studies performed at each of T1 and T2, (ii) an overview of the findings from the long-term study, and (iii) the overall implication reached from both methods of research. This will be followed by a discussion of how the findings related to similar fields of knowledge, in the expectation of gaining a deeper insight into understanding the Arabic literacy process and its relation to orthography. The findings will also be used to present a framework for Arabic literacy predictors, at least as conceived by the findings from the current piece of work, which will form part of a discussion of the practical implementations of the work, particularly in terms of the development of assessment tools relevant to dyslexics and in the field of typical early pedagogical teaching. Finally, the discussion will consider the short-comings experienced in the current research together with recommendations for future research.

Synopsis on Findings
The key finding in the present work was that, whether considered longitudinally or concurrently, phonological awareness appeared as the main predictor of early Arabic reading and early Arabic spelling amongst the Bahraini sample of grades one, two, and three mainstream school children. Phonological awareness was defined by the ability to discriminate and analyze sound stimuli at the level of the phoneme and/or the level of the rhyme. In addition, it appeared that the particular level of phonological awareness that acted as a predictor varied with level of literacy and type of literacy task. More specifically, at the very early stages of Arabic literacy acquisition, rhyme awareness appeared as the main predictor. However, at more advanced literacy levels (in the second and the third grades), phoneme awareness appeared as an Arabic literacy predictor, though mainly in addition to rhyme awareness. Although the performance of children in
the reading and spelling tasks within a particular level of development was predicted by
the same overall phonological awareness levels, the specific tasks (e.g. word rhyme/non-
word rhyme; word phoneme/non-word phoneme) and the amount of variability predicted,
varied somewhat across the different literacy measures (see Tables 8.1a, 8.1b, and 8.1c),
possibly reflecting differences in aspects or levels of phonological awareness processing
that may be involved in the development of a particular literacy skill. For example, in the
longitudinal data, the main phonological awareness predictor of reading was phoneme
awareness, whereas for spelling, rhyme awareness was found to be the primary
phonological awareness predictor (see Table 8.1c). However, despite these variations in
primary predictors across literacy measures, the main finding was that phonological
awareness measures requiring the need to recognize rhymes and phonemes within
verbally presented Arabic words were the main cognitive-based predictors of Arabic
literacy achievement identified in this study. These findings are consistent with the
importance of phonological awareness in the development of literacy.

With regards to the other predictors used in the study, block design, backward digit span
and picture arrangement measures appeared as predictors of early Arabic literacy in the
initial series of regression analyses. These analyses suggest that block design was found
to be associated with reading and backward digit span was found to be associated with
spelling. However, when second and third grade children were the focus of analysis in the
second series of regressions a year later, only block design appeared as a predictor; albeit
uniquely for non-word reading. When literacy levels were predicted by measures taken
one year earlier, temporal order, block design and backward digit span measures were
found to predict Arabic literacy. In these analyses, temporal order and block design were
found to predict variability in Arabic reading, whereas temporal order and backward digit
span were identified as predictors of Arabic spelling (see Table 8.2a and 8.2b).
Table 8.1a - Concurrent Phonological Awareness Predictors of Early Arabic Literacy at T1.

<table>
<thead>
<tr>
<th>Reading Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
<th>Spelling Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>NW Rhyme</td>
<td>12</td>
<td>W</td>
<td>NW Rhyme</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>W Rhyme</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW</td>
<td>W Rhyme</td>
<td>10</td>
<td>NW</td>
<td>NW Rhyme</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>NW Rhyme</td>
<td>3</td>
<td></td>
<td>W Rhyme</td>
<td>3</td>
</tr>
</tbody>
</table>

Adapted from Table 6.5; W = Word; NW = Non-Word

Table 8.1b - Concurrent Phonological Awareness Predictors of a more advanced level of Early Arabic Literacy at T2.

<table>
<thead>
<tr>
<th>Reading Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
<th>Spelling Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>NW Rhyme</td>
<td>25</td>
<td>W</td>
<td>NW Phoneme</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>W Phoneme</td>
<td>6</td>
<td></td>
<td>W Rhyme</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>W Rhyme</td>
<td>3</td>
<td></td>
<td>NW Rhyme</td>
<td>3</td>
</tr>
<tr>
<td>NW</td>
<td>NW Rhyme</td>
<td>22</td>
<td>NW</td>
<td>W Rhyme</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>W Phoneme</td>
<td>3</td>
<td></td>
<td>W Phoneme</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NW Rhyme</td>
<td>3</td>
</tr>
</tbody>
</table>

Adapted from Table 7.5; W = Word; NW = Non-Word; Phoneme predictor in italics; Rhyme predictor in bold

Table 8.1c - Longitudinal Phonological Awareness Predictors of a more advanced level of Early Arabic Literacy at T2.

<table>
<thead>
<tr>
<th>Reading Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
<th>Spelling Measure</th>
<th>Predictor</th>
<th>Predicted Amount (approx. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>W Phoneme</td>
<td>12</td>
<td>W</td>
<td>W Rhyme</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>NW Rhyme</td>
<td>5</td>
<td></td>
<td>W Phoneme</td>
<td>3</td>
</tr>
<tr>
<td>NW</td>
<td>NW Phoneme</td>
<td>6</td>
<td>NW</td>
<td>W Rhyme</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NW Phoneme</td>
<td>3</td>
</tr>
</tbody>
</table>

Adapted from Table 7.6; W = Word; NW = Non-Word; Phoneme predictor in italics; Rhyme predictor in bold
Table 8.2a - The overall resultant pattern of early Arabic reading predictors produced from the regression analyses at different time periods (T1&T2); and via using different approaches.

<table>
<thead>
<tr>
<th></th>
<th>Early Reading (Cross-sectional)</th>
<th>More Advanced Reading (Cross-sectional)</th>
<th>More Advanced Reading (Longitudinal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W NW</td>
<td>W NW</td>
<td>W NW</td>
</tr>
<tr>
<td>Phonological Awareness Predictors</td>
<td>Rhyme (W &amp;/ NW)</td>
<td>X X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Phoneme (W &amp;/ NW)</td>
<td>X X</td>
<td>X</td>
</tr>
<tr>
<td>Other Predictors</td>
<td>Block Design</td>
<td>X X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Temporal Order</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Backward Digit Span</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Picture Arrangement</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

The control predictors (age, grade, and sex) have not been included above; W=Word; NW=Non-Word

Table 8.2b - The overall resultant pattern of early Arabic spelling predictors produced from the regression analyses at different time periods (T1&T2); and via using different approaches.

<table>
<thead>
<tr>
<th></th>
<th>Early Spelling (Cross-sectional)</th>
<th>More Advanced Spelling (Cross-sectional)</th>
<th>More Advanced Spelling (Longitudinal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W NW</td>
<td>W NW</td>
<td>W NW</td>
</tr>
<tr>
<td>Phonological Awareness Predictors</td>
<td>Rhyme (W &amp;/ NW)</td>
<td>X X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Phoneme (W &amp;/ NW)</td>
<td>X X</td>
<td>X</td>
</tr>
<tr>
<td>Other Predictors</td>
<td>Block Design</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Temporal Order</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Backward Digit Span</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Picture Arrangement</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

The control predictors (age, grade, and sex) have not been included above; W=Word; NW=Non-Word
Reconciling Findings of the Study with Theoretical Models of Reading: The Dual Coding Theory and the Dual Route Model

In the introduction chapters to this thesis, a general model of cognition (The Dual Coding Theory; Paivio, 1971) was presented with its more recent version (Sadoski and Paivio, 2004) which includes a general theory of the reading process (see chapter 3 of this thesis). Although such general theories may be useful as a starting point from which to build a theoretical framework for research into Arabic literacy acquisition, the current data highlight the importance of specific phonological awareness processes over general auditory and visual systems in predicting levels of literacy attainment amongst young Arabic learners. Of course, audition and vision are important for processing normal Arabic written words; however, theories that focus on processes related to phonological awareness seem more likely to provide a basis on which to better understand, and predict, the development of Arabic literacy.

A second theoretical model presented in the introduction, again derived from the English language literature, was the Dual Route Model (see Ellis, 1993). This has the advantage of incorporating aspects of phonological processing in its explanations of reading. As with the above model, it too discusses aspects of auditory and visual processing by considering two routes in reading, a ‘reading by ear’ route and a ‘reading by eye’ route. However, as befits a theory of reading, these processes are embedded within current views of reading. The ‘reading by ear’ route is basically a process of converting a written stimulus into a phonological form in order to access meaning via its verbal label. The ‘reading by eye’ route involves recognizing the orthographic form of the written stimulus to provide direct access to meaning. This direct access process would seem to be analogous to processes involved in the accessing of verbal labels, such as in the rapid naming task incorporated in the current study. Phonological awareness measures, on the other hand, seem more likely to incorporate processes that play a part in the conversion of a written stimulus to a phonological form. The data derived from the current Arabic research argue for the latter processes (i.e., those that recognize within-word sounds) as primarily predictive of literacy levels amongst Arabic grade 1 to 3 children. As such,
these children seem more likely to be using phonological processes to support better levels of literacy acquisition, findings that seem more consistent with a single route (from written symbol to phonological form) being used in the literacy acquisition of this cohort.

One major limitation of the original Dual Route Theory was its lack of an explanation of the development or acquisition of literacy and the two hypothesized routes to reading. In models of literacy development (e.g., Frith, 1985), more direct access (‘reading by eye’) processes are considered to be characteristic of older readers/spellers, whereas phonological processes involves in sounding out or decoding words are thought to be primary strategy used by younger readers/spellers. The present Arabic data, suggesting that phonological conversion processes are predictive of early literacy levels, are consistent with the views that grade 1 to 3 Arabic children are still in this earlier, phonological, stage of literacy development and have not yet developed a functioning direct access route to a level where it can differentiate good readers/spellers from those with weaker literacy skills. It may also be the case that orthographies that are relatively regular in their letter-sound correspondences do not require the rapid development of a direct access route to reading. If decoding from letters to sounds is successful in early literacy, then there would seem to be little need to develop an alternative strategy/route for accurate reading, and maybe it is only with increased practice that improvements in efficiency lead to reliable use of direct access processes. Clearly further research over a longer period of development than that incorporated in the present research is necessary to determine the developmental process in Arabic literacy acquisition, but the data reported in this thesis are consistent with the need to revise models of literacy based on skilled English readers, such as the Dual Route Model, to take account of differences in orthographies which may affect strategy use, route formation and developmental stages.

Reconciling Findings of the Study with Dyslexia Research

One of the primary aims of the research reported in this thesis was to inform the development of screening or assessment tools that can be used to identify dyslexia.
Hence, it is appropriate to consider these Arabic findings in relation to current theories of dyslexia. Research in the field of dyslexia has been carried out at different levels of analysis (see chapter 3). For a reconciliation to be meaningful, it is necessary that the level of analysis in both the findings of the present research and those from previous dyslexia work be of a similar level. Consequently, as the findings of the current research are of a psychological nature, the reconciliation will focus on the dyslexia findings at the cognitive-behavioral level.

Several explanations of dyslexia have been proposed that focus on the sort of processes studied in the current Arabic research. Visual deficit theories (e.g., Stein and colleagues) were not the focus of the present work; however, the low level of prediction provided by measures of visual processing that reduced the need to process information in a phonological form (e.g., block design and picture completion) argue against these processes being vital for the development of literacy in Arabic; although the finding that block design predicted variability in some tasks (such as non-word reading) may suggest a role for visual-based processes in Arabic word reading which may be related to the complex orthographic form of Arabic letters (see discussions above). Similarly, arguments for automaticity deficits to be the primary cause of dyslexia (Nicolson & Fawcett, 1990) are inconsistent with the present findings for a lack of relationship between measures of automatic processing (i.e., Stroop interference) and levels of literacy achievement. Finally, although theories that argue for a double deficit leading to different subtypes of dyslexia (see Bowers & Wolf, 1993) are partially supported by the current data, the failure of the rapid naming measure to predict variability in literacy independently of phonological awareness is not consistent with this viewpoint. In the current Arabic data, the evidence argues for phonological awareness to be the primary source of variability in literacy levels rather than a combination of phonological awareness and speed of processing. However, given that these theories were not the primary focus of the current research, further specific assessment is required to determine their value as explanations of Arabic literacy difficulties.
The dominant theories of dyslexia focus on deficits related to phonological processing (see Stanovich, 1988) and, therefore, the current research included measures that assessed this area of cognitive functioning. According to the phonological deficit hypothesis (Stanovich, 1988), the main difficulty that an individual with dyslexia has in acquiring literacy has been argued to lie in their lack of phonological awareness. Such deficits in phonological awareness are seen as making it difficult to learn spelling-sound correspondences which hinders progress in learning to read and spell. Consistent with this position, the current investigation found that the main indicator of variability in early Arabic reading and spelling was phonological awareness. Bahraini children learning Arabic literacy may show a pattern of acquisition consistent with the argument of Stanovich and others (see Snowling, 2000; Stanovich, 1994; see also introduction to this thesis) in which weak phonological awareness skills lead to poor literacy acquisition characteristic of dyslexia. A similar conclusion can be drawn from the results reported by al Mannai & Everatt (2005). Their analyses identified non-word reading as well as phonological awareness as the main predictors of variability in Arabic word reading and spelling, and an interrelationship between an awareness of sounds within words and decoding novel Arabic letter strings.

The conclusion that reading and spelling difficulties may be related to poor phonological processing skills is also consistent with the phonological representation hypothesis (Fowler, 1991; Swan & Goswami, 1997; see introduction section). This theory focuses the area of deficit at the level of the representations of phonological information in memory. This has, in turn, led to a more general developmental theory, the psycholinguistic grain size theory (Ziegler and Goswami, 2005), which has aimed to explain a common underlying phonological deficit across languages/orthographies. This cross-language theory, therefore, provides the main theoretical position on which the current findings can be discussed. The psycholinguistic grain size theory was put forward to explain normal reading acquisition and developmental dyslexia across languages (see chapter 3). According to this theory, the rate of transparency of a language is expected to affect the facilitation of gaining access into the smallest grain size (i.e. phonological
unit), the phoneme, which is needed for accurate reading to occur. Additionally, this will be expected to more likely to occur after formal instruction (see also Ziegler & Goswami, 2006b). With the Arabic language in the early years being introduced in its vowelized form, it would therefore be appropriate to consider the findings of the present research to be gathered from a language that follows a transparent orthography. Therefore, theoretically according to the psycholinguistic grain size theory, the transparency of the vowelized Arabic language would make it a very consistent language with the expectation that children by the end of grade one, to receive an almost perfect score in reading. In turn reflecting the ability of processing phonological information at the phoneme level; prior to which children should have been processing at larger units of analysis (e.g. syllabus; onset and rime). Moreover, theoretically with the experience of having a very consistent mapping of its orthography (grapheme vs. phoneme), readers of vowelized Arabic were expected to be able to progress in their reading at a pace faster than readers from a less consistent orthography such as the English language. However, with closer inspection of the results of the present study, it could be seen that readers across both time periods (T1 and T2) and even at grade three, their word and non-word reading scores had never reached full marks (see Tables 6.2 and 7.2), which was something that was not expected based on the assumption of fast acquisition of a regular orthography, which has formed a part of the arguments of cross-orthography differences in the psycholinguistic grain size theory. Yet rhyme awareness was found to be predictive of the early years of Arabic reading, followed additionally by phoneme awareness with greater reading experience. Hence, although the processing of the Arabic language follows the psycholinguistic grain size assumption of how the learning processes are expected to occur, it did not appear to follow the developmental rate that might be anticipated based on relatively transparent languages such as the German (Frith et. al., 1998), Italian (Cossu, Gugliotta, & Marshall, 1995), Greek (Porpodas, Pantelis, & Hantziou, 1990), and Hebrew (see Share & Levin, 1999) (see also Seymour, Aro, & Erskine, 2003 large-scale study on reading in 14 European languages; and Ziegler & Goswami, 2005). In fact, the vowelized Arabic language appears to follow a pace in learning to read similar to that of the English language, a less transparent orthography.
An interesting point in Ziegler and Goswami (2005) proposal with regards to its compatibility with dyslexia manifestation is that regardless of the consistency of the orthographical structure of the concerned language, phonological awareness problems will somehow be present. All dyslexics would be expected to show deficits because of “reduced phonological sensitivity” (p. 20, Ziegler & Goswami, 2005). This argument seems to contradict studies of transparent orthographies that have found dyslexics to score as high as the chronological age matched controls on some phonological measures (de Jong & van der Leij, 2003; Wimmer, 1996) on which dyslexics from less transparent orthographies have been found to produce low scores relative to both their reading level matched controls and chronological age matched controls (Sprenger-Charolles, Cole, Lacert, & Serniclaes, 2000). However, Ziegler and Goswami (2005) have argued that although “the incidence of developmental dyslexia will be similar across consistent and inconsistent orthographies … its manifestation might differ with orthographic consistency” (p.20, Ziegler & Goswami, 2005). These researchers had noted that searching within the supra-levels of phonological units, particularly in consistent orthographies, would be expected to show areas of deficits amongst developmental dyslexics. Such a proposal supported Ramus (2001) theoretical argument for phonological deficits to be embodied within similar phonological units, at the sub-lexical aspect of phonology.

Accordingly, in extending Ziegler and Goswami (2005) argument further, it could be that although the vowelized Arabic language has a very transparent orthographical structure, there may be areas within its supra-phonological processing that has as yet not been mastered (i.e. by third grade), which may in turn have hindered progress at the rate expected from a transparent orthography. The reason for the preceding suggestion is because it was observed that during the administration of the phoneme task for familiar as well as unfamiliar words (i.e. words and non-words respectively), there were cases where the researcher could hear the child re-iterate the items within a trial, capturing accurate pronunciation. Despite this, mistakes were made in the blending of sounds together when responses were eventually given. On the other hand, according to the psycholinguistic
grain size theory, a child surrounded by his/her language should have been able to take in such supra-phonological aspects of his/her language along side the phonological aspects from the surrounding environment (via experience with the spoken language). If this is so, then as experience with the orthography of a language allows for eventually grasping the smallest grain size unit of language, it should also be expected to allow for the supra-phonological aspects to be grasped. However, at least in the vowelized Arabic language, this does not appear to be the case. The Arabic language is unlike most of the transparent languages mentioned above. It is embodied with the diglossia concept (Abu-Rabia, Share, & Mansour, 2003). Theoretically, and according to diglossia, Arab children are not in constant contact with the vowelized Arabic as taught in schools. This formal language becomes more familiar to Arab children, with greater instruction and experience with texts. Consequently, although the written language of the Arab children is transparent, their every day spoken language follows a different phonological structure from formal Arabic. This peculiarity of Arabic may make it more difficult for Bahraini children to grasp the smallest grain size along with its supra-aspects at a rate as fast as those children from other transparent orthographies who have been hearing the same language from birth. The added complexity that vowelized Arabic contains phonemes that sound very similar (see Table 2.1 for pronunciation guide) may further impede the rate of grasping phonemic units at least for the period of time that it takes for the children to become familiar with these relatively new sounds. The close sounding of some phonemes implies greater effort to be required in order to determine the fine auditory difference between sounds; whereas, dissimilar sounding phonemes would be expected to be easier to distinguish and grasp.

Ziegler & Goswami (2006a), in exploring areas of literacy teaching across orthographies based on their psycholinguistic grain size theory, had advised in their concluding remarks of the importance that future research be directed towards searching “at different points in development and across different language environments” (p.435, Ziegler & Goswami, 2006a). Obviously, issues related to such ‘language environments’ could involve factors akin to supra-phonological processing, diglossia, and the sound proximity of phonemic
units within a language; all of which along with the grain size theory, and Arabic literacy merit further researching, before confirmation of the above rational could be granted. However, the interesting point to note, that with such a rational, the results of the present study could be perceived compatible with the psycholinguistic grain size theory. Additionally, it opens up a new area of study that requires supplementary investigation of which should be taken seriously, particularly when concerned with setting up assessment tools for dyslexics of the Arabic language.

The Position of the Early Arabic Literacy Predictors within the Different System of Orthographies as Implicated by the Study

To a certain extent, the present findings appeared compatible with findings from other transparent languages on phonological awareness processing’s involvement in early literacy acquisition (for evidence from studies on different transparent languages see Harris & Hatano, 1999) and on the roles visual spatial and short-term memory sequential processing play in reading (see Share & Levin, 1999). However, the findings of the current investigation diverged from findings of studies from other transparent orthographies on issues related to the duration of phonological awareness as a potent predictor of literacy and the role rapid naming plays as a literacy predictor (see discussion of chapter 6). Phonological awareness, in the present study appeared to continue to act as a predictor for literacy levels up to grade three; whereas in other transparent orthographies, such as the German language, the effectiveness of phonological awareness as a reading predictor for grades higher than the first appeared to be reduced (Wimmer, Landerl, & Frith, 1999); with other measures such as rapid automatized naming appearing as a better predictor of reading (Wimmer, 1993; Wimmer, Mayringer, & Landerl, 1998; Landerl, 2001). Alternatively, it could be argued that although the German language is considered a transparent alphabetical language, just as the vowelized Arabic language, it does not share a Semitic origin. However, even when considering the pointed Hebrew language which does have similar Semitic origin as well as being a
transparent alphabetical language as the vowelized Arabic language, Hebrew children were reported to having high accuracy scores in decoding by end of grade one (82%; Shatil, 1997, cited in Share & Levin, 1999) whilst the mean accuracy scores in decoding, even by grade three, did not reach a high level (see Table 6.2). On the other hand, the rate of literacy development as proposed by the psycholinguistic grain size theory (Goswami & Ziegler, 2005), and the developmental progression of the involvement of the different types of phonological units (rhyme awareness and phoneme awareness) at different periods of literacy acquisition (see Goswami, 1999) both appear to be somewhat compatible with findings from English studies, a less transparent orthography. However, the level of prediction provided by different phonological awareness measures may not be the same across Arabic and English (see Elbeheri et al, 2006; Hogan, Catts, & Little, 2005).

Therefore, with the early Arabic literacy processes appearing to neither reflect of what is typically expected from a transparent orthography nor to reflect of what it is typically expected from a less transparent orthography, then prudence should be considered in the generalizations of findings across languages with similar levels of transparency.

Development of Dyslexic Assessment Measures for children of the Arabic Language: Issues for Considerations as Proposed from Current Findings

Findings of the present study pointed towards the pattern of predictors for concurrent literacy predictors being somewhat different from the longitudinal ones. Therefore, in developing dyslexic assessment measures for young Arab children, it is recommended to first determine the exact purpose from the testing procedure; whether it is towards anticipating future reading problems or to ascertain immediate reading deficits. In addition, there was some evidence for the best predictor, as well as the level of prediction, to vary across different grade levels. Given these findings, it would seem prudent to suggest that a range of phonological awareness measures is considered to
provide reasonable estimates of phonological skills related to literacy acquisition across developmental and experience levels. Furthermore, it seems advisable to include both phoneme- and rhyme-based measures in an assessment procedure since they both played significant roles in predicting normal early Arabic literacy acquisition.

Other cognitive predictor measures such as block design, backward digit span, temporal order, and picture arrangement were identified as potential predictors; although, their participation may have been minor. As such, measures of visual/spatial processing and auditory/verbal short-term sequential memory would appear to be worthy of further investigation to determine their efficacy at increasing the level of validity of Arabic literacy/dyslexia assessment procedures.

Limitations of the Current Research

Although the present research achieved its aim of providing a basis on which to start to develop potential dyslexia-related assessment procedures that are appropriate for an Arabic language context, some of the measures included in the study may require further assessment to determine whether they are capable of measuring the underlying process they were chosen to assess. For example, different measures of visual spatial processing and speed of processing would have been desirable. The coding task was particularly disappointing, given that it was used as a standardized measure in the study, but following the first year of the data collection, preliminary analyses revealed that the standardization was inappropriate. Additional measures of this area of cognitive functioning may have to be considered in the future. Similarly, the inclusion of an alphanumeric rapid naming measure may have provided a further measure by which to assess the level of prediction of early Arabic literacy provided by an assessment of speed of processing.

Moreover, although the overall sample size was relatively large, when considered by grade it could be regarded as somewhat limited. A larger sample size for each grade may
have helped heighten understanding of the early Arabic literacy process by grade and may have helped provide greater confidence in the explanations of the results.

Finally, it is vital to understand that in dealing with issues related to human behavior, such psychological aspects cannot be directly handled and measured. Alternative indirect measures need to be established and as such it is only with continuous researching, critical securitization of resultant findings and the persistent attempt at foregoing limitation, that findings with time could be closer to representing the human behavior processes under investigation.

**Proposals for Future Research**

Throughout the thesis, suggestions for areas requiring further investigation on various matters discussed at the time were appropriately offered. However, in the present section, the proposals for future research will be to pin point some of the main ones that may help understand the aim of present study better.

In general, the Arabic language in its original form has a shallow orthography. It is only in the way it is treated in the various environmental settings that allows for it to be considered as a deep orthography. Examples of various environmental settings are the phonological distance between the spoken language and the literary language taught to the child (i.e. diglossia; see Saiegh-Hadda, 2005) and the dropping of vowels in the texts of children with increasing grades levels (see chapter 2), including their absence in everyday text, such as newspaper articles, magazines, and sign boards. All of which add to the uniqueness of the acquisition process of Arabic language and, therefore, calls for research to attempt to investigate the way the Arabic acquisition process develops in young children who are confronted with the task of becoming literate in the face of such impeding environmental settings.
One way of taking such observation further is to observe classroom behaviors of children at differing grade levels (e.g. one to three and even higher with time) in order to develop a ‘phonemic vocabulary’ list of the spoken language for each grade level. This could then be used to develop ‘phonemic awareness-based’ tests for the spoken language. This would then be compared against ‘phonemic awareness-based’ tests of the Formal Arabic language (i.e. the language the child is taught to be literate in), in order to establish which of the two ‘phonemic awareness-based’ tests more strongly predicts reading performances at differing grade levels. In addition, such a step would be expected to help indicate the phonemic boundaries for each of the spoken and taught Arabic languages, as well as help identify the differences in phonemic boundaries between both forms of the Arabic language. This should provide further information to understand the various phonemic-related processes entailed in the learning to read process of the Arabic language and inform the development of reading models that are specific for the Arabic language. Although a general reading model for the Arabic language has been proposed (Abu-Rabia, 2002), as yet it has not been tested for its applicability, nor has it considered issues related to diglossia as suggested above. The point to note is that with the diglosia context that the Arabic language is embodied in, it makes it difficult to propose at first hand a single general reading theory for the learning to read process in Arabic. Instead, it is perhaps best that different models are developed for different Arabic speaking regions of the World, each with its applicability tested. These models could then be used, if possible, in the building up of a composite model for the Arabic reading processes as a whole.

On the other hand, with regards to learning to spell in the Arabic language, further study should be pursued in the area of morphology. The Arabic language belongs to the non-concatenated morphological process in which words get formed on the basis of a discontinuous root of three or four consonants between which sets of vowels get inserted. Such morphological processes of prefixation, infixation, and suffixation provide information about type of gender, grammar, and function. Accordingly, by investigating whether children with experience could be capable of recognizing word patterns to
support building up a lexicon knowledge which could guide them in their spelling of words may help in the understanding of the learning to spell process of the Arabic language. A simple demonstration of this is that an understanding of the way female gender suffixation combines with a root of a particular word could be used to guide the written production of other female based gender words. Specifically, children could be given examples of some female gender words, and then tested on spelling other words that carry similar patterns, mixed with other words with different patterns, across different grade levels. A similar scheme could be developed for other more complex word patterns, allowing with time the development of a list for the different potential word patterns children are capable of using in their spelling across the different age groups; which could then be tested to find out whether knowledge of the various word patterns each of which are compatible with an appropriate age level could be perceived as a predictor of spelling for that grade level. In addition, such an investigation may lead to the development of morphological patterns potentially appropriate for different grade levels which could be compared against phonological awareness measures and other cognitive measures in predicting spelling and eventually reading.

Furthermore, it is advised that future research should attempt to concentrate at a single grade, one at a time, particularly in the early years of learning, using larger sample sizes (e.g. n = 200) and study them over time (about 2 to 3 years). Such a large sample size makes it feasible to study children whose literary levels fall in the bottom 15% of the cohort. Comparisons of literacy, phonological awareness and other potential assessment tasks across time shall provide a better understanding of literacy deficit in the Arabic language than is currently available.

With regards to Arabic literacy predictors, additional measures of visual spatial processing (other than block design), particularly those that include an element of orthographical processing seem necessary. The development of an alphanumeric rapid naming measure in order at least help clarify the role of rapid automatized processing in Arabic literacy acquisition with increasing grade levels would also seem necessary.
Furthermore, inclusion of measures on morphological aspects, sub-lexical aspect of phonology (both of which after in-depth researching is achieved) and phonological measures based on local sounds (i.e. sounds of the spoken language) may, together, provide a better understanding of the role predictors could play in early Arabic literacy and consequently in identifying predictors of poor reading and spelling, and hence dyslexia.

Moreover, given the change in the form of transparency the Arabic language displays across grades, research into predictors of literacy of the early Arabic language acquisition process should be extended to include the investigation of children from grades four to six along side children from grades one to three.

Finally, the role training in any of the areas found to predict early Arabic literacy acquisition could be researched further so as to develop an understanding of whether training on any of the predicted measures has any effect on improving early literacy performance, and if so to accordingly attempt to identify the range of predictors that could be perceived to speed up the Arabic literacy acquisition process.

**Conclusion**

To conclude, the aims of the present study have been partially supported. The research has been able to demonstrate that phonological awareness predicts early Arabic reading and spelling at least amongst the Bahraini sample of children that have been studied, thus stressing the role phonological awareness plays in early Arabic literacy acquisition. This conclusion is supported by other studies of Arabic and work on transparent orthographies with Semitic origins, such as Hebrew. Additionally, it was found to be in line with other studies carried out on other transparent languages of Latin origin (e.g. German) and languages of less transparent orthographies (e.g. English). However, the manifestation of the pattern of predictors in the Bahraini study did not follow that of a typical transparent
orthography. When compared to the pattern of predictors expected from a transparent orthography, rapid naming was not found as a better alternative predictor to phonological awareness. In fact, rapid naming did not appear as an independent predictor in the current investigation. Instead, the current findings appeared closer to findings from English studies (a less transparent orthography); with rhyme awareness being the only major predictor in the very early stages of the Arabic literacy acquisition process and still being present in the later stages of the early Arabic acquisition process along side phoneme awareness. Furthermore, as expected from a transparent language with a Semitic origin, other cognitive predictors, such as visual spatial ability and short-term memory processes have been found accompanying phonological awareness in predicting early Arabic reading and spelling; though their contribution have been found to be minor relative to phonological awareness processes and as such are worthy of further researching. In addition, although the orthography of the English language is not the same as that of Arabic, the way literacy is acquired in Arabic suggests that English tests may provide a basis on which to develop measures of dyslexia in the Arabic language.
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APPENDICES
Appendix A-1

Permission Letter from the Ministry of Education in the Kingdom of Bahrain
الموضوع: تسهيل مهام بحث

اسم الباحثة: هيا أحمد عبد اللّه المناعي.

الجهة الطالبة: كلية التربية - جامعة البحرين.

مواضيع البحث: دراسة استطلاعية لقياس قدرات أطفال المرحلة الابتدائية (الحلقة الأولى).

الواجبات المطلوبة تنفيذها: تطبيق الدراسات على أربع مدارس (مدينة عيسى - المنامة).


رأي مركز البحوث الابتدائية والتخطيط:

أوضحته الباحثة حول إجراءات الدراسة، لا يرى المركز مانعًا من السماح للباحثة تنفيذ المهمة
المطلوبة أعلاه.

الاسم: ليتيا علي المناعي.

الوظيفة: رئيسة مركز البحوث الابتدائية والتخطيط.

التاريخ: 17/1/2004 م

رأي الهيئة المذكورة: إدارة التعليم الابتدائي.

بعد الاطلاع على المواقع وبناء على موافقة مركز البحوث الابتدائية والتخطيط لا ترى
الإدارة مانعًا من السماح للباحثة تنفيذ المهمة المطلوبة أعلاه.

الاسم: خ.ي.ع.ر.غ.ب.

الوظيفة: مدير إدارة التعليم الابتدائي.

التاريخ: 17/1/2004 م

ختم الإدارة.

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Appendix A-2

Permission Letters for use of five subtests from the WISC-III (Bahraini version - 1998)
Dear Customer:

Thank you for your request to use materials published by The Psychological Corporation and/or its division, Therapy Skill Builders. Please note the following concerning your request:

- Your request has been approved. Please review the enclosed agreement, sign and return both originals to Legal Affairs for countersignature. A fully executed original will be returned for your file.
- Please submit the minimum fee of $\text{\param{}}$ with the signed agreements and include purchase order, if required by your procedures.
- The non-refundable up-front minimum fee of $\text{\param{}}$ was not included with the signed agreements. We have enclosed an invoice along with a copy of the executed agreement.

Your request has been denied for the following reason(s):

- We are unable to extend permission to reproduce the material for this use. Please contact Customer Care at 800-872-1726 or via e-mail at customer.care@harcourt.com for purchasing and qualifications information.
- We cannot grant this permission because the requested quantity of materials is more than 10% of the total product. If you are able to reduce the quantity you wish to use, please resubmit your request and we will be happy to reconsider.
- We are unable to process your request because we do not own the product. Please contact the copyright owner at the following address:

Thank you for your interest in our products.

Sincerely,

Robin Snyder
Contract Specialist
Legal Affairs

Enclosure(s)
SECOND REQUEST

May 12, 2004

Haya AI-Mannai
Psychology Department, College of Education
University of Bahrain
P.O. Box 32038
KINGDOM OF BAHRAIN

Dear Mr. AI-Mannai:

This is a reminder that your license fees are now due for permission to reproduce the Arabic version of the Digit Span, Coding, Block Design, Picture Comprehension, and Picture Arrangement subtests from the *Wechsler Intelligence Scale for Children: Third Edition (WISC-III)* for use in your dissertation research to investigate the underlying patterns of cognitive factors displayed by monolingual and bilingual poor Arab readers within the Bahraini culture. In accordance with the Fee Permission Agreement, dated March 1, 2003, please check your records and report the number of additional reproductions made above the 720 of each inventory authorized so we can initiate billing.

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</thead>
<tbody>
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<td>Wechsler Intelligence Scale for Children: Third Edition (WISC-III) Digit Span, Coding, Block Design, Picture Completion, and Picture Arrangement subtests</td>
<td>$1.75</td>
<td>0</td>
<td>From: April 1, 2003 Thru: Present</td>
</tr>
</tbody>
</table>

*If no copies were made, please indicate 0.

Signature: [Signature]

Printed Name: HAYA AL-MANNAI

Title: MRS.

Date: 1st June 2004

Additionally, your Fee Permission Agreement expired on February 28, 2004. Please indicate if you wish to renew by checking the appropriate box:

- [ ] PLEASE RENEW
- [ ] DECLINE RENEWAL

Approximate number of reproductions needed for new year.

Return to: Harcourt Assessment, Inc. or via Fax to: Legal Affairs at 210-339-5059
Attn: Legal Affairs
19500 Bulverde Road
San Antonio, TX 78259

Thank you for your cooperation. If you need additional assistance, please contact me directly at 800-228-0752, ext. 5574.

Sincerely,

Robin Snyder
Contract Specialist
Legal Affairs

Harcourt Assessment, Inc. 19500 Bulverde Road San Antonio, Texas 78259-3701

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*PsychCorp*
A brand of Harcourt Assessment, Inc.
Appendix A-3

Samples of Prepared Arabic Instructions on the Six Tasks Personally Prepared *:

The Stroop Task - Temporal Ordering Task - Phoneme Task (Lists A & B for Word & Non-word) - Rhyme Task (Odd-Sound Out Lists A & B for Word & Non-word) - Reading Task (List A & B for Word & Non-word) - Spelling Task (List A & B for Word & Non-word).

* Only the first page of the Arabic Instruction on each task was provided. For Full detailed Arabic Instructions see author.
بطاقات الألوان
(Stroop Test)

مواد الإختبار:

- خمسة بطاقات:
  - البطاقة (1) - عليها أربعة مستطيلات ملونة.
  - البطاقة (2) - عليها أربع كممة مختارة عشوائيًا من إحدى الكلمات التالية: "أزرق، أحمر، أصفر".
  - البطاقة (3) - عليها أربع مستطيل ملونة عشوائيًا بإحدى الألوان الأربعة: أزرق، أحمر، أصفر، ورمادي.
  - البطاقة (4) - عليها أربع كممة مختارة عشوائيًا من إحدى الكلمات التالية: "أزرق، أحمر، أصفر".
  - البطاقة (5) - عليها أربع كممة مختارة عشوائيًا من إحدى الكلمات التالية: "أزرق، أحمر، أصفر".

ساعة إيقاف:

ساعة واحدة تسجيل الزمان الذي يستغرقه المفحوص في قراءة كل كلمات البطاقة وساعة ثانية لتسجيل كل خطأ يقوم بالمحتر بتدوينه.

التعليمات:

1- إعرض على المفحوص بطاقة رقم (1) وقل له:

"شور البطاقة هاذي عليها ألوان. وكل لون تحته مكتوب كلمة. أنا أبيك. إنقل لي شنو الألوان إلي إنشوفها وتنقلي إلى الكلمات إلي تحت كل لون".

بعد التأكد من تعرف المفحوص على الألوان وقراءته لكلمات الألوان

2- إعرض على المفحوص بطاقة رقم (2) وقل له:

"هذي بطاقة ثانية، أنا هالمره أبيك تقرأ لي الكلمات إلي عليها كلها وحده وحده وبالدور وبسرعه وأبيك تبتدي من إهنني". وأشر على أول كلمة من جهة اليمنين.

إضغط بساعة الإيقاف وإحسب الزمن الذي يستغرقه المفحوص في قراءة كل كلمات البطاقة. أيضاً عليك باستخدام ساعة الإيقاف الأخرى وسجل كل خطأ وإحسب الوقت الذي يستغرقه المفحوص في تعديل كل خطأ.

مثال:

إذا أخطأ المفحوص في قراءة كلمة ما، أعطه وأطلب منه أن يحاول قراءتها مرة أخرى. إذا فشل في قراءة الكلمة مرة ثانية صحح له خطأه وأتركه يواصل في قراءة بقية كلمات البطاقة وأحسب الزمن الذي يستغرق في تعديل الخطأ (أي سجل الزمن من الوقت الذي طلبت من المفحوص أن يقرأ الكلمة مرة أخرى إلى أن تم تصحيح الكلمة نفسها).
مهمة النظام الزمني
(Temporal Ordering Task)

مواد الاختبار:
• قرص "سي دي" - CD - مسجل عليه جدول النغمات.
• جهاز تسجيل.
• إستمارة تسجيل الإجابات لكل مفحوص إستمارة خاصة به.

التعليمات:
يتكون الاختبار من ستة عشرة محاولة ، وأول محاولة (الأولى والثانية) تستخدم للتأكد من إتمام المفحوص بمتطلبات الاختبار . وكل محاولة تعتمد على الاستماع إلى نغمة:
النغمة الأولى والنغمة الثانية. والمطلوب من المفحوص التعرف على ما إذا كانت النغمةان متشابهتين أم لا.

يطلب الفاحص من المفحوص بالجلوس أمامه ويقول له بلطف ومرح:

"شيئًا هنا ليس منطقه شيء ... أنت تتبع نغمتين ... نغمه أولى ونغمه ثانية . وكل نغمه تتشابه من نغمة عالية وأصوات طبيعية . إنه علىك تسمع النغمتين وبعدين إنقول لي إذا ها النغمتين متشابهتين أو لا .\n
علشان إنعرف تلعب هالله وياي بيسوي مع بعض تمرينين وبدين بابتدي ألعب معك اللعبه صح ... يله ينبدي بالتمرين الأول".

يقوم الفاحص بتشغيل المحاولة الأولى وبعد إنهاء المحاولة يوقف جهاز التسجيل ويقول للفاحص:

"هوا شلون النغمتين يتشابهون؟ أو ما يتشابهون؟؟".

إذا أجاب المفحوص بأن النغمتين متشابهتين فعلى الفاحص أن يهدي المفحوص على أداءه.
ويقول له:

"متناف .. وادي زين . يله الحين إنسوي التمرين الثاني ... يله إسمع مرة ثانية ... بارز".

يقوم الفاحص مرة ثانية بتشغيل جهاز التسجيل لإصدار المحاولة الثانية وبعد إنهاء المحاولة يوقف جهاز التسجيل ويقول للفاحص:

"هوا شلون النغمتين يتشابهون؟ أو ما يتشابهون؟؟".
اختبار الصوت المضاف - القائمة (أ)

(Adding Phoneme - List A)

مواد الاختبار

القائمة (أ) : تحتوي على 28 سؤال. كل سؤال يتكون من كلمة ذات معنى، وكلمة
في كل سؤال مقسمة إلى جزءين بشكل يؤدي إلى إنتاج فونيما واحد وكلمة لا معنى لها.

- إستمارة الإجابة للقائمة (أ). لكل مفحوس إستمارة إستجابة خاصة به.

التعليمات

ياعب اختبار الصوت المضاف من الاختبارات الفردية التي تقوم لكل مفحوس على حدا
ويتكون الاختبار من جزءين : القائمة (أ) والقائمة (ب). يبدأ الفاحص مع المفحوس
في تقديم الجزء الأول من الاختبار - القائمة (أ) - ثم يواصل معه بعد إستراحة قصيرة في
تقديم الجزء الثاني من الاختبار - القائمة (ب).

تعليمات القائمة (أ)

لطلب الفاحص من المفحوس الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"أنا الحين بالعب معك لعبة. في اللعبة هذي أنت يتسمع صوتيين. هاي الصوتين إذا
جمعتهم مع بعض بيخطوك كلمة واحدة. الحين أنا أبيك... أول... تسمع هاي
الصوتين. ويعدين إتقول لي الكلمة اللي يحصل عليها من جمع الصوتين. علشان
تعرف تلعب اللعبة علّ أنا نفسوي وياك تمارين إنثنين وبعدين بينبدي تلعب اللعبة
صح".

يجب على الفاحص أن يتأكد من أن المفحوس لا يستطع رؤية الأسئلة المكتوبة على
القائمة (أ) وأن تكون الإجابة المفحوسة مبنية فقط على سماعه للأصوات الصادرة من
المفحوس عند قراءته للأسئلة المكتوبة. أيضا يجب على المفحوس عند قراءته للأسئلة من
القائمة أن يقرأها بتأتي ووضوح.

يواصل الفاحص مع المفحوس ويقول:

"يله بارز لسمع الأصوات الإثنتين... ثما مع /ار/ ببعديني الكلمة
التي هي... تقدر نقول".

إذا أجاب الفاحص الجواب الصحيح وقال "يثنى" يثنى المفحوس على أداءه ويواصل
الفاحص معه في تقديم المثال الثاني بنفس طريقة المثال الأول. وإذا كانت إجابة المفحوس
للمثال الثاني أيضا صحيحة بأن أجاب "جرس"، يثنى المفحوس على أداءه ويواصل
الفاحص معه ويقول له:
اختبار الصوت المضاف - القائمة (ب)

Adding Phoneme - List B

مواد الاختبار

القائمة (ب): تحتوي على 28 سؤال. كل سؤال يتكون من كلمة لا معنى لها.
والكلمة في كل سؤال مقسمة إلى جزءين بشكل يؤدي إلى إنتاج فونيزما واحداً وكلمة أخرى لا معنى لها.

· إستمارة الإجابة للقائمة (ب). لكل مفحوس إستمارة استجابة خاصة به.

التعليمات

يجب اختيار الصوت المضاف من الاختيارات الفردية التي تقدم لكل مفحوس على حدة.
ويتكون الاختيار من جزءين: القائمة (أ) والقائمة (ب). يبدأ الفاحص مع المفحوس في تقديم الجزء الأول من الاختبار - القائمة (أ) ثم يواصل معه بعد استراحة قصيرة في تقديم الجزء الثاني من الاختبار - القائمة (ب).

تعليمات القائمة (ب)

يطلب الفاحص من المفحوس الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"انا الحين باللعب معاك لعبة، في اللعبة هذا أنت مرمى صوتين. هاي الصوتين إذا جمعتهم مع بعض بيطوكلك كلمة واحدة... بس هالكلمة ما لها معنى... ما فقط سمعتها من قبل، الحين أنا أبيك... أول... تسمع هاي الصوتين وتعدين إقولة لي الكلمة اللي تحصل عليه من جمع الصوتين. عشان أعرف تلعب اللعبة عدل أنا نسي وياك تمرين بنتين وبعدين بنتيدي تلعب اللعبة صح"

يجب على الفاحص أن يتذكر من أن المفحوس لا يستطيع رؤية الأسئلة المكتوبة على القائمة (أ)، وأن تكون استجابة المفحوس مبنية فقط على سمعه للأصوات الصادرة من المفحوس عند قراءته للأسئلة المكتوبة. أيضا يجب على المفحوس عند قراءته للأسئلة من القائمة أن يقرأها باللغة العربية.

بواصل الفاحص مع المفحوس ويقول:

"اليه بارز إسمع الأصوات الإثنينه... سكي مع 1/2 ببطيني الكلمة اللي هي... تذكر".

إذا أجيب الفاحص بالجواب الصحيح وقال "سكي"، يثير الفاحص على إدائه ويواصل الفاحص معه في تقديم المثال الثاني بنفس طريقة المثال الأول. وإذا كانت الإجابة المفحوس للمثال الثاني أيضاً صحيحةً بأن أجيب "سكي"، يثير الفاحص على إدائه ويواصل الفاحص معه ويقول له:
إختبار الصوت الشاذ - القائمة (أ)
(Odd Sound Out – List A)

مواد الإختبار

- القائمة (أ): تحتوي على 28 سؤال. كل سؤال مكون من ثلاثة كلمات ذات معنى معرفة.
- إستمارة الإجابة للقائمة (أ). لكل مفحوص إستمارة إجابة خاصة به.

التعليمات

يعتبر إختبار الصوت الشاذ من الاختيارات الفردية التي تقدم لكل مفحوص على حدة. ويتكون الإختيار من جزأين. يبدأ الفاحص مع المفحوص في تقديم الجزء الأول من الاختيار القائمة (أ) ثم يواصل معه بعد إستراحة قصيرة في تقديم الجزء الثاني من الاختيار القائمة (ب).

تعليمات القائمة (أ)

يطلب الفاحص من المفحوص الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"أنا الحين بالعب معاك لعبة. في اللعبة هذا أنا باقولك ثلاثة كلمات. أثنيه من هاي الكلمات يتشابهون. لهم نفس الصوت. و كلمة وحده تختلف شويا في الصوت عن الكلمات الثلاثة. الحين أنا أبيك... أول... تسمع الكلمات الثلاثة وبعدين إنقول لي أي كلمة اللي صوتها شوي يختلف عن الثانين. علشان إنعرف تلعب اللعبة عدل أنا بسوي وياك تمارين إثنين وعدين بتبتدي نلعب اللعبة صبح"

يجب على الفاحص أن يتأكد أن المفحوص لا يستطيع رؤية الكلمات المكتوبة على القائمة (أ). وأن تكون إجابة المفحوص مبنيه فقط على سماعه للكلمات. أيضا يجب على المفحوص عند قراءته للكلمات من القائمة أن يقرأها بتأتي ووضوح.

يواصل الفاحص مع المفحوص و يقول:

"يله بارز إسمع الكلمات الثلاثة... "خز مرُ فّل". الحين أبيك

إقول لي الكلمة اللي صوتها شويه غير عن الثانين".

إذا أجاب الفاحص الجواب الصحيح وقال إما "الكلمة الثالثة" أو "فّل" ينتهي المفحوص على أداءه ويواصل الفاحص معه في تقديمه للمثال الثاني بنفس طريقة المثال الأول. وإذا كانت إجابة المفحوص للمثال الثاني صحيحا بأن أجاب "الكلمة الثنائية" أو "روسة"، ينتهي المفحوص على أداءه ويواصل الفاحص معه و يقول له:

"الحين أنت عرفت تلعب هال لعبة خبيتدي نلعب... بارز...

"
اختبار الصوت الشاذ - القائمة (ب)
(Odd Sound Out – List B)

مواد الاختبار

القائمة (ب) : تحتوي على 28 سؤال. كل سؤال مكون من ثلاثة كلمات ذات معاني غير معروفة. إستمارة الإستجابة للقائمة (ب). لكل مفحوشة إستمارة إستجابة خاصة به.

التعليمات

يعتبر اختبار الصوت الشاذ من الاختبارات الفردية التي تقوم بكل مفحوشة على حدي ويتكون الاختبار من جزأين. يبدأ الفاحص مع المفحوش في تقديم الجزء الأول من الاختبار القائمة (أ) ثم يواصل معه بعد إستمارة قصيرة في تقديم الجزء الثاني من الاختبار القائمة (ب).

تعليمات القائمة (ب)

يطلب الفاحص من المفحوشة الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"أنا الحين باللعب معك لعبة. في اللعبة هادي أنا بأقولك ثلاثة كلمات. الكلمات هاي مالها معنى ... لكن إثنيم من هاي الكلمات يتشابهون. لهم نفس الصوت. و كلمة وحدها تختلف شوهي من الصوت عن الكلمات الاثنين. الحين أنا أبيك ... أول ... تسمع الكلمات الثلاثة وبعدين أقول لي أي كلمة اللي صوتها شوي يختلف عن الاثنين.

علشان إتعرف تلعب اللعبه عدل أنا بسوي وياك تمارين إثنيم وبعدين بليدي

تلعب اللعبه صج"

يجب على الفاحص أن يتأكد من أن المفحوش لا يستطيع رؤية الكلمات المكتوبة على القائمة (ب). وأن تكون إستجابة المفحوش مبنيه فقط على سماعه الكلمات. أيضا يجب على المفحوش عند قراءته للكلمات من القائمة أن يقرأها بتأتي ووضوح.

يواصل الفاحص مع المفحوش ويدعو:

"بله بارز إسمع الكلمات الثلاثة ... نوكي مكي كجم. الحين أبيك" 

إقول لي الكلمة اللي صوتها شويه غير عن الاثنين.

إذا أجاب الفاحص الجواب الصحيح وقال إما "الكلمة الثالثة" أو "كجم" ينعي المفحوش على أداء ويوصل الفاحص معه في تقديم المثال الثاني بنفس طريقة المثال الأول. وإذا كانت إجابة المفحوش للمثال الثاني صحيحا بان أجاب "الكلمة الثانية" أو "كرسوك" ينعي المفحوش على أداء ويوصل الفاحص معه ويقول له:

"الحين أنت عرفت تلعب هال لعبة خنيدتي نلعب ... بارز ..."
اختبار القراءة
(Reading Test)

مواد الاختبار
- قائمة (أ) والقائمة (ب)
- القائمة (أ) تحتوي على أربعين كلمة ذات معنى مفهوم، وأربعة مستويات، وفي كل مستوى عشرة كلمات.
- القائمة (ب) تحتوي على مستوى واحد وعشرة كلمات ذات معاني غير مفهومة.
- إستمارة الاستجابة للقائمة (أ) لكل مفاهيم إستمارة إستجابة خاصة به.
- إستمارة الاستجابة للقائمة (ب) لكل مفاهيم إستمارة إستجابة خاصة به.
- ساعة إيقاف.

التعليمات
يعتبر اختبار القراءة من الاختبارات الفردية التي تقدم لكل مفاهيم على حدة. ويتكون الاختبار من جزءين: القائمة (أ) والقائمة (ب). بدأ الفاحص مع المفاهيم في تقديم الجزء الأول من الاختبار - القائمة (أ) ثم يواصل معه بعد استراحة قصيرة في تقديم الجزء الثاني من الاختبار - القائمة (ب).

تعليمات القائمة (أ)
يطلب الفاحص من المفاهيم الجلوس أمامه ويقول له بلطف ومرح ووضوح:
"أنا الحين أبي أسمعك تقرأ. أبيك تقرأ في هال الكلمات على هال اللوحة وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده وحده.
بعض وبالحركات. حاول ما هو أصعب من أصعب. زين بالله بارز. ابديه."

يجب على الفاحص عندما بدأ المفاهيم القراءة بالضغط على ساعة الإيقاف لتسجيل الزمن المستغرق في قراءة جميع الكلمات التي على لوحة القائمة (أ).

كما يجب على الفاحص أن يعمل على تسجيل إستجابة المفاهيم بشكل المذكور في "طريقة تسجيل الأجوبة للقائمة (أ)". وأن لا يتصفح المفاهيم أخطاً ولا يعزز أجابته وأن يدلي فقط في حالة نسبيه المفاهيم لقراءة كلمة ما. وفي هذه الحالة يجب على الفاحص أن ينهب المفاهيم وينبأ له:
"إنتبه هال كلمة نسبتها... شنو هيه."

عند انتهاء المفاهيم من قراءة الكلمات يجب على المفاهيم أن يعمل مباشرة على ضغط ساعة الإيقاف وتسجيل الزمن المستغرق في أداء هذه المهمة. كما يجب على الفاحص، عند الإنتهاء، أن يقول للمفاهيم:
"أنت وaid إشتعلت اليوم. إرتحل الحين إشوية و بعدين بكامل معاك.

بعد فترة الراحة، يبدأ الفاحص في تقديم إختبار القائمة (ب).

طريقة تسجيل الأجوبة للقائمة (أ)

يُسجل الفاحص الزمن الذي يستغرقه المفصول في قراءته لكل الأربعين كلمة. وعند
إنتهاء المفصول من القراءة يُدود الفاحص الزمن المستغرق على إستمرار الإستجابة
الخاصة بالمفصول.

تسجل أجوبة المفصول عند قراءته لكل كلمة في خانة التصحيح الموجودة على
إستمرار الإستجابة للقائمة (أ) وذلك بالشكل التالي:

- إذا قرأ المفصول الكلمة قراءة صحيحة فعلي الفاحص وضع إشارة في خانة هذه الكلمة
تحت العمود الذي يحمل عنوان "القراءة صحيحة".
- أما إذا قرأ المفصول الكلمة قراءة غير صحيحة فعلي الفاحص وضع إشارة في خانة
هذه الكلمة تحت العمود الذي يحمل عنوان "القراءة خاطئة".

إضافةً يطلب من الفاحص تسجيل الكلمة التي يصل عندها المفصول في كل فترة مدتها
ثلاثين ثانية (30 ثانية) وذلك بوضع إشارة في خانة الكلمة تحت العمود الذي يحمل
عنوان "كل 30 ثانية تسجل الكلمة التي تم التوصل عندها".

تعليمات القائمة (ب)

يطلب الفاحص من المفصول الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"أنا الحين أهي أسمعك تقرأ مرة ثانية. لكن هال المره الكلمات مُهيّبة واديد... وبد هاي الكلمات
إنت ما سميتها من قبل... لكن أنا أهي أسمعك تقرأها لي من على هال اللوحة وحديو و
ورد بعض وبالحركات. حاول وما توقف ليين إختلُف تقرأ كل الكلمات على اللوحة. زين ياله
بارز. أيتدي"

يجب على الفاحص عندما يبدأ المفصول القراءة بالضغط على ساعة الإيقاف لتسجيل الزمن
المستغرق في قراءة جميع الكلمات التي على لوح القائمة (ب).

كما يجب على الفاحص أن يعمل على تسجيل إستجابة المفصول بالشكل المذكور في
"طريقة تسجيل الأجوبة للقائمة (ب)". إن لا يصبح المفصول أخطاء وللا يعزز أجوبته
وأن يدخل فقط في حالة نسبان المفصول لقراءة كلمة: ما. وفي هذه الحالة يجب على
الفاحص أن يئبه المفصول ويقول له:

"إنتبه هال كلمة نسبتها... شنو هيه"
الاختبار الإملائي
(Spelling Test)

مواد الاختبار
- قائمة (أ) والقائمة (ب)
- القائمة (أ) تحتوي على أربعين كلمة، كل منها ذات معنى مفهوم. وهذه الكلمات موزعة على أربعة مستويات، في كل مستوى عشرة كلمات.
- القائمة (ب) تحتوي على مستوى واحد وعشرة كلمات ذات معاني غير مفهومة.
- استمارة الإجابة للقائمة.
- أوراق بيضاء ورقائق لكل مفحوص للكتابة عليها.
- ساعة إيقاف.

التعليمات
يمكن إعداد الاختبار الإملائي من الاختبارات الفردية التي تقدم لكل مفحوص على حدا أو من الاختبارات الجماعية التي تقدم لجميع المفحوصين معاً في أن واحد ولكن يفضل الأول على الثاني.

يتكون الاختبار من جزأين: القائمة (أ) والقائمة (ب). يبدأ الفاحص مع المفحوص في تقديم الجزء الأول من الاختبار - القائمة (أ) - ثم يواصل معه بعد استراحة قصيرة في تقديم الجزء الثاني من الاختبار - القائمة (ب).

تعليمات القائمة (أ)
يطلب الفاحص من المفحوص الجلوس أمامه ويقول له بلطف ومرح ووضوح:
"أنا الحين أبي أشفوك تكتب بعض الكلمات إلى أنا بمالها عليك. أليك تسم الكلمة التي أنا باقولها عقب أبيبيك تكتبها لي بالحركات على هالورقية، إذا ما عرفت تكتب الكلمة م عليه. بس أنت لأزم تحاول تكتبها بالطريقة التي إشوفها. زين ياله بارز. بابتي."

يبدأ الفاحص بالضغط على ساعة الإيقاف لحساب الزمن المستغرق وفي الوقت نفسه يقوم بقراءة الكلمة من على اللوحة (أ) بحيث تقرا كل كلمة مرتبة على حدا ويتأتي وصوت واضح. ويجب على الفاحص أن يعلو الكلمات بالسلسل المذكور في اللوحة (أ) وآن لا يترك كلمة، بل يقرأ كل كلمة واحدة تلو الأخرى. كما يجب على الفاحص تسجيل الزمن الذي يستغرق المفحوص في كتابته لكل كلمة على حدة. وللمفحوص زمناً غير محدود في كتابة لهذه الكلمات.

بعد ذلك يجب على الفاحص، أن يقول للمفحوص:
"أنت وايد إستغلت اليوم، ارتاح الحين إشوه وبعدين بكم معاك."

بعد فترة الراحة، يبدأ الفاحص في تقديم القائمة (ب) للإختبار الإملائي.
طريقة تسجيل الأجوبة (أ)

يُسجل الفاحص الزمن الذي يستغرقه المفحوص في كتابته ، لكل كلمة من كلمات اللوحة (أ) ، على إستمارة الإجابة التابعة للاختيار الإملائي.

بعد إنهاء المفحوص من أداء الإملاء على الورقة البيضاء المقدمة من قبل الفاحص ، وبعد التأكد من أن المفحوص سجل إسمه على ورقة الإداء ، تؤخذ هذه الورقة من المفحوص وترفق مع إستمارة إجابة الإختيار الإملائي التابعة له.

تعليمات القائمة (ب)

طلب الفاحص من المفحوص الجلوس أمامه ويقول له بلطف ومرح ووضوح:

"أنا الحين أتمنى أن تكتب بعض الكلمات إلى أني يمكنها عليك.

أولاً الكتابة يمكن بدءك عليك وما لها معنى . لكن أنا أطلب تسميع الكلمة اللي أنا باقولها سأكتبها في الحرفات على هاروقة .

وأبيك تحاول تكتبها بالطريقة اللي أبديها. زين باله بارز. بابتي".

يبدأ الفاحص بالضغط على ساعة الإيقاف لحساب الزمن المستغرق. وفي الوقت نفسه يقوم بقراءة الكلمة من على اللوحة (ب) بحيث تقرأ كل كلمة مرتان وعلى حدا وتبنيو وصوت واضح. ويبعث على الفاحص أن يُلقى الكلمات بالتسليسل المذكور في اللوحة (ب) وأن لا يترك كلمة ، بل يقرأ كل كلمة واحدة تلو الأخرى . كما يجب على الفاحص تسجيل الزمن الذي يستغرقه المفحوص في كتابته لكل كلمة على حدا. وللمفحوص زمناً غير محدود في كتابة لهذه الكلمات.

بعد ذلك يجب على الفاحص، أن يقول للمفحوص:

"أنت وادي إشتعلت اليوم. أرتاح الحين إشوبه ".

طريقة تسجيل الأجوبة (ب)

يُسجل الفاحص الزمن الذي يستغرقه المفحوص في كتابته ، لكل كلمة من كلمات اللوحة (ب) ، على إستمارة الإجابة التابعة للاختيار الإملائي.

بعد إنهاء المفحوص من أداء الإملاء على الورقة البيضاء المقدمة من قبل الفاحص ، وبعد التأكد من أن المفحوص سجل إسمه على ورقة الإداء ، تؤخذ هذه الورقة من المفحوص وترفق مع إستمارة إجابة الإختيار الإملائي التابعة له.

لذا بانهاء تقديم الاختيار الإملائي لمفحوص ما يكون توفر له:

- أسماء الإجابة للاختيار الإملائي وعليه مسجل الزمن المستغرق
  لكل كلمة في اللوحة (أ) و(ب).
- ورقة الإداء للقائمة (أ).
- ورقة الإداء للقائمة (ب).
Appendix A-4

Samples of Prepared Arabic Instruments *

- Appendix A-4.1 - Stroop Task
- Appendix A-4.2 – Phoneme Task (Word & Non-Word)
- Appendix A-4.3 – Rhyme Task (Word & Non-Word)
- Appendix A-4.4 - Reading Task (Word & Non-Word)
- Appendix A-4.5 - Spelling Task (Word & Non-Word)

* Instrument prepared for Temporal Order task consisted of a CD. For copy see author.
Appendix A - 4.1 - The Stroop Task

(Card 1, card 2, card 3, card 4 & card 5 are presented in consecutive order)
أصفر
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Appendix A - 4.2 - Phoneme Task

1. Word (List A – Consists of example sheet followed by main study items)
2. Non-Word (List B – Consists of example sheet followed by main study items)
Phoneme Task - List A
Part I: Adding Phonemes
(Examples)

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Ljý (JAW, c am’ý9r`ý’ý) is lw, J l±ýi t)_ý )

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الأمشلة

الموقع صحية

(التمارِج)

(جرَّسَ)
<table>
<thead>
<tr>
<th>الإجابة الصحيحة</th>
<th>المسألة (تُقرأ شفويًا على الطفل)</th>
</tr>
</thead>
<tbody>
<tr>
<td>سمّك (سَمْكٌ)</td>
<td>سمّ / ك / مَرَ / نَقْوَ / رِيا / جِهَ / عَشَا / تَرْسُ / يُحِي / نَقْوَ / حَافِ / جَنْدِي / حِزَاء / طَرِيُ</td>
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<tr>
<td>نقود (نَقْوَدُ)</td>
<td>د / نَقْوَ / رِيا / جِهَ / عَشَا / تَرْسُ / يُحِي / نَقْوَ / حَافِ / جَنْدِي / حِزَاء / طَرِيُ</td>
</tr>
<tr>
<td>رياح (رِيَاحٌ)</td>
<td>ح / رِيا / جِهَ / عَشَا / تَرْسُ / يُحِي / نَقْوَ / حَافِ / جَنْدِي / حِزَاء / طَرِيُ</td>
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<tr>
<td>جهان (جِهَانَ)</td>
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<tr>
<td>عشاء (عِشَاءُ)</td>
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<td>ترسو (تَرْسُو)</td>
<td>و / تَرْسُ / يُحِي / نَقْوَ / حَافِ / جَنْدِي / حِزَاء / طَرِيُ</td>
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<td>حافظ (حَافِظُ)</td>
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<td>حزاء (حِزَاء)</td>
<td>م / حِزَاء / طَرِيُ</td>
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<td>طريق (طَرِيُقٌ)</td>
<td>ق / طَرِيُ</td>
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</table>

(Main Study Items)
<table>
<thead>
<tr>
<th>الإجابة الصحيحة (الموقع مخفيًا من الطفل)</th>
<th>بقية الأسئلة (تُقرأ شفويًا على الطفل)</th>
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</thead>
<tbody>
<tr>
<td>إخلاص</td>
<td>ص</td>
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<td>ساعه</td>
<td>ه</td>
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<tr>
<td>فارغ</td>
<td>غ</td>
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<td>لنذي</td>
<td>ذ</td>
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<tr>
<td>ساحل</td>
<td>ل</td>
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<td>جدار</td>
<td>ر</td>
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<td>أزدت</td>
<td>ت</td>
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<td>جيران</td>
<td>ن</td>
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<td>عبئت</td>
<td>ث</td>
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Phoneme Task – List B
Part II: Adding Phonemes
(Examples)
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<td>(سماء)</td>
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<td>(جَلْثِر)</td>
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<td>(ساهم)</td>
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<td>بِروْ</td>
<td>(بيك)</td>
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<td>الإجابة الصحيحة</td>
<td>بقية الأسئلة</td>
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<tr>
<td>الموقع سماه من الطفل (مَعَوَّفٌ)</td>
<td>تسفر شفوفاً عن الطفل (فَ)</td>
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<td>مُخاصٌ</td>
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<td>أَصْلَغْ</td>
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<td>قُمِّيْدَ</td>
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<td>دوَجِنَ</td>
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<td>بَسْوَنَ</td>
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<td>خَلَاثٌ</td>
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<td>مَطْيِ</td>
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<tr>
<td>مَلوِسَ</td>
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</tbody>
</table>
Appendix A - 4.3 – Rhyme Task

3. Word (List A – Consists of example sheet followed by main study items)
4. Non-Word (List B – Consists of example sheet followed by main study items)
Rhyme Task – List A
Part I: Rhyme Test (Odd Sound-Out)
(Examples)

الأسئلة:

الأجوبة الصحيحة

(موضع سجاعها من الطفل)

(فل)

(رونق)

(بقد)

(سم)

(شوفاً على الطفل)
لسلة ملاحظات مشكلة

(الموقع ساجها من الطفل)

(صيبة)

(زل)

(ريبع)

(عامل)

(طائرات)

(خلطل)

(ساعي)

(فاس)

(قوص)

(وطن)

(حسر)

(نمل)

(بنود)

(عاون)

(رطل)

(كوب)

(زجر)

(طرير)

(سعيدة)

(غبار)
Rhyme Task – List B
Part II: Rhyme Test (Odd Sound-Out)
(Examples)

الأمثلة:

الإجوبة الصحيحة
(الموقع سماعها من الطفل)

(كَجَر)

نَك

(كَسَول)

بَوصوَع

(كَرَسَول)
Appendix A - 4.4 – Reading Task

5. Word List
6. Non-Word List
الدُّمانية
البَيْنَة
أَسْرَة
سَدَادَة
اللِّيل
مَكَافَأَة
تُفَافَات
الطَّبِيب
الكِهْرَباء
أَضَاءَة
ไฟْضَفَاضَا
الأَجْهَزة
طَائِرَتَه
أَرْتَدِي
ضَفَايَة
الطَّماَنَينة
الضُّباَطَي
مَنْذُه
مُبَارَكَات
الظَّمَان
مَسْؤُولَيَة
الدِّسَانِس
قُدْسِيَة
تُبَارَى
فُشُّعْرِيَة
الشُّمسِ
حَيْوَانات
غيْوَم
نُوم
القُطْة
الرَّمل
نَفَان
شَجَر
البَحْر
رَطب
فَنَبُو
مَاما
فَنَبُو
حَلَادِي
أَرْتَبُ
زانوئيات
روذوب

أنغماء

السؤول

النفيئة

صلحن

نامكيل

فكامأة
Appendix A - 4.5 - Spelling Task

7. Word List
8. Non-Word List
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<td>فَجَاءَ</td>
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<td>أَبْيَأ</td>
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<td>خَضْيَة</td>
<td>وَثَاقِق</td>
<td>وَثَاقِق</td>
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</table>
Literacy Task – Spelling
Level 5 (Non-words)

أَنْرَعْ
تَمْزِ

صارِي
نيماء

قَعَدْدَ
مَزْحُورَة

طَلَعَة
المَكَحَة

مَائِفَين
دَمَّانٌ
Appendix A-5

Samples of Prepared Record Forms on the Six Tasks Personally Prepared:

The Stroop Task - Temporal Ordering Task - Phoneme Task (Lists A & B for Word & Non-word) - Rhyme Task (Odd-Sound Out Lists A & B for Word & Non-word) - Reading Task (List A & B for Word & Non-word) - Spelling Task (List A & B for Word & Non-word).
<table>
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<tr>
<th>ملاحظات (Notices)</th>
<th>الوقت المستغرق لتعديل كل خطا (Time Span for correction of errors)</th>
<th>الأخطاء (Errors)</th>
<th>وقت الانتظار المستغرق (Time Span)</th>
<th>المطلوب (Requirements)</th>
<th>رقم البطاقة (Card Number)</th>
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</table>
| 1         | تتغير +  
 |           | وقع ثم +  
 |           | تتغير ثم +  
 |           | تتغير ثم -  
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 |           | تتغير ثم -  
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المفتاح
A high tone - صوت عالي – (+)
A low tone - صوت منخفض – (-)
وقفة ينْتِبَج الفاحش عن إصدار أي صوت لمدة ثانية.
The researcher stops for two seconds.
قرص "سي دي" - CD - مسجل عليه جدول النغامات .
جهز تسجيل .

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(الدرجة العظمى 12)
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- **الفصل الأول: الكلمة (أ)**
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**مثال 1: حُرّ مُفرَّ فُتُّل**
لا تحسب

**مثال 2: فُطُدُق رُؤِّدُقُ بُلِّدقُ**
لا تحسب

- طَيِّعَة
- ضَيْع
- زَلْل
- تَيِّبَة
- تَيِّبَة
- رَيْغ
- طَيِّب
- عَابِل
- عَابِل
- طَيَّات
- طَيَّات
- كُلِّف
- كُلِّف
- هَادِي
- سَاي
- سَاي
- عَاف
- عَاف
- فَلُوس
- فَلُوس
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- غَرَاب

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**مجمع الدرجات:** 

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