The development of vocabulary, working memory and phonological awareness among Kuwaiti Arabic individuals with Down syndrome and typically developing children

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Abstract

A large body of research has focused on language development throughout childhood among typically developing (TD) children due to its importance for communication, expressing feelings and needs, and maintaining relationships. Most research on language development within the context of intellectual disability, such as Down syndrome (DS), has been conducted among English speakers. However, there is a lack of research examining how trajectories among Arabic-speaking DS individuals might differ.

This study employed a cross-sectional developmental trajectory approach to investigate vocabulary, phonological short-term memory and phonological awareness (PA) in relation to non-verbal mental ability as measured by Ravens Coloured Progressive Matrices (RCPM) raw scores in Gulf Arabic (Kuwaiti) DS and TD groups. It also addressed the relationships between phonological awareness and vocabulary knowledge (related to the lexical restructuring [LR] model), as well as theorized relationships between phonological short-term memory and vocabulary, and phonological short-term memory and phonological awareness.

Forty-eight individuals with DS aged 6–20 years old were matched on RCPM with 44 TD children aged 3–10 years old. Data were collected for each participant in two sessions, assessing phonological short-term memory using a non-word recognition (NWR) test, testing receptive and expressive vocabulary, and assessing phonological awareness at the level of syllable, rhyme and phoneme.

The findings show a similar onset and rate of development in PA and vocabulary across non-verbal mental ability for the DS and TD groups, but not in phonological short-term memory. In addition, there is a strong correlation between non-verbal mental ability (NVMA) and these skills in the DS group, but not with phonological short-term memory. Significant correlations between NVMA and some language skills would be predicted by neuro-constructivist theory, while further findings showing an association between vocabulary and phonological awareness to a similar extent across the DS and TD groups are in line with the LR model. Another important finding is that phonological short-term memory is associated with phonological awareness in different ways in the DS and TD groups. Moreover, phonological short-term memory is not significantly correlated with non-verbal mental ability or vocabulary measures in the DS group, implying that NWR plays no part in vocabulary development for individuals with DS. In contrast, there is a strong correlation between phonological short-term memory and vocabulary in the TD group, consistent with the phonological short-term memory theory. The

educational, clinical and policy implications discussed highlight the need for further study in this area, as well as for standardized Arabic tests.

Dedication

This thesis is dedicated to my father, Dr Musaed AlSaeed, and my mother, Dr Samirah AlAwadhi,
my beloved parents.

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Abbreviations

AEVT	Arabic Expressive Vocabulary Test
APVT	Arabic Picture Vocabulary Test
BPVT	British Picture Vocabulary Test
CELF-P	Clinical Evaluation of Language Fundamentals – Preschool
CTOPP	Comprehension Test of Phonological Processing
DLD	Developmental language disorder
DS	Down syndrome
DV	Dependent variable
EOWPVT	Expressive One Word Picture Vocabulary Test
EVT	Expressive Vocabulary Test
IQ	Intelligence quotient
IV	Independent variable
MSA	Modern Standard Arabic
MLU	Mean length of utterance
NWR	Non-word repetition
PPVT	Peabody Picture Vocabulary Test
RCPM	Raven's Coloured Progressive Matrices
SES	Socio-economic status
SLI	Specific language impairment
TACL	Test of Auditory Comprehension of Language
TD	Typically developing

Chapter 1. Introduction

1.1 Overview

This thesis investigates and examines the relationship between vocabulary (assessed using the Arabic Picture Vocabulary Test [APVT] and the Arabic Expressive Vocabulary Test [AEVT]), non-word repetition (NWR) and phonological awareness (PA) among Kuwaiti Arabic individuals with Down syndrome (DS) and typically developing (TD) children. Furthermore, it employs the developmental trajectory approach (see 1.3) to investigate whether DS and TD children/adolescents matched on the Raven's Coloured Progressive Matrices (RCPM) differ in terms of the onset and rate of development of vocabulary, NWR and PA across non-verbal mental abilities.

This chapter begins with an introduction to the whole study and its purpose, followed by the background to the developmental trajectory approach and language profiles in individuals with DS. It also considers the differences between the Arabic and English languages. In addition, this chapter discusses the Kuwaiti special education law and system, similarities with specific language impairment and the importance of including a control group. This chapter ends with the significance of the study and an outline of the structure of the thesis.

1.2 Background to the study

Language development throughout childhood is generally understood through literature concerning the TD context. In this study, several skills were selected based on their importance for language learning and academic development. Vocabulary knowledge has been found in TD children to be a predictor of verbal comprehension, reading comprehension, academic skills and behavioral functioning and an important aspect of cognitive functioning (Bowey, 2001) and a higher level of comprehension (Silva and Cain, 2015). Similar associations have been identified for individuals with DS, with receptive vocabulary skills being a predictor of academic success, including aspects such as spelling, reading and social skills (Laws and Gunn, 2002). Van der Schuit *et al.* (2011) suggested that vocabulary development may be even more important and stronger in individuals with DS than in those developing typically, as they found the relationship between vocabulary and syntax to be stronger in their DS group.

Phonological short term memory can be assessed using NWR tasks (Gathercole, 2006). There is evidence of the role of phonological short-term memory in the acquisition of vocabulary in TD children and in those with language disorders (Gathercole and Baddeley, 1990). It therefore seems likely that poor phonological short-term memory would be a limiting factor in vocabulary development in DS, although vocabulary is an area of relative strength in this

population (Gathercole and Baddeley, 1990). PA can be defined as the awareness of sound structure, or the phonological structure of a spoken word (Gillon, 2012). In TD children, it has been found to be highly correlated with academic skills (Adams, 1990) and is an essential part of the acquisition of literacy (Gathercole and Alloway, 2004). Similarly, the same relationship has been found among individuals with DS (Laws and Gunn, 2002). However, the bulk of research on the relationship between vocabulary, phonological short-term memory and PA has been conducted among English-speaking TD children and it is unclear how this relationship presents in Gulf Arabic-speaking TD children and individuals with DS, and whether the findings are consistent with English studies.

DS is the most common genetic cause of intellectual disability and leads to speech and language deficits (Parker *et al.*, 2010). A wide range of English studies have been conducted assessing language development in individuals with DS. Some studies have found that language development in individuals with DS is particularly slow and plateaus at the onset of adolescence, or in early adulthood (Turner and Alborz, 2003; Couzens *et al.*, 2011). Understanding language development in individuals with DS is an increasingly researched topic and might have important ramifications for how therapists treat language difficulties in those with this condition. Comparing individuals with DS to TD individuals might suggest the inclusion of individuals with DS in mainstream education with TD of similar mental ages (Byrne *et al.*, 2002; Buckley *et al.*, 2006). This might be the case when cognitive abilities predict language measures in a similar away across both groups. The increasing trend for mainstreaming in schools in Kuwait has led to the investigation of language development among DS children and comparison with that of TD children, as DS may influence speech and language development, language therapy plans and educational/academic success.

The ability to repeat multisyllabic non-words is the most effective predictor of language development (e.g. vocabulary), especially during the early stages of the process (Gathercole, 2006). Studies of TD children have shown that NWR is a significant predictor of vocabulary learning (Baddeley *et al.*, 1998; Briscoe *et al.*, 2001; Coady and Evans, 2008; Khater, 2016). Therefore, TD children with good receptive vocabulary skills tend to score better on NWR tasks than children with poor vocabulary skills (Bowey, 2001). These studies have shed light on this association in different ways, based on phonological short-term memory (Gathercole and Baddeley, 1989) and phonological processing (Snowling *et al.*, 1991). Vocabulary knowledge (e.g. receptive vocabulary) has been observed to be a relative strength in the language profile of individuals with DS (Abbeduto *et al.*, 2007). However, NWR is known to be challenging for individuals with DS as many experience difficulties in hearing, speech discrimination. planning

and articulation (Mengoni, 2012). A relationship between NWR and vocabulary has been identified in English speakers. Likewise, some studies have found a significant correlation in DS populations (Laws, 1998; Comblain, 1999; Laws and Bishop, 2003; Cairns and Jarrold, 2005; Loveall *et al.*, 2016). The findings of these studies suggest that there are similar correlations between vocabulary and repetition accuracy in the DS and TD groups. Yet, other studies have found no correlation between NWR and vocabulary knowledge (Laws and Gunn, 2004), which might be due to small sample size possibly affecting the correlation. This suggests that individuals with DS could be learning vocabulary via a different route, which minimizes the role of phonological short-term memory. The correlation between NWR and vocabulary has not been looked at in the context of the Gulf Arabic DS population, a gap that is addressed in this study.

As studies of TD children have shown a correlation between NWR and vocabulary development, it has been suggested that phonological short-term memory is important for retaining information about a new word long enough to store it. This association may depend on PA and reflect participants' ability to segment spoken words (Gathercole *et al.*, 1992; Metsala, 1999). Understanding the relationship between PA and vocabulary skills is the first step to understanding PA and its correlation with speech and language. One of the theories that explains the relationship of PA development and vocabulary skills is the lexical restructuring (LR) model (see 3.3).

The correlations between NWR and vocabulary knowledge, between NWR and phonological awareness, and between vocabulary and phonological awareness remain largely unexplored among individuals with DS in the Gulf Arabic context. Equally, there is a lack of research in this context on whether a similar correlation exists with TD children matched on non-verbal cognitive abilities. From a Gulf Arabic speech and language therapist perspective, it is not clear whether the results of research undertaken in the English language context may be generalizable to a Gulf Arabic context. The Arabic context and cultural background are completely different from the English context (see 2.9 for more detail). Investigating the development of language in individuals with DS and comparing it to the development of TD children matched on the RCPM has implications for assessment, intervention and educational settings. The sparsity of research into language development among DS children in the Gulf Arabic context has led me to investigate this population of intellectual disability. The findings of this study will benefit both DS participants and their families in terms of educational and clinical implications.

1.3 Introduction to Down syndrome (DS)

DS is the leading genetic cause of learning disabilities and cognitive impairment. The most common form of DS is trisomy 21, which is caused by an extra copy of chromosome 21, so there are 47 chromosomes rather than the usual 46. DS can also be caused by mosaicism (only some cells in the body include an extra copy of this chromosome) or translocation (a part of chromosome 21 is attached to another chromosome during cell division) (Chapman and Hesketh, 2000; Mengoni, 2012). The incidence of DS is 1 in 691 live births (Parker *et al.*, 2010). DS has shown an increasing trend in pregnancies in various countries in the world, contributing to an increase in the number of those born with DS every year. It has been suggested that increasing maternal age may explain some of the increase in overall numbers of trisomy cases diagnosed (Loane *et al.*, 2013). DS can be diagnosed during pregnancy through amniocentesis of the foetal cell, or after birth through diagnostic examinations (Weijerman *et al.*, 2008). The incidence of DS in Gulf Arabic countries has increased from approximately 1 to 3 in every 1,000 births (Murthy *et al.*, 2007). The factors underlying this increase are considered to be the same as in other countries. However, while previous research in the Arabic context has studied the medical, psychological and oral health of individuals with DS, cognition and language have remained largely unexplored.

Cognitive impairment is one of the features of DS, with IQ ranging from 30 to 70 (Mason-Apps *et al.*, 2020). Life expectancy among individuals with DS has increased over time, reaching approximately 47 years in 2007 (Presson *et al.*, 2013). This change in life expectancy is likely due to better medical guidance, which enables individuals with DS to be more involved in the community rather than living in institutions/organizations (Bittles and Glasson, 2004). In recent years, social expectations have changed and there has been a move towards mainstream education. Early intervention programmes and vocational training have increased (Buckley *et al.*, 2006). During educational years, individuals with DS make significant progress in literacy and academic skills, although there is much individual variability. A ‘plateau’ is often reported in adulthood (Turner and Alborz, 2003; Couzens *et al.*, 2011).

While there is variability in the abilities of individuals with DS, there appears to be a specific cognitive profile accompanying DS, that is poor verbal skills in comparison with non-verbal abilities (Jarrold *et al.*, 1999; Abbeduto *et al.*, 2007). In terms of the oral language domain, individuals with DS obtain lower scores in expressive vocabulary in comparison to receptive vocabulary and there are greater impairments in grammar than vocabulary. There are strengths in social skills, single word reading and visual memory (Laws and Bishop, 2003; Fidler and Nadel, 2007).

Individuals with DS frequently suffer from medical and physical complications, such as congenital heart disease, muscle hypotonia, weak muscle articulators, hypothyroidism, hearing impairments and visual weaknesses (Antonarakis *et al.*, 2004; Schieve *et al.*, 2009). These have the potential to affect learning and are therefore important aspects to consider when studying language development. Socially, children with DS tend to have more psychological problems than their TD peers. These psychological problems are defined as anxiety and depression and correlate with an increase in age (Dykens *et al.*, 1994).

Individuals with DS have atypical speech motor anatomy, which might affect their speech production and intelligibility. Stoel-Gammon (1997) describes the areas of oral structure in individuals with DS, such as a small oral cavity, a narrow high arched palate, weak facial muscles, irregular dentition, a large tongue that protrudes forward and weak facial muscles affecting the oral muscle tone, such as the lips and tongue. These weaknesses lead to challenges in acquiring normal speech patterns and affect voice quality (e.g. hypernasality) and articulation. Visual weaknesses are also common in individuals with DS and there is a high rate of astigmatism and refractive errors (e.g. short-sightedness and long-sightedness) (Caputo *et al.*, 1989). If the visual defects are not treated with corrective measures, this may affect child's learning, specifically reading skills. However, if visual problems are corrected with spectacles (glasses), learning will not be affected significantly (Mengoni, 2012).

Adequate hearing is important for language and cognitive development. Hearing impairment is very common in individuals with DS, occurring in about two-thirds of children, because of conductive or sensorineural hearing loss or both. It has been found that narrow auditory canals and cranial facial differences cause otitis media, resulting in hearing loss, as well as leading to increased respiratory illness (Roizen and Patterson, 2003). Some studies have examined the correlation between hearing and language measures, finding no significant relationship between hearing (using audiometry or speech discrimination tests) and receptive language (Abbeduto *et al.*, 2003; Miolo *et al.*, 2005). Hearing impairment itself cannot be the only reason for the language difficulties in individuals with DS as there are those with normal hearing who also experience language impairments (Laws and Bishop, 2004). In addition, a further study found no association between the severity of hearing impairments and levels of language development (Chapman *et al.*, 1998). In contrast, other studies have found a weak, but significant correlation (Chapman *et al.*, 1991; Laws and Gunn, 2004). Thus, hearing difficulties do not seem to be the root of language impairment, but may compound difficulties in the case that the hearing problems are severe.

1.4 Developmental trajectory

In the past, most studies have investigated neurodevelopmental disorders such as DS by comparing the mean task scores of this population with a group matched for chronological age or mean age. This group matching method usually collapses individual totals and ability levels to give a group mean and distribution representative of overall performance. It can be argued that this approach offers little indication of how skills change over time, how the disordered group may have arrived at that level of performance and whether this pattern differs from the typical pattern (Carney *et al.*, 2013).

An alternative is the developmental trajectory approach, which attempts to test group differences in the relationship between the dependent measure (i.e. language skills) and independent measures (i.e. chronological/mental age) formally (Thomas *et al.*, 2009) over time. In contrast to assessing differences in cross-sectional group means at one point in time, which masks changes associated with age or non-verbal mental abilities, group differences are evaluated in terms of onset/intercept and rates of development over developmental trajectories. Testing these variables provides more information about the nature of language impairment (i.e. whether there are delays in onset, or the rate of development, or both) and provides guidance for future longitudinal studies (Thomas *et al.*, 2009). It has been claimed to provide a picture that is richer than the cross-sectional approach in terms of whether development is merely delayed (lower intercept, but same gradient), or slower (smaller gradient). In addition, the developmental trajectory approach can accommodate a wide age/ability range in the clinical/disorder group and experimental tasks across this range. These features contrast with a single time-point approach, which will focus on a narrow age/ability range.

The aim of the developmental trajectory approach used here is to construct a function that links performance with non-verbal mental age/developmental level on an experimental task for the whole clinical group (DS); this trajectory can then be compared with the TD trajectory to assess whether the clinical group shows a significant difference in terms of onset and rate of development. An example of the cross-sectional developmental trajectory approach (Thomas *et al.*, 2009) in a clinical group was used in a study of autism spectrum disorder (ASD) (Kover *et al.*, 2013). This aimed to investigate the onset/intercept of the trajectory and rate of development for receptive vocabulary across chronological age for ASD and TD groups. The findings suggested that the onset/intercept for receptive vocabulary development scores across age was lower for individuals with ASD than for the TD group. Further findings suggested that the rate of the development of receptive vocabulary was steeper for the TD group than the ASD group. The developmental trajectory approach can be applied using either a) a cross-sectional

sample (at a single/one point in time, with different ages or abilities), or b) a longitudinal sample (across different time points, or tracing changes within the same individuals) (Thomas *et al.*, 2009).

This study applies the cross-sectional developmental trajectory approach, also comparing trajectories across the DS and TD groups matched according to non-verbal mental ability. In this study, I extended the work of Glenn and Cunningham (2005), who found strong correlations between non-verbal mental ability and vocabulary in a single group of DS individuals, but did not use matched groups or the developmental trajectory approach. I examined the nature of this relation in a group of Arabic-speaking individuals with DS compared to a group of TD Arabic-speaking children matched within the same range of non-verbal cognitive abilities. Specifically, and similarly to Phillips *et al.* (2014), I used cross-sectional developmental trajectory analysis for vocabulary and group matched on non-verbal mental abilities but with Arabic-speaking participants with DS and TD. The RCPM was used as an independent variable as a measure of non-verbal mental ability, making it possible to investigate interactions between cognitive domains over time. This is the key to the neuro-constructivist approach, which suggests that language development occurs through the influences and interaction of cognition (Karmiloff-Smith, 2009). The rationale for using non-verbal mental abilities as a predictor of cognitive ability in the study rather than chronological age is because the latter is a poor predictor of cognitive ability in DS since levels of cognitive impairment can vary widely. Although chronological age is a good predictor of cognitive ability in TD children, it is not for DS participants, and it is unlikely to systematically predict other cognitive/linguistic skills. This ties in with the neuro-constructivist approach (see 1.5 for details). According to this approach, there should be interactions between different cognitive domains over an extended developmental period and these interactions should be relatively similar across groups. Therefore, to test the neuro-constructivist approach, I needed both dependent and independent variables to measure cognitive domains. I could not test this approach accurately including chronological age as one of the variables.

The motivation for selecting a cross-sectional rather than longitudinal developmental trajectory approach was that I could investigate a much wider developmental timescale than would feasible with a genuine longitudinal design. A longitudinal study design is theoretically better because it controls for an individual's variation in developmental trajectories. With a cross-sectional study designs, the data point to different ages of different individuals, but the individuals' variation is not controlled. Nonetheless, the ability to investigate a wide age range is an advantage. Performance on language skills was assessed through vocabulary, NWR and

PA across RCPM raw scores, looking at the intercept of the line, which can be defined as the onset of development, and the gradient of the line, which is the rate of the development on the task. Using this approach, it is possible to investigate the main effects of group (between-subjects factor) and developmental level (within-subjects factor), determining whether development (on the language task) is merely delayed, i.e. characterized by a lower intercept, or slower, i.e. characterized by a group developmental-level interaction.

As the cognitive profile of individuals with DS is often characterized as 'uneven', various control groups are commonly used when conducting studies with individuals with DS and other developmental language disorders (DLDs). These are typically matched on chronological age, mental age and non-verbal cognitive abilities (Chapman and Hesketh, 2001; Hodapp and Dykens, 2001).

This study undertook a cross-sectional investigation of the developmental trajectory in language skills in DS and TD groups. Having a control group is useful when examining the developmental trajectory of language skills in groups with developmental disorders. Having TD individuals matched on NVMAwas warranted in the study because I was interested in whether a language/cognitive skill would be a relative weakness within the DS phenotype. Chronological matching considers different biological maturation and life experiences that can influence task performance, and one would expect the disorder group to exhibit slower development compared with the TD controls matched on chronological age. Therefore, when matching a DS group with a TD group on non-verbal mental abilities, we can eliminate confounding effects around the expected delays in development due to the DS group's lower cognitive functioning and provide information about cognitive behavioural profiles. Matching on cognitive abilities typically results in group comparisons with significantly different chronological age. Controlling for non-verbal mental age it is possible to tell if a skill in people with DS develops more slowly than might be expected given their general level of intellectual functioning as all of their cognitive skills will develop at a slower rate than in TD peers of the same age. Non-verbal mental age is a control that has been employed in many studies with DS participants (Vicari *et al.*, 2000; Fidler *et al.*, 2006). It is worth noting here that given the uneven pattern of strengths and weaknesses in DS, the estimate of mental age depends on the task applied (Chapman and Hesketh, 2000). Sometimes receptive vocabulary measures are used as a matching variable; however, it is not possible to match on the task investigated in this study. In addition, non-verbal tasks are preferable due to DS individuals' weakness in verbal ability. Therefore, this study used non-verbal cognitive abilities (RCPM) and matched TD children with similar NVMA raw scores as a control group. RCPM has not been standardized on a

Kuwaiti population; it was therefore thought sensible to use raw scores on RCPM for the comparisons made in this study.

1.5 Cognitive ability and language development

To understand language development among individuals with DS, it is necessary to understand current accounts of typical language development. There has been theoretical debate regarding the development/acquisition of language, the effects of genetics and environmental inputs and whether language development is related to cognitive ability or not. Chomsky (1976) proposed 'nativist theory', arguing that a child's language abilities are innate and develop from birth, requiring only a small amount of input in terms of exposure from the environment. In addition, Chomsky (1976) suggested that language is a domain-specific element and consequently the language system does not rely on cognitive processes. Thus, if an individual/child has a language disorder, nativist theory would suggest that it is due to an impaired language module, which is genetic and cannot be remedied by the environment.

In contrast, 'neuro-constructivist' theory posits that language development occurs through the influences and interaction of cognition, the brain, the environment and genes (Karmiloff-Smith, 2009). This theory argues that language impairment in those with genetic disorders (such as DS) is due to an atypical developmental trajectory (Steele *et al*., 2013). According to Piaget (1980), language is a manifestation of intelligence and not disconnected from it. In addition, several studies have addressed the importance of cognitive precursors to language acquisition (Stojanovik, 2014). The notion of cognitive precursors suggests that language development is dependent on the development of other cognitive abilities. These abilities include speech segmentation (Newman *et al*., 2006) and joint attention (Markus *et al*., 2000). Thus, from the nativist perspective, the challenge lies in testing the idea that language development is independent of cognitive development because in TD children different cognitive skills develop in synchrony (Stojanovik, 2014). Based on this theoretical approach, a child with a developmental disorder (e.g. DS) would also be expected to show language development in line with cognitive development.

Some studies have suggested that language abilities may not be fully dependent on non-verbal cognitive abilities in individuals with DS. This has led to the suggestion that some language abilities do develop independently of cognitive abilities as the nativist hypothesis would suggest (Stojanovik, 2014). However, the association between language and cognitive abilities has not undergone detailed investigation. In addition, only a limited number of studies have used a developmental trajectory approach to shed light on the delay in language development and

cognitive abilities among individuals with DS. If it transpires that the developmental trajectory of language and non-verbal cognitive abilities is atypical in DS and there is no clear disconnection between abilities in language and cognition, one could argue that DS provides evidence for the neuro-constructivist theory. The language and cognitive profiles of individuals with DS are mostly characterized as 'uneven'. Children with DS are slow to acquire language and their language performance tends to be lower than their cognitive development (Fowler *et al*., 1994; Chapman and Hesketh, 2000). However, in one exception, it was found that their language abilities were higher than their cognitive abilities (Rondal, 1994). A large body of studies have addressed the matter of cognitive precursors to language acquisition.

1.6 Language profiles among individuals with DS

This section discusses the language development of individuals with DS in relation to chronological age and non-verbal mental age/cognitive abilities, as well as making a comparison with TD children.

Like other children with DLDs, those with DS are at risk of impaired language development. The patterns of their language development are generally slow compared to TD children (Berglund *et al.*, 2001; Facon *et al.*, 2012; Facon and Magis, 2016; Loveall *et al.*, 2016). Several studies have argued that language development in individuals with DS is slow and reaches a plateau between adolescence and early adulthood (Fowler, 1988, 1990; Fowler *et al.*, 1994). Moreover, language production (e.g. expressive vocabulary) is affected to a greater extent than language comprehension (e.g. receptive vocabulary). In tests of receptive vocabulary, it has been reported to exceed general non-verbal ability (Abbeduto *et al.*, 2007; Roberts *et al.*, 2007; Ypsilanti and Grouios, 2008). Children with DS under the age of 5 years tend to have a language profile characterized by receptive language abilities that are in line with and similar to their non-verbal mental/cognitive age, whereas their expressive language abilities are lower than their matched non-verbal mental age (Miller, 1999).

It is well known that language development in DS does not reach TD levels in adulthood (Chapman and Hesketh, 2000), but it is not clear when the language plateau is reached. Does language development among those with DS slow early in adolescence, or beyond early adulthood? These questions relate to the critical period hypothesis proposed by Lenneberg (1967), who identified a slowing in progress of language learning by the time a child reached adolescence due to maturational constraints related to changes in neuroplasticity. In further work, Rondal and Comblain (1996, 2002) have argued that the critical period for the development of phonology, morphology and syntax ends in adolescence, while semantics and

pragmatics would be affected once individuals with DS reach adulthood (e.g. 30–40 years). The deterioration of receptive language abilities has been recognized as a possible early sign of dementia. This relationship with dementia shows that understanding the developmental trajectory of receptive language (e.g. vocabulary) in individuals with DS prior to the age when the onset of dementia would be predicted would be a beneficial endeavour (Cuskelly *et al.*, 2016).

Vocabulary knowledge in TD children has been found to be a predictor of verbal and reading comprehension (Silva and Cain, 2015). Similar associations have been found for individuals with DS, with receptive vocabulary being a predictor of academic performance (e.g. reading, spelling) and social skills (Laws and Gunn, 2002). Van der Schuit *et al.* (2011) have suggested that vocabulary development may be more important – indeed essential – for individuals with intellectual disabilities (e.g. DS) than for those developing typically because they found that vocabulary predicted syntactic development in this group. To the best of my knowledge, the development of receptive and expressive vocabulary among Gulf Arabic individuals with DS remains largely unexplored. Therefore, this study will investigate the development of vocabulary in individuals with DS in relation to chronological age and non-verbal cognitive abilities, in addition to making a comparison with the TD control group.

Phonological short-term memory is another language domain that can be measured by NWR (for further details, see Chapter 2). A deficit in phonological short-term memory in individuals with DS has been confirmed by a wealth of studies (Laws and Gunn, 2004; Conners *et al.*, 2018; Penke and Wimmer, 2020). In addition, NWR has been found to be related to sentence comprehension measures and vocabulary development. This study aims to provide a further step in exploring the nature of the relationship between NWR and chronological age/cognitive abilities among Gulf Arabic individuals with DS.

The following sub-sections review cross-sectional and longitudinal studies that have investigated the development of certain language components in individuals with DS related to this research.

1.6.1 Cross-sectional studies

Language development might slow down once individuals with DS reach the onset of adolescence, or earlier, at about 7 years of age (Fowler, 1990). The development of expressive language was studied by Chapman *et al.* (1998). They investigated 47 children and adolescents aged 5–20 years and compared them to 47 TD children aged 2–6 years matched for non-verbal mental age. Expressive language skills were tested through 12-minute narratives and 6-minute

conversations using various measures, e.g. mean length of utterance (MLU), total words, intelligibility, etc., to evaluate the development of expressive language in relation to chronological age. This was tested through linear trends and showed significant age sub-group effects (an increase in development on all tasks with an increase in age). This study suggested the continued development of expressive language among adolescents with DS.

Chapman *et al.* (1991) further studied the development of receptive language skills cross-sectionally by examining receptive vocabulary (Peabody Picture Vocabulary Test [PPVT]) and syntactic comprehension (Test of Auditory Comprehension of Language [TACL]) in children and adolescents with DS aged 5–20 years matched on non-verbal age with 48 TD children aged 2–6 years. The results showed that both groups performed significantly higher in the vocabulary tasks than in the syntax comprehension tasks. Moreover, the TD group performed significantly higher than the DS group in vocabulary and syntax comprehension. In addition, chronological age and mental age predicted vocabulary comprehension more strongly than syntax comprehension. A multiple regression analysis was applied using a stepwise method as a second step after conducting correlation analyses to see if the participants' chronological age/mental age might predict receptive vocabulary in both the DS and TD groups. In terms of the DS group, it was found that participants' chronological age and mental age could predict 64% and 78% of the variance in receptive vocabulary respectively. It is worth noting that mental age was a better predictor than chronological age of receptive vocabulary. Another multiple linear regression was undertaken for the TD control group, also to predict receptive vocabulary based on chronological age and mental age. It was found that participants' chronological age could predict 78% of variance in receptive vocabulary and mental age 84%.

Chapman *et al.*'s (1991) findings highlight the importance of continuing speech and language therapy sessions in adolescents and young adults with DS to increase their communicative skills in terms of receptive vocabulary, particularly given the association found with vocabulary rather than syntax in both DS and TD individuals. However, their findings are not in line with those of Fowler (1988), who investigated MLU and syntactic production in 10 children with DS (4–13 years old) longitudinally every 6 months for 4–7 years. The findings showed that MLU and production of syntax levelled off and reached a plateau as early as 8 years of age. One might argue that the number of the participants was very small, potentially reducing the statistical power, and that there was no control group, so no conclusions can be drawn regarding possible developmental specificities among individuals with DS.

A more recent cross-sectional and cross-linguistic study was undertaken by Facon and Magis (2019), who investigated the development of receptive vocabulary and receptive syntax in French-speaking children, adolescents and young adults with DS (n = 62) aged 5–25 years, matched on chronological age and non-verbal cognitive abilities to individuals with intellectual disability (ID) (n = 62) of similar aetiology. The aim of this study was to compare the developmental trajectories of vocabulary and syntactic comprehension of individuals with DS and ID to investigate whether there was a language development plateau for individuals with DS. Multiple linear regression analysis showed that chronological age significantly predicted receptive vocabulary and syntactic comprehension in both groups. The rate of development for vocabulary and syntax was similar in the two groups and there was no significant interaction between chronological age and group in terms of predicting vocabulary/syntax measures. Furthermore, the correlation between chronological age and vocabulary was significantly stronger than the correlation between chronological age and syntax for both groups. Chronological age predicted 15% of the variance in receptive vocabulary and 3% of variance in receptive syntax. These results suggest continuous progress in vocabulary and syntax as measured in test scores between childhood and adulthood for both groups. In addition, they highlighted the importance of including vocabulary comprehension in intervention programmes.

These findings challenge the idea of a language plateau among individuals with DS. Moreover, they argue against Lenneberg's (1967) and Fowler's (1988) pessimistic expectations in contesting the importance of language therapy for individuals with DS in adolescence. In addition, Facon and Magis's (2019) findings contradict those of Chapman *et al.* (2002), who showed that syntactic comprehension (TACL) decreased between adolescence and adulthood among those with DS. This discrepancy could be due to different study designs – cross-sectional in Facon and Magis's (2019) study and longitudinal in Chapman *et al.*'s (2002) work. In addition, there is the difference in assessment methods used to assess syntactic comprehension. In particular, the cross-sectional design has potential limitations, providing a snapshot of the participants' abilities. Indeed, as suggested by Hertzog (1996), one of the optimal ways of studying development is to start with comparisons of different age groups, continue with a cross-sectional design and then extend the study analysis using a longitudinal design.

The development of receptive vocabulary has further been investigated by Phillips *et al.* (2014). They examined the development of receptive vocabulary (using the Peabody Picture Vocabulary Test [PPVT]) in three groups matched on mental age: individuals with DS (n = 54) aged 10–21 years old; an intellectual disability group (n = 29) aged 10–21 years; a TD group

(n = 35) aged 4–13 years. They considered the correlation between mental age using Leiter-R and receptive vocabulary (PPVT) by performing developmental trajectory analysis in the three groups matched on mental age. They employed a cross-sectional developmental trajectory approach (see 1.3 for further detail) and undertook analysis of covariance (ANCOVA). The results of the ANCOVA indicated no differences between the groups, either in terms of onset or rate of development of receptive vocabulary, as there was no significant effect of mental age or group interaction in predicting vocabulary knowledge. The results of this study extend those of Glenn and Cunningham (2005), who examined the correlation between mental age and vocabulary only in individuals with DS. Philips *et al.* (2014) suggested that the rate of development of vocabulary in children and adolescents with DS is similar to that of TD and intellectual disability groups matched on mental age. These findings might suggest the inclusion of DS children in mainstream education with TD and intellectual disability children of similar mental age, as they might learn from each other's experience.

The development of short-term memory in individuals with DS was also investigated cross-sectionally by Carney *et al.* (2013). They used a developmental trajectory approach (see 1.3) and tested auditory short-term memory (word span task) and visual short-term memory (block span task) in 30 children, adolescents and young adults with DS (10–21 years old), compared to 69 TD children matched on mental age (4–9 years old). The researchers found the rates of development were similar in the DS and TD groups and the results for both auditory and visual short-term memory tests improved as a function of increasing chronological age. Further findings were that visual short-term memory performance was significantly better than auditory short-term memory performance in the DS group, but the rate of development was similar in both groups. These findings suggest that development as tested by word span and block span tasks keeps up with mental age. This also suggests continuous development of short-term memory in individuals with DS and these outcomes challenge the notion of a language plateau among individuals with DS.

1.6.2 Longitudinal studies

Cuskelly *et al.* (2016) investigated the developmental trajectory of receptive vocabulary (using the PPVT) longitudinally among Australian individuals with DS (n = 205) from early childhood to adulthood within an age range of 2–29 years old. The full sample comprised three groups: group 1, born between 1973 and 1978; group 2 born in and after 1978; group 3 comprised the youngest group. All the age groups were followed over a period of time. A significant correlation was found between chronological age and receptive vocabulary from schooling until around 20 years of age. Latent growth curve models (participants were tested at different ages

and had different test points) were used to determine the trajectory of receptive vocabulary. Maternal education, non-verbal mental age and gender were used as the predictors for rate of development. The results of the latent growth model suggested that the rate of development of vocabulary appeared to be slower in individuals with DS than TD matched on non-verbal mental ability. No significant effect of maternal education or gender was found on the development of vocabulary. However, non-verbal mental age (Stanford-Binet) was found to be a significant predictor of the development of receptive vocabulary in the DS group.

The explanation for the downward curve in the development of vocabulary at about 20 years and above was considered to lie in the neurological changes evident in many adults with DS (i.e. the risk of early onset dementia), as this might lead to deterioration in their performance (Coppus *et al.*, 2012). Another possible explanation was the low number of participants in the older age group (Cuskelly *et al.*, 2016). In addition to health and environmental characteristics, the educational experiences of adults differed from those of younger participants, who were more likely to attend regular schools and might have received early interventions (Couzens *et al.*, 2012; Cuskelly *et al.*, 2016). The effect of using non-verbal ability/mental age to predict receptive vocabulary skills was consistent with the work of Campbell *et al.* (2013), but these studies used a different measure of non-verbal mental abilities. This suggests that vocabulary development in individuals with DS is related more to cognitive abilities than chronological age. The decline in receptive vocabulary at around 20 years of age found by Cuskelly *et al.* (2016) contradicts the results of a study adopting a similar longitudinal design conducted by Carr (2012), which did not find such a decline in vocabulary after 21 years among DS participants in the United Kingdom (UK). The justification for this might be the different experiences adults were exposed in the UK and Australian cohorts (Cuskelly *et al.*, 2016).

The development of phonological short-term memory was studied longitudinally by Laws and Gunn (2004), in addition to vocabulary skills. They investigated the development of receptive vocabulary using the British Picture Vocabulary Test (BPVT) and NWR among 30 adolescents and young adults with DS. They tested the groups at two points over a 5-year period and calculated correlations between chronological age and language scores at time 1 and time 2 for the whole sample. The development of vocabulary was found to continue into young adulthood, consistent with Fowler (1995). However, the development of NWR showed a decline with an increase in age. These findings indicated that older participants were likely to make less progress than younger ones (Laws *et al.*, 1995). In addition, hearing deteriorated with age and the hearing threshold correlated with NWR as those who wore hearing aids performed significantly lower than those who did not (Laws and Gunn, 2004).

In addition, a relatively recent longitudinal study by Hick *et al.* (2005) investigated the development of verbal short-term memory (digit span, word span), visuo-spatial short-term memory (pattern recall) and vocabulary (British Picture Vocabulary Score [BPVS], EVT) 3 times in 1 year in 3 groups. In all, the study included 12 children with DS (8–11 years), 9 children with DLD (3–4 years) and 12 TD children (3–4 years). All the groups were matched on mental age. The TD children showed higher scores for vocabulary and verbal short-term memory measures than the clinical groups. This confirmed the results of previous studies documenting difficulties in verbal short-term memory among individuals with DS (Jarrold and Baddeley, 1997; Jarrold *et al.*, 2002; Laws, 2002). The DLD children made progress over time, but the children with DS showed a plateau between time 2 and time 3. However, individuals with DS showed a similar rate of development in pattern recall to the TD group. These findings support the notion of an advantage of visuospatial memory over verbal short-term memory in individuals with DS (Jarrold and Baddeley, 1997; Laws, 2002). A clinical implication that can be suggested from this study is that visually based intervention approaches in education and language therapy sessions for individuals with DS are likely to be successful. It is suggested that investigations be undertaken among individuals with DS over wider age ranges, including adolescents and young adults, as such research might aid the design of effective interventions.

A recent longitudinal study by Mason-Apps *et al.* (2020) investigated developmental trajectories in early stages of language development by comparing infants with DS (n = 30) to TD infants (n = 35) with similar non-verbal mental abilities longitudinally in two ways: i) at 3 time points over a 12-month period; ii) at 2 time points when the DS and TD groups had made equal progress in non-verbal mental age. The language measures used to assess language development were: a) receptive and expressive vocabulary, tested through a parental report measure comprising a checklist of the words the child might know; b) auditory comprehension and expressive communication, tested through a subscale that evaluated the child's understanding of language and how well the child communicated with others, vocally and socially. The results showed that the TD group performed significantly higher on language and vocabulary assessments by the end of the 12-month period. The findings further showed a main effect of time, with all language measures increasing between the two time points for the DS and TD groups. In addition, the expressive communication and expressive vocabulary measures showed the same rate of development in the DS and TD infants. The receptive vocabulary and auditory comprehension results were significantly higher in the DS infants than in the TD infants. Overall, the developmental trajectories for all language measures were similar for the DS and TD groups. This was based on the lack of interaction between time and group in all the

analyses. The results showed that when non-verbal mental abilities were considered, infants in the DS group displayed a receptive language advantage relative to their non-verbal mental abilities.

Mason-Apps *et al.*'s (2020) findings were consistent with those of Galeote *et al.* (2011), who investigated Spanish-speaking infants with DS and reported that expressive vocabulary did not lag behind TD infants matched on non-verbal mental abilities. In addition, the receptive vocabulary skills of infants with DS were higher than those of the TD cohort matched on non-verbal mental abilities. The findings of Galeote *et al.* (2011) and Mason-Apps *et al.* (2020) suggest that the language of infants with DS may not be developing atypically compared to neurotypical infants. The findings of these studies indicate that non-verbal mental abilities/cognitive skills are related and can support the development of language (Casby, 1992). In addition, considering early interventions is very important as they may provide an opportunity to target aspects with infants with DS in the early stages of language development before they become areas of weaknesses.

To summarize, sections have 1.5.1 and 1.5.2 reviewed the development of language among individuals with DS in relation to chronological age and cognitive abilities. The findings vary based on study design, context, sample and methods. Cross-sectional studies, such as those of Chapman *et al.* (1991) and Facon and Magis (2019), found a significant correlation between chronological age and the development of vocabulary in individuals with DS and TD matched on cognitive abilities. These outcomes might suggest the importance of continued speech and language therapy sessions for adolescents and young adults with DS to increase their communicative skills. Furthermore, Phillips *et al.* (2014) found the rate of vocabulary development in relation to mental age to be similar for DS and the TD groups. This suggests that the rate of vocabulary development among individuals with DS is consistent with non-verbal mental abilities. It seems to be related to cognitive mental abilities rather than chronological age. However, Fowler (1988) studied the development of language longitudinally and found language development in individuals with DS slows down once they reach 8 years of age. This might have been related to the small number of participants in the study and the different methods used to assess language development. Similarly, Cuskelly *et al.* (2016) found slower development between chronological age and receptive vocabulary among adolescents with DS; the justification for the lack of correlation in adolescents was the small number of participants. Interestingly, non-verbal mental age was a significant predictor of receptive vocabulary in individuals with DS. However, Cuskelly *et al.*'s (2016) study used a different measure for cognitive abilities from Phillips *et al.* (2014). This suggested that the rate of

vocabulary development among individuals with DS was consistent with non-verbal mental abilities. It seems to be related to cognitive mental abilities rather than chronological age in both cross-sectional and longitudinal studies.

The development of phonological short-term memory and phonological awareness remains largely unexplored. Therefore, this study aimed to examine these language measures in the Gulf Arabic context, in addition to their relationship with non-verbal cognitive abilities. The discrepancy in the development of language found in existing studies might be due to the different study designs used (e.g. cross-sectional vs. longitudinal). Based on the different methods used by prior work, this research adds a cross-sectional developmental trajectory approach to provide evidence focused on the development of vocabulary (receptive and expressive), phonological awareness and phonological short-term memory (e.g. NWR) in Kuwaiti Arabic individuals with DS matched to a TD cohort on mental age.

These studies are encouraging from the viewpoint of undertaking speech and language interventions for individuals with DS. A further recommendation would be to ensure that the learning environments for children with DS provide the chance to learn vocabulary appropriate for those of a similar mental age (e.g. related to vocational work).

1.7 Similarities with Developmental Language Disorder (DLD)

Furthering understanding of the complex language difficulties in individuals with DS, some studies have drawn comparisons with the language profiles associated with specific language impairment (SLI), defined as a developmental disorder indicated by the presence of significant receptive or expressive language impairments with a normal IQ level and in the absence of any known physical or neurological cause or sensorimotor deficits (Bishop, 2006). Currently, there is a debate concerning whether language impairment can exist without a deficit in other cognitive areas (Bishop *et al.*, 2017). There have been recent changes in terminology, proposing the acceptance of DLD in preference to SLI (Bishop, 2017). The child with DLD is defined as having difficulties across a range of linguistic areas, such as grammatical morphology, word learning and comprehension of syntax. Poor prognosis (i.e. lack of improvement over time without intervention) is considered to be a key characteristic (Bishop et al, 2017). It may also co-occur with other cognitive, physical or neurological deficits. In contrast, the term SLI could be taken to mean that the child has no difficulties except with language. Individuals with DLD face a variety of challenges in education and employment, as well as mental health difficulties. The term DLD is widely used in the UK and Europe (whereas SLI is used in North America) and will be used in this thesis based on Bishop (2017). However, it should be noted that SLI

has been used widely to describe this population in earlier studies because DLD was not proposed until 2017. Individuals with DLD, similar to individuals with DS, tend to have impairments with expressive rather than receptive vocabulary. Moreover, phonological and grammatical skills are more impaired than vocabulary (Laws and Bishop, 2003, 2004; Ypsilanti and Grouios, 2008; Laws *et al.*, 2015). These parallels have led to the assumption that the language deficits in DS may be a type of DLD as they are somewhat independent of general cognitive difficulties. Therefore, drawing similarities between the two disorders (DS and DLD) may lead to the identification of a common causal factor.

The development of language has been studied among DS, DLD and TD children longitudinally. Hick *et al.* (2005) compared the development of vocabulary (receptive and expressive) and verbal short-term memory (digit span and word span) in 12 children with DS and 9 children with DLD to that of 12 TD children. All participants were matched on mental age and they were tested 3 times over 1 year. At the final time point, both clinical groups scored significantly lower than the TD group. Similarities were seen in vocabulary and verbal short-term memory measures and for the DS and DLD groups. The results of this study showed that the clinical groups shared similar language profiles in terms of vocabulary skills and verbal short-term memory. It might be that a therapeutic approach for DLD could be adapted and also be appropriate for those with DS.

DS and SLI may share similar language profiles, but a comparison made between them found some differences. Laws and Bishop (2003) found that although both groups were impaired in terms of producing grammatical morphemes, the DS group only had difficulty producing the regular past tense, while the SLI group had difficulty with both regular and irregular past tenses (Laws and Bishop, 2003). A similar pattern was observed in children with DS for the production of regular and irregular third person singular (Eadie *et al.*, 2002). The justification for the better performance on irregular morphemes in groups with DS may be due to their slightly higher vocabulary skills. Furthermore, irregular morphemes do not follow a consistent pattern and may be learned as an isolated vocabulary element (Laws and Bishop, 2003).

Based on the findings of previous studies, there is no convincing evidence that language disorders associated with DS and DLD share a common causal factor; perhaps a key difference is the genetic condition in DS, entailing a physical phenotype that is not present in children with DLD. However, some studies contend there may be similarities in language features, such as vocabulary and grammar, which are more exposed than others to a host of risk issues resulting in many similarities between DS and DLD groups (Laws and Gunn, 2004).

1.8 Rationale for studying DS

There are several reasons for the increased interest in studying genetic syndromes such as DS. One strong reason is because of the uneven profiles of individuals with DS, categorized by dissociations of cognitive abilities (Stojanovik, 2014). Therefore, it is important to understand the behavioural manifestations of a genetic abnormality and to gain a better understanding of the condition and provide diagnosis and remediation. Another motivation for studying DS is the potential contribution that such research can make to theoretical arguments concerning the role of cognitive mechanisms supporting the development of language (Stojanovik, 2014). Does DS have the potential to determine (a) the nature of a plateau (whether it exists, when it is reached) and (b) the degree to which language development is supported by non-verbal cognitive abilities?

In recent years, there has been a tendency to include individuals with DS in mainstream schools (Dobrić and Nemet, 2015) and there has been an increasing trend for mainstream schooling in Kuwait. The findings of this study might affect educational support for DS children. In particular, a positive correlation between chronological age and language might suggest the usefulness of continuing education for adolescents with DS. Therefore, a better understanding of language development in Gulf Arabic individuals with DS could lead to the development of evidence-based practice that might have clinical, educational and policy implications. In addition, it is clearly less than optimal for Arabic speech and language therapists to have to rely on literature and research undertaken in English-speaking contexts as Arabic is entirely different.

It could be argued that speech and language therapists might play an important part in the provision of intervention services for individuals with DS if there is a wish to promote their cognitive development. There is ongoing discussion concerning whether cognitive development in individuals with DS follows a developmental pattern that reflects that present in TD, or whether the developmental trajectory is different as a result of the abnormal gene (Stojanovik, 2010a). Therefore, the findings of this study may help speech and language therapists in their role conducting sessions (e.g. continuing to provide speech therapy sessions up to adolescence and continuing education), as well as contributing by including DS and TD participants matched on mental age, and addressing the relationship with TD and SLI.

1.9 Difference between English and Arabic

One of the interesting characteristics of Arabic is diglossia (Ferguson, 1959), namely that it is a language that has two different types. Modern Standard Arabic (MSA) is the language of

media, generally used in formal education and formal speech and writing, such as newspapers, textbooks, children's books and some television and radio programmes. Spoken Arabic Vernacular (SAV), referred to as the Kuwaiti dialect (KD), is used socially as the primary mode of communication in informal communication. Children grow up speaking and listening to KD. They will be exposed to MSA when they start going to kindergarten at 4 years of age, but even before starting formal education, most children watch foreign cartoons translated into MSA.

All Arabic speakers, regardless of their SAV, use MSA for formal spoken and writing purposes. This study used MSA to examine phonological awareness, vocabulary and NWR. However, the instructions were given in KD. The linguistic distance between two types of Arabic was not an issue as both the DS participants and TD children were able to speak and understand both KD and MSA. Following on from diglossia, the phonology and morphology of Arabic will be discussed in Chapter 2.

1.10 Kuwaiti special educational law and system

Kuwait provides compulsory education free to students in primary and middle school from grades 1 to 9. High school is also free, but not compulsory, from 10^{th} to 12^{th} grade (Burney and Mohammed, 2002). Special education services are offered by two governmental organizations that work independently of each other: the Ministry of Education and the Public Authority of the Disabled. The Ministry of Education has 29 schools providing education to special needs students with different disabilities (e.g. visual, mental, physical) and around 1,739 students with intellectual disability aged 6–22 years old. The Public Authority of the Disabled has 51 schools for special needs and educates 7,102 special needs students within an age range of 3–21 years. The total number of students with special needs in Kuwait City is around 8,841, representing 2% of the general student population. The cost of special educational school provision in Kuwait for 2014–2015 was $93 million, representing 13% of the national budget (Ochoa *et al.*, 2017).

The Ministry of Education has two specialized schools only for DS students, one school for males consisting of 10 classrooms and the other one for females also consisting of 10 classrooms. There are approximately 6 students in each classroom and 3 teachers, i.e. 1 teacher for 2 students (AlMusaileekh, 29 October 2019).

Mainstream schools are developing in Kuwait. To the best of my knowledge, however, there are only a few mainstream schools in Kuwait that have both TD students and special needs students with high cognitive abilities.

1.11 Significance of the study

The study investigates the developmental trajectory of vocabulary knowledge, NWR and PA in relation to non-verbal mental abilities among DS and TD Kuwaiti Arabic-speaking children. It also investigates the relationship between language measures. This research is significant for several reasons, as follows:

- Several studies undertaken with English speakers have suggested that individuals with DS show a different language profile compared to TD children. In addition, there has been a theoretical debate concerning whether language development interacts with cognitive ability or is not related. This study contributes to this debate by investigating the developmental trajectory of language skills across RCPM, which represents nonverbal cognitive abilities in DS and TD groups in the Gulf Arabic context.

- Correlations between NWR, vocabulary and PA have been identified in studies of English-speaking TD and DS groups as having an impact on language development. This study adds to the existing literature by studying the correlation between vocabulary, PA and NWR among Gulf Arabic-speaking individuals with DS and TD participants. This study will be one of the first investigations of these language skills in Gulf Arabic-speaking individuals with DS using Arabic language measures. While not a focus of this research, the results of the study will also give an indication of whether the language difference has an impact on the development of language skills in individuals with DS. Arabic differs from English in that it is a morphologically rich language and it is a nonconcatenative, root and pattern language with interaction between phonology, syntax and morphology. Arabic has a flexible word order in which subject-verb-object and verb-subject-object are commonly used. The verb-subject-object pattern is commonly used in Classical Arabic and MSA (Shaalan, 2010). The Gulf Arabic context differs from previous studies in terms of language, cultural context and educational setting (see 1.9 for further detail).
- The findings from this study may also enable educators and researchers to develop effective educational and research approaches appropriate for the population of DS learners. Educational and clinical implications can be drawn from the outcomes of the study (e.g. the continuation of language and speech therapy sessions in adolescence).

1.12 Thesis structure

The thesis is organized in seven chapters, including this introduction chapter, which has provided an overview of and background to the study for the reader. The other chapters in this thesis are organized as follows:

Chapter 2 will review NWR and its relation to vocabulary development in TD individuals and those with DS. It will consider the main theories concerning NWR, highlighting two main theories that try to explain NWR impairments in individuals with DS, namely phonological short-term memory theory and the phonological processing account. The processes involved in NWR and common NWR tests used widely in English studies will be reviewed. This chapter will conclude with the rationale for studying NWR in the Arabic context and a comparison of scoring methods.

Chapter 3 will review PA and the development of PA in English, Arabic and DS studies. This chapter will also explain the relationship between PA and vocabulary (e.g. using the LR model). The crucial importance of vocabulary for PA and findings from TD and DS studies will also be reviewed. A further objective of this chapter is to demonstrate the importance of the correlation between PA and short-term memory evidenced in TD studies. Finally, the research questions and hypotheses of the study will be presented at the end of the chapter.

Chapter 4 will present the study methodology, including detailed information concerning the participants in the DS and TD groups, the methods used and procedures, as well as the pilot study procedure. In addition, it will outline the data analysis.

Chapter 5 will present the study findings, including analysis using descriptive statistics, correlation analysis, Fisher's z transformation and general linear models/ANCOVA, to address the research questions.

Chapter 6 will present the discussion of the findings of this study and set out the theoretical, clinical and educational implications of the findings. The limitations of the study and directions for future research in the field will be discussed. This chapter ends with the conclusions of the study as a whole.

1.13 Summary

This chapter has provided an introduction to the study for the reader. It has identified DS, the developmental trajectory and the language profile among individuals with DS. An overview has been presented concerning language profiles in cross-sectional and longitudinal DS studies. Furthermore, it has considered similarities with DLD, provided the rationale for studying this genetic syndrome, outlined differences between English and Arabic, introduced the Kuwaiti special education law and system, and discussed the importance of having a control group. This chapter has ended with the significance of the study and thesis structure. Following on from this chapter, the coming chapters examine the literature regarding the language aspects

addressed in this study and the nature of phonological skills as measured based on NWR, PA and vocabulary.

Chapter 2. Non-Word Repetition and Vocabulary

2.1 Introduction

This chapter begins within a general overview of non-word repetition (NWR) and its relation to vocabulary development. Various studies that have investigated the correlation between NWR and vocabulary in individuals with DS and TD are then reviewed. An account of the main theories of NWR and vocabulary, namely phonological short-term theory and phonological processing, is given. In addition, the process involved in NWR is discussed, as are common NWR English tests. This chapter also provides the rationale for studying NWR in Arabic, including the properties of the phonology and morphology of Gulf Arabic. This chapter ends with the two scoring methods used to score the NWR test.

2.2 Non-word repetition (NWR)

NWR is the most effective predictor of language development, especially during the early stages of language development (Gathercole, 2006). Furthermore, it has been considered a major tool for identifying children with language impairment (Weismer *et al.*, 2000; Norbury *et al.*, 2001; Khater, 2016), in addition to correlating with various language measures (Gathercole and Baddeley, 1990). Thus, there has been increased interest in investigating individuals' ability to repeat non-words to investigate the underlying psychological mechanisms that may predict language abilities in TD children and atypically developing children as poor performance in NWR tasks is considered a clinical marker of DLD (Conti-Ramsden and Hesketh, 2003).

NWR has been used with different populations – TD and DLD children, adolescents and adults – and across different languages. NWR scores are significantly correlated with receptive and expressive vocabulary tests in Arabic TD children, but there is evidence that this relationship is weaker in Arabic DLD populations (Khater, 2016). The small number of participants (n = 15) was suggested as the reason for this result and therefore there is a need for further studies to corroborate this finding.

A large number of studies have shown that individuals with DS have significant problems with NWR (Bird and Chapman, 1994; Fowler *et al.*, 1995; Jarrold and Baddeley, 1997; Jarrold *et al.*, 2000; Laws and Gunn, 2004). However, this deficit has not been linked to hearing loss (Jarrold and Baddeley, 1997; Seung and Chapman, 2000; Laws, 2004), or speech-motor deficits (Jarrold *et al.*, 2002). It is not affected by socio-economic differences (Dollaghan and Campbell, 1998; Oetting and Cleveland, 2006; Engel *et al.*, 2008) or differences in intelligence quotient

(IQ) (Bishop *et al.*, 1996; Weismer *et al.*, 2000). Although the correlation between NWR and vocabulary knowledge has been investigated among TD and DLD populations in the Gulf Arabic context (Shaalan, 2010; Khater, 2016), the correlation between NWR and vocabulary development in terms of neurodevelopmental disorder (e.g. DS) has not yet been explored. Therefore, this study will investigate and explore the correlation between NWR and vocabulary growth among Kuwaiti Arabic individuals with DS, compared to the TD control group matched on mental age.

2.3 The relationship between NWR and vocabulary in TD studies

The association between NWR and receptive vocabulary is well documented in TD studies (Baddeley *et al.*, 1998; Briscoe *et al.*, 2001; Coady and Evans, 2008; Khater, 2016). These studies have shed light on this association in different ways, based on two theories explained in 2.5.2 and 2.5.3. The first is the phonological short-term memory account of NWR (Gathercole and Baddeley, 1989, 1990) and the second is the phonological processing account developed by Snowling *et al.* (1991). A significant relationship between NWR and receptive vocabulary is commonly posited as it is argued that NWR mimics child behaviour when learning a new lexicon; doing so entails attending to novel auditory information that is used to create phonological representations. Thus, TD children with good vocabulary skills tend to score better on NWR tasks than children with poor vocabulary performance (Bowey, 1996; Metsala, 1999; Bowey, 2001).

A strong correlation between NWR and vocabulary knowledge has been documented as evident at the age of 4 years (Gathercole and Baddeley, 1989; Gathercole *et al.*, 1991), but this correlation is no longer significant by the age of 5 (Gathercole *et al.*, 1992). Thus, the influence of phonological short-term memory in prompting vocabulary growth becomes weaker and it is rather child vocabulary that seems to affect NWR through the use lexical and sub-lexical information. Between the ages of 4 and 5 years, NWR has been suggested to be influenced by vocabulary development, while before the age of 4 it is NWR that exerts a stronger influence on vocabulary development (Gathercole *et al.*, 1992). However, Gathercole *et al.*'s (1992) study did not clarify how the effect between NWR and vocabulary reverses with age. Gathercole *et al.* (2005) reported other factors that may influence NWR, such as the phonological complexity of the task (i.e. consonant clusters). Gathercole *et al.* (1994) found that vocabulary development and NWR scores were highly correlated at 4, 5 and 6 years old ($r = .52$), with $p < .01$ in each case, but the correlation had declined at 8 years old ($r = .28$). The association between vocabulary knowledge and NWR is typically strongest during the early stages of acquiring a language.

The association between NWR and vocabulary seems to hold better for receptive vocabulary knowledge than expressive vocabulary knowledge. Briscoe *et al.* (2001) claimed that this is one possibly unclear aspect of the link between NWR ability and vocabulary. When Briscoe *et al.* (2001) studied the correlation between NWR and vocabulary knowledge in three groups (n = 35) – TD, DLD and mild-to-moderate sensorineural hearing loss (SNHL) – with a mean age of 8 years, the results revealed that receptive vocabulary, but not expressive, tended to be associated more strongly with NWR in all groups. No clarification was provided concerning the reasons for this.

A recent Gulf Arabic cross-sectional study undertaken by Khater (2016) investigated the syllable length of NWR and tested the correlation between NWR and receptive and expressive vocabulary in 44 TD children aged 2–4 years. The TD group scored significantly higher for shorter syllable NWR than for longer syllable NWR. Moreover, there was a significant correlation between NWR and receptive vocabulary (r = .37) and between NWR and expressive vocabulary (r = .47). Thus, it would be worth investigating whether similar relations exist among older TD children, as is done in this study with an age range of 3–10 years.

2.4 The relationship between NWR and vocabulary in DS studies

NWR is a complex task and involves many processes that are known to be challenging for individuals with DS, including hearing, speech discrimination, planning, speech motor-output and articulation (Mengoni, 2012). Therefore, it is expected that individuals with DS will perform significantly lower than TD children. Several studies of NWR in individuals with DS have found evidence supporting Laws' (1998) claims that individuals with DS have significant deficits in NWR (Varnhagen *et al.*, 1987; Bower and Hayes, 1994; Fowler *et al.*, 1995; Seung and Chapman, 2000; Laws, 2004). To my knowledge, the first study that used an NWR task with DS individuals to establish whether it could be used reliably was that of Laws (1998). The researcher assessed the repetition of words and non-words of different lengths and receptive vocabulary with 33 children and adolescents with DS aged 5–18 years and found that they scored lower on longer items than shorter items, similar to the length effect found in TD children related to short-term memory (Gathercole *et al.*, 1991; Archibald and Gathercole, 2007).

Furthermore, Laws' (1998) study investigated the correlation between NWR and vocabulary, the results showing a significant correlation (r = .43). Further findings indicated that NWR is a reliable measure of short-term memory in this population. A pattern of strong association between NWR and other phonological memory measures (i.e. word repetition, auditory digit

span) provided evidence of its validity as a test of phonological memory (Gathercole and Baddeley, 1993). NWR is strongly correlated with grammatical understanding and with reading, predicting language comprehension and reading ability. These outcomes of Laws' (1998) study contributed to growing evidence that relationships in the process involved in language and memory development among DS individuals may be parallel to those established by studies of TD children (Gathercole *et al.*, 1991; Gathercole and Adams, 1993).

Laws and Bishop (2003) extended this work by assessing NWR among individuals with DS and DLD, with a control group of TD children. They investigated the correlation between NWR using the Children's Test of Nonword Repetition (CNRep; Baddeley and Gathercole, 1996) and receptive vocabulary using the British Picture Vocabulary Scale II (BPVS-II) with three groups: a) 19 individuals with DS aged 10–19 years; b) TD children matched for cognitive development on raw Raven's scores (within one point) aged 4–7 years; c) children with DLD matched to the DS group on raw Raven's scores. The results showed no significant differences between the mean scores for receptive vocabulary and NWR in either the DS or DLD groups. However, significant differences were found between the language-impaired groups and the TD group. In terms of the lengths of NWR, it was more difficult to recall longer nonwords than shorter ones for all three groups, similar to the findings of previous studies (Bishop *et al.*, 1996; Laws, 1998). In terms of the correlation between NWR and receptive vocabulary, there was no significant relationship between NWR and receptive vocabulary scores in only the DLD group. These results are in line with other studies of DLD (Edwards and Lahey, 1998; Briscoe *et al.*, 2001; Shaalan, 2010; Khater, 2016), which also found no relationship between NWR and vocabulary in participants with DLD. A significant correlation was found in both the DS and TD groups in Laws and Bishop's (2003) study.

A further investigation by Laws and Gunn (2004) tested the correlation between NWR and vocabulary (using the original BPVS) in a wider age range, 10–24 years, among individuals with DS. They found a significant correlation between NWR and vocabulary understanding ($r = .51$) in the whole group of DS and showed NWR to be a significant predictor of vocabulary knowledge. Further investigation was undertaken to see whether the relationship between NWR and vocabulary knowledge varied with the age of the participants. They were divided into two groups: a) children and young adolescents (mean chronological age = 149 months); b) older adolescents (mean chronological age = 230 months). The younger group showed a strong significant correlation between NWR and vocabulary knowledge ($r = .83$), while the older group did not present a significant relationship between NWR and vocabulary knowledge ($r = .33$). One possible explanation for the latter weaker relationship could be that the older group

might not necessarily have the high vocabulary scores necessary to support NWR. Another possible explanation might be that hearing deteriorates with age and hearing level is correlated with NWR (Laws and Gunn, 2004). One might argue that this study did not include a control group and therefore the degree of any impairment in performance is not clear. It would be interesting to control for mental age and investigate whether NWR predicts vocabulary knowledge to a similar extent across DS and TD groups matched on mental age. This might help establish whether individuals with DS should be included in mainstream education or clubs matched to TD students on mental age.

One year later, Cairns and Jarrold (2005) studied the correlation between receptive vocabulary and NWR in children and adolescents with DS aged 12–19 years matched on receptive vocabulary to TD children aged 5–7 years. Individuals with DS performed significantly lower than TD in NWR. Both groups performed significantly lower with increasing complexity of syllable length and frequency pattern (i.e. high phonotactic probability [PP] vs. low PP). However, no significant interaction was found for group-by-length effect, nor was there any significant interaction for group-by-frequency pattern. Although the DS individuals performed significantly lower in terms of length and frequency of NWR, both the DS and TD groups presented a similar pattern with respect to length and frequency of NWR. Further findings suggesting a significant correlation were observed between NWR and receptive vocabulary in both the DS and TD groups. The findings suggested that the DS group derived similar benefits from linguistic knowledge on repetition accuracy to those in the TD group. Moreover, there was a similar pattern for NWR length and frequency with the TD group matched on vocabulary knowledge. This suggested that individuals with DS had similar short-term memories and cognitive levels to TD individuals (Brock and Jarrold, 2005). This finding for repetition is consistent with other studies showing that individuals with DS rely more on linguistic knowledge than on verbal short-term memory. The results of this study are not consistent with other studies that showed a significant interaction between syllable length and group, demonstrating that the deficit due to impaired verbal short-term memory is more pronounced in DS individuals than the TD population (Gathercole and Baddeley, 1990; Montgomery, 1995; Weismer *et al.*, 2000).

Loveall *et al.* (2016) examined the correlation between NWR and receptive vocabulary using the Peabody Picture Vocabulary Test (PPVT) (Dunn *et al.*, 1997), a subtest of the Comprehension Test of Phonological Processing (CTOPP) (Wagner *et al.*, 1999), in three groups: 50 individuals with DS aged 10–21 years; 29 TD children aged 4–9 years matched on non-verbal ability; 29 participants with ID aged 10–21 years. In terms of NWR, the ID and TD

groups scored significantly higher than the group with DS. In terms of receptive vocabulary, there were no significant differences between the DS and TD groups. These findings suggest that the DS group relied more on linguistic knowledge and vocabulary learning as they performed at mental age on vocabulary knowledge, despite having poorer NWR. However, the ID group performed significantly better than the DS and TD groups and there was no significant difference between the DS and ID groups ($p = .67$) A significant correlation was found between NWR and receptive vocabulary for only the DS and TD groups. No significant correlation between the aforementioned variables was found for the ID group. Chronological age and schooling experience could explain the similarities in performance in the DS and ID groups. Previous studies have found a significant correlation between chronological age and receptive vocabulary in ID and DS groups (Facon and Facon-Bollengier, 1997; Facon *et al.*, 1998). Chapman *et al.* (2006) also note the benefits of chronological age and the additional life experience it affords for receptive vocabulary in individuals with ID and DS. However, other studies have failed to find significant correlations between chronological age and vocabulary knowledge in individuals with DS, but instead have found that vocabulary is correlated with non-verbal cognitive abilities (Zampini and D'Odorico, 2013).

2.5 Theories of NWR and vocabulary

This section reviews some of the theories concerning NWR and vocabulary knowledge in detail, for example the working memory model (Baddeley and Hitch, 1974; Baddeley, 2003) and phonological short-term memory (Gathercole and Baddeley, 1989; Gathercole and Baddeley, 1990). It has been well documented that the language and memory problems associated with DS are like those of children with DLD (Miller, 1985, 1988; Miller and Miller, 1999; Laws and Gunn, 2004). The strengths and weaknesses of linguistic profiles are similar across the two populations (see 1.6). NWR tests rely on both working memory and short-term memory. The stimulus must be held in the phonological loop while the child converts it into speech output.

Several studies have found a correlation between performance on NWR and vocabulary size in TD individuals and those with DS (Laws, 1998; Laws and Bishop, 2003; Laws and Gunn, 2004; Loveall *et al.*, 2016). These studies have argued that the learning of words is supported by the phonological loop that supports verbal working memory (Gathercole and Baddeley, 1989; Gathercole and Baddeley, 1993). Based on Baddeley and Hitch's (1974) working memory model, some studies have found that phonological working memory facilitates an enhancement in children's vocabulary knowledge before 5 years of age, with the phonological representation of unfamiliar words stored in the phonological loop for the time being until unfamiliar words

find a place in the mental lexicon (Gathercole, 1995; Gathercole *et al.*, 1999a). These findings suggest a causal role for phonological memory in the development of vocabulary in young children. In contrast, when the same children were tested at 6 and 8 years old, their vocabulary knowledge was a significant predictor of NWR. By this age, children use their vocabulary knowledge to facilitate NWR. For individuals with intellectual disabilities such as DS, Baddeley (2003) consider that deficits in the phonological loop components (e.g. phonological store and subvocal rehearsal process) are the main reason for language deficits.

2.5.1 The working memory model

Baddeley and Hitch (1974) first described working memory as a limited capacity system consisting of three components: i) the central executive component; ii) the phonological loop; iii) the visuospatial sketchpad. As shown in Figure 2.1, the central executive is dependent on both subcomponents and the central executive is responsible for the control of working memory and interactions between the other components. The visuospatial sketchpad is responsible for integrating visual and non-verbal information. However, the phonological loop is specialized for storing verbal information and has two subcomponents: a) a temporary phonological storage system, which holds speech over matter of seconds; b) a subvocal rehearsal component, which converts words into articulation before the entry of phonological storage (Baddeley and Hitch, 1974). Baddeley (2003) reported that deficits in the phonological loop components are the main cause of language impairment in children with DLD (e.g. DS). Deficits in this part of working memory can cause difficulties in producing appropriate phonological representations and learning new words (Gathercole *et al.*, 1999b; Archibald and Gathercole, 2006). According to Baddeley (1992, p. 556), working memory is also defined as a 'brain system that provides temporary storage and manipulation of the information necessary for complex cognitive tasks such as language comprehension, learning, and reasoning'.

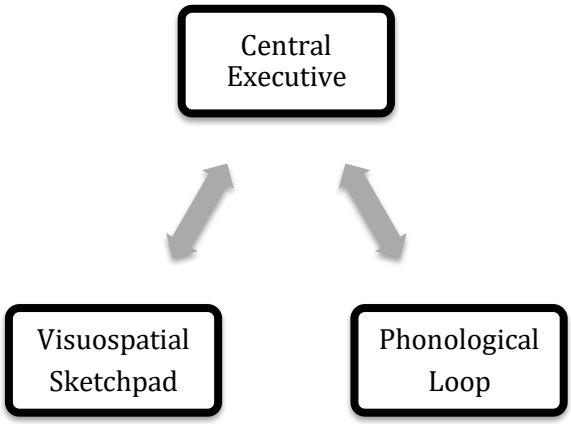

Figure 2.1. The three components of working memory (Baddeley and Hitch, 1974, reproduced from Baddeley, 2003, p. 191)

The working memory model might be able to explain the distinctive factors involved in working memory, but it is not clear how these elements work together. As previously stated, the phonological loop specializes in storing sound combinations and any impairment in this element would affect performance in learning new words (Gathercole and Baddeley, 1989, 1990; Gathercole, 1995; Gathercole *et al.*, 1999b; Archibald and Gathercole, 2006). However, it is not yet clear if impairment in the phonological loop might combine with other components of working memory. Also, the working memory model does not explain how semantic, syntactic and lexical components interact in NWR (Baddeley *et al*., 1998).

Further to Baddeley`s working memory model (1974, 2003), other working memory theories have been propounded to explore this model by investigating the process underlying NWR in the light of the model. They have also examined whether verbal/phonological short-term memory represented by NWR is supported by long-term memory represented by a linguistic account or by phonological memory only. The first theory relates to the phonological short-term memory hypothesis (Gathercole and Baddeley, 1989, 1990) and the other is the phonological processing account (Snowling *et al.*, 1991). It is worth noting that both theories support the notion that the phonological loop is a key component in the working memory model and the participant stimulus must be held in the phonological loop during the conversion into speech output. However, these accounts vary in terms of identifying how each account recognizes the main processes that underlie the performance of NWR. The following section discusses these theories in greater detail.

2.5.2 The phonological short-term memory hypothesis

The phonological short-term memory hypothesis anticipates that individuals' ability to repeat what they hear helps in learning new words (Gathercole and Baddeley, 1989, 1990). Phonological short-term memory and working memory can be assessed using NWR tasks, such as Gathercole and Baddeley's (1996) Children's Test of Non-Word Repetition or Dollaghan and Campbell's (1998) Non-Word Repetition Test (see 2.7).

According to the phonological short-term memory hypothesis, the phonological loop is responsible for storing temporary sound information, which reflects the ability to produce NWR. Therefore, NWR is considered a pure measure of phonological short-term memory and the phonological structure of NWR does not require a long-term lexical memory; the clear repetition of non-words requires only the temporary storing of phoneme sequence in the phonological loop (Dollaghan and Campbell, 1998). The phonological short-term memory hypothesis suggests that vocabulary learning difficulties in individuals with language

impairments is due to impairment of the phonological loop and speech output (Gathercole and Baddeley, 1990; Gathercole *et al.*, 1999a; Gathercole, 2006).

Gathercole (2006) contended that there is a strong relationship between NWR and novel word learning as both are controlled by phonological storage. To be specific, if a child can repeat an unfamiliar sequence of phonemes, this will influence the ability to learn and store sequences of sounds related to a novel word. When the word is heard for the first time, it is considered a novel word. Both NWR and vocabulary development share cognitive and neural mechanisms (Gupta and MacWhinney, 1997). The supporters of the phonological short-term memory hypothesis have stated that the storage of phonological information in the phonological loop is essential for language development, including vocabulary learning (Gathercole and Baddeley, 1990; Gathercole *et al.*, 1997). However, Gathercole (2006) further proposed that phonological short-term memory alone is not sufficient for word learning; rather, the primitive learning mechanism is an important factor in the early stages of language acquisition.

Several studies have demonstrated that individuals with DS have an impairment in the phonological loop (McDade and Adler, 1980; Bird and Chapman, 1994; Fowler *et al.*, 1995; Jarrold and Baddeley, 1997; Jarrold *et al.*, 2000). Baddeley (2003) argues that a deficit in the phonological loop is the main cause of difficulties in creating appropriate phonological representations and learning new words (Gathercole and Baddeley, 1990; Gathercole *et al.*, 1999a; Archibald and Gathercole, 2006).

The following sub-section, which addresses the phonological processing account, argues that there are other variables that should be taken into consideration in NWR.

2.5.3 The phonological processing/linguistic account

The phonological processing account is also known as the linguistic account. This tries to provide an additional explanation for the nature of the correlation between NWR and vocabulary knowledge (Snowling *et al.*, 1991), considering the phonological loop to be the initial process in NWR. Snowling *et al.* (1991) argued that there are various phonological factors involved in NWR, such as phonological awareness (e.g. syllable skills), prosodic structure, articulatory instructions and perceptual processing. In addition to these factors, there are other factors that play a role in NWR, for example vocabulary size, non-word length, word likeness, phonotactic probability, neighbourhood density and stress patterns.

In section 2.6, the process involved in NWR is discussed, related to the mediation between NWR and language learning.

2.6 Processes involved in NWR

According to Gathercole (2006), there are three potential skills, other than phonological storage, that underlie phonological short-term memory and can be a source of difference, consequently potentially arbitrating the relationship between NWR and vocabulary learning. As shown in Figure 2.2, the three potential skills are: 1) auditory processing, 2) phonological processing and 3) speech motor processing.

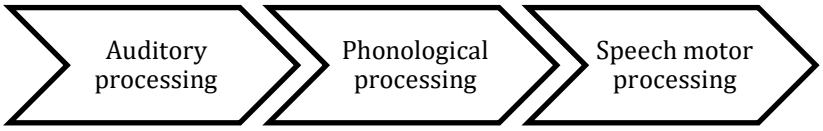

Figure 2.2 The processes involved in NWR

2.6.1 Auditory processing

It is known that impairment of the peripheral auditory system can affect language development. Briscoe *et al.* (2001) investigated NWR scores using Gathercole and Baddeley's (1996) test, examining three groups: children with mild to moderate sensorineural hearing loss, an DLD group and a TD group. They found that DLD children and those with mild and moderate hearing loss scored significantly lower on repeating non-words than the TD group and the hearing-impaired group performed significantly lower than the DLD group. These findings suggest that the auditory level plays a potential role in NWR performance. Moreover, they found an obvious difference between the groups regarding the length (range 2–5 syllables) and complexity (presence and absence of consonant clusters) of NWR. There was a significant group effect and there were significant group-by-length and group-by-complexity interactions at the .01 level. The group with hearing impairment performed significantly lower than the DLD group and the DLD group performed significantly lower than the TD group with increased length and complexity of NWR. Surprisingly, the four- and five-syllable stimuli were easier to recall than the two- and three-syllable stimuli for the children with hearing impairment. The justification for this finding was that the longer non-words provided the hearing loss group with more acoustic and auditory cues that might help them in repetition, while for the DLD group the deficit was mainly in their phonological memory, not aided by acoustic and auditory cues.

Otitis media with effusion (OME) is a common condition in TD childhood and involves fluids in the middle ear. Children with DS may be particularly vulnerable to otitis media due to the narrow auditory canals and cranial facial differences seen in this group (Austeng *et al.*, 2013). Gathercole *et al.* (2005, as cited in Khater, 2016) studied the impact of OME on NWR and assessed 39 children aged 5 years with OME. Each child was individually tested on an NWR

test (Gathercole and Baddeley, 1996) and on an auditory digit span task. All the children with OME performed better on the repetition of longer non-words compared to the shorter non-words. This outcome is in line with the outcomes for the hearing-impaired group in the study conducted by Briscoe *et al.* (2001). Difficulty in repeating shorter non-word responses may be due to the reduced accessibility of prosodic and supra-syllabic cues to segment identity in the shorter items. However, Laws (2004) investigated the correlation between phonological memory (on NWR) and the hearing of 30 adolescents and young adults with DS (six participants wore hearing aids) and found no correlation between hearing level and phonological memory (on NWR) based on Pearson's correlation.

To conclude, although hearing has been found to affect the complexity of NWR (e.g. syllable length) in individuals with DS, it has also been found that it is not correlated with NWR performance (Jarrold and Baddeley, 1997; Laws, 2004).

2.6.2 Phonological processing

Following the auditory processing of incoming speech, phonological processing can be defined as one of the main mechanisms driving NWR. Two theories underlie phonological processing; the phonological storage hypothesis and the phonological sensitivity hypothesis. The phonological sensitivity hypothesis can be defined as relating to the global set of phonological processing skills, presenting a hierarchy of sensitivity to different levels of phonological complexity in different cognitive operations (Adams, 1990; Adams and Gathercole, 1995). According to Burt (1999), phonological sensitivity can be measured by phonological awareness tasks: alliteration, and rhyme awareness tasks (see 3.2.3).

Based on Gathercole's (2006) phonological sensitivity hypothesis, vocabulary growth is the trigger in the developmental correlation, driving segmental analytic skills that help both the representation and learning of new words and especially responses containing unfamiliar sound sequences (low word-likeness). Therefore, Metsala (1999) and Bowey (2001) have recommended using NWR to measure phonological memory, while awareness of segmental information can be measured by phonological sensitivity. The phonological sensitivity account contributes to performance on NWR and vocabulary development. This account argues that NWR is not a pure measure of phonological working memory as suggested by Gathercole *et al.* (1997), but rather there are other factors contributing to performance on NWR that correlate with vocabulary development. Bowey (2001) showed that when controlling for age and IQ, both NWR and phoneme sensitivity, as measured by phonological awareness tasks, contributed significantly to vocabulary size, therefore ruling out NWR as a unique contributor.

2.6.3 Speech motor processing

The production of NWR requires a conversion of the auditory representation of NWR to a motor sequence for repetition. This procedure requires coordination between articulators (e.g. tongue, jaw) and muscles. As previously discussed, individuals with DS present differences in the structure of the oral facial area that affect speech production and intelligibility. This involves low muscle tone in the lip and tongue, soft palate, a small mouth, enlarged tonsils and mouth breathing, resulting in an open mouth posture (Borea *et al.*, 1990; Kumin, 1996). Several factors could interfere with the accuracy of articulation in NWR:

i) The presence of speech/language impairment (e.g. individuals with poor scores on NWR might possibly have a phonological disorder or speech-motor disorder, such as dysarthria) as individuals with DS commonly suffer from dysarthria (Rupela *et al.*, 2016).

ii) The complexity of stimuli, i.e. the more complex the stimuli, the less accurate the repetition; Comblain (1999) found that children and adults with DS showed more deficits in repeating non-words containing consonant clusters compared with non-words with single consonants. Further findings from Gathercole *et al.* (1991) showed that children with DS had greater difficulty with non-words containing fricative and affricate phonemes than non-words without affricatives and affricates.

iii) Non-word production improves with age as children's motor skills articulators start to develop (Smith, 2006).

Although this study did not investigate the phonological complexity of NWR, it is expected that there will be a significant interaction between group and phonological complexity. This might suggest that the DS and TD groups would find complex items (e.g. stimuli with consonant clusters) more difficult than simple items (e.g. stimuli without clusters). Furthermore, greater impairment is expected in the DS group than in the TD group.

To summarize, NWR accuracy is maintained by important processes, such as auditory processing, phonological processing and speech-motor processing. Any impairment to any of these processes would affect NWR accuracy. However, there are other factors that might influence NWR accuracy: word likeness, stress pattern and non-word length. In addition, the design of NWR tests differs, specifically in terms of word length, phonological complexity and scoring methods.

2.7 Common NWR English tests

The Children's Test of Non-Word Repetition (CNRep) (Gathercole and Baddeley, 1996). This was one of the first tests used to assess NWR in the UK. It involves 40 non-words divided equally into non-words 2–5 syllables long. The test uses typical English stress patterns: some of the non-words contain cluster consonants, while others do not. The CNRep contains many non-word items that correspond to real words (e.g. ***under***braunted) as there was no control for real morphemes. Moreover, many non-words have real morphemes (e.g. *defer*mica*tion*). Furthermore, there are consonant clusters (e.g. blonde**rst**aping) containing three consonant clusters.

The Non-Word Repetition Test (NRT) (Dollaghan and Campbell, 1998). The NRT is commonly used in the United States (US). It was developed two years after the CNRep and overcame some of the limitations found in the CNRep, such as the presence of lexical and sub-lexical elements (e.g. words ending with '_ing') and the prevalence of consonant clusters in the non-word items. Therefore, the NRT comprises 16 non-word items divided into lengths of 1–4 syllables, equally distributed. The NRT contains mostly early developing sounds and vowels (tense vowels) and does not contain any clusters (CV syllable shape). None of the syllables is a lexical or sub-lexical element (e.g. words ending with '_ing'). Furthermore, the stress pattern is not typical of English language stress as the non-words used in this test do not contain any weak syllables.

As the CNRep and NWR are widely used in NWR studies, Archibald and Gathercole (2006) undertook a comparison and found that both could distinguish between children with DLD and TD cohorts with a high level of accuracy. However, on the CNRep test, which contained many non-words with clusters and sub-lexical units, children with DLD performed significantly worse than TD controls.

The Preschool Repetition (PSRep) Test (Roy and Chiat, 2004). Whereas the aforementioned tests are commonly used with school age children of 4 years and above, the PSRep can be used to measure the phonological skills of children between 2 and 4 years. The factor differentiating the PSRep from the CNRep and NWR is the prosodic structure. The PSRep comprises 18 real words and 18 non-words, i.e. 36 items in total. All the test items are equally divided into 1–3 syllables (words/non-words), with systematic control of stress; half of the test items have strong/weak stress, while the other half have weak/strong stress. The non-word items were created by converting the vowel in single-syllable words (e.g. 'mouse' becomes /mis/) and reversing two consonants in each word to create a corresponding non-word (e.g. 'dinosaur' becomes /sinodaur/). It was found that performance on this test was not influenced by socio-

economic (SES) status or gender. However, there were strong effects of age, word length and stress (Chiat and Roy, 2007). The most common tests used in UK studies are the NWR and CNRep tests.

2.8 The importance of studying NWR in Arabic

The interest in studying NWR is due to its task simplicity. It is free of gender, socio-economic and cultural influences compared with other speech and language assessments. It is well established that the social environment exerts a strong influence on vocabulary and language tasks (Walker *et al.*, 1994; Hoff and Tian, 2005). However, when high and low SES were compared on responses to NWR, no significant group differences were found (Engel *et al.*, 2008). Non-word tests can be used with different populations and a wide range of ages, from childhood to adulthood. In addition, such tests have been used in different languages and with different DLD.

NWR has been used with different disabilities: DLD (Botting and Conti-Ramsden, 2001; Coady and Evans, 2008; Shaalan, 2010; Khater, 2016)LD, dyslexia (Catts *et al.*, 2005), autism spectrum disorder (Bishop, 2008; Riches *et al.*, 2011; Williams *et al.*, 2013) and DS (Comblain, 1999; Abdelhameed and Porter, 2010; Næss *et al.*, 2015) Most of these studies found that the clinical population had significantly lower scores compared with TD children. NWR helps understand the process underlying the performance of different DLD groups as DLD and autism spectrum disorder groups perform differently on NWR, indicating a significant effect of group and syllable length for two, three, four, and five syllables (Riches *et al.*, 2011). Similar differences have also been found for DLD groups compared to DS groups, i.e. a significant effect of group and syllable length (Laws and Bishop, 2003).

This study is the first investigation of NWR among Gulf Arabic children and adolescents with DS and therefore has implications for Arabic. There are few resources or studies and limited tests and tools. Thus, in these circumstances, NWR is recommended as it is flexible and easy to apply with individuals with DLD. Moreover, Arabic is a morphologically rich language, characteristically different from other morphologically rich European languages, such as Italian, French and Spanish. Arabic has a root and pattern morphological system. In 2.9.1, the phonology of Gulf Arabic will be discussed. In 2.9.2, the morphology of Arabic will be addressed to understand how the specificities of how Arabic might affect the underlying process in the NWR task.

2.9 The phonology and morphology of Gulf Arabic

As discussed in 1.5.1, Arabic is one of the Semitic languages characterized by diglossia. MSA is the official language, which is commonly used in newspapers, advertisements, books and television programmes. Spoken dialects (diglossia) are typically used in daily communication and everyday situations. In the following sub-sections, the phonology and morphology of Gulf Arabic are briefly explained.

2.9.1 The phonology of Gulf Arabic

Gulf Arabic consists of 30 consonant phonemes in addition to the short vowels /a, i, u/ and long vowels /a:, i:, u:/. Table 2.1 shows the consonants of Gulf Arabic.

Table 2.1. Consonant inventory of Gulf Arabic (Bukshaisha, 1985, as cited in Khater, 2016)

	Bi-labial	Labio-dental	Inter-dental	Alveolar	Palato-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Stop	b			t d tˤ			k g	q		ʔ
Nasal	m			n						
Fricative		f	θ ð ðˤ	s z sˤ	ʃ			x	ɣ ħ	h
Affricate					ʧ ʤ					
Trill				r						
Lateral				l ɬ						
Approximant						j	w		ʕ	

A limited number of studies have investigated the acquisition of Arabic phonology among Gulf Arabic children. To the best of my knowledge, Ayyad's (2011) study was the first to investigate the phonological development of Kuwaiti Arabic in 80 preschool children aged 3–5 years through developing a single word object elicitation test (showing pictures and objects) to evaluate the production of consonants across different word positions. This group was further divided into two groups: younger children (3.0–4.5 years) and older children (4.6–5.0 years).

The younger children acquired the following consonants across different word positions /b/, /t/, /d/, /k/, /g/, /q/, /m/, /n/, /ħ/, /h/, /ʧ/, /r/ and /w/, /j/. The older children also acquired /l/ and /ʃ/. In addition to this study, Amayreh (2003) investigated the acquisition of consonants in Jordanian Arabic speakers, which is a Gulf Arabic country but shares many of the speech sounds of Gulf Arabic. The results revealed some agreement in terms of the consonants acquired at 3–4 years. However, some later developing consonants, such as /θ/ and /ð/, developed earlier in Kuwaiti children compared with Jordanian children. These results show that phoneme frequency in the lexicon of children has a strong effect on phonological acquisition (Edwards *et al.*, 2015). In light of phonological development, Shaalan (2010), Al-Sulaihim (2014) and Khater (2016) developed language materials to assess vocabulary, phonological awareness and NWR, as used in this study. Furthermore, this study developed a

phoneme isolation test to assess the phoneme level on phonological awareness tasks. This will be discussed in detail in Chapter 4.

2.9.2 The morphology of Gulf Arabic

Arabic is a morphologically rich language, characteristically different from other morphologically rich European languages, such as Italian, French and Spanish. Arabic has a root and pattern morphological system. Most Arabic stems are based on roots of two to three consonants with vowels inserted between them. In general, the consonantal root provides the semantic meaning of the word, while vowel-consonant ordering reflects the word's inflection and its part of speech. For example, the from the tri-consonantal root 'ktb' (write), several words can be formed, as shown in Table 2.2, by adding inflectional prefixes and attaching suffixes to the infex (Versteegh, 2014).

Table 2.2. Derivatives of the root √k.t.b (Versteegh, 1997, p. 85)

Root	Derived Form	Class/Number	Gloss
	Kataba	Verb	He wrote
	Yaktub	Verb	He writes
	Kitaab	Noun, singular	Book
k.t.b	Kutub	Noun, plural	Books
	Katib	Noun, singular	Writer
	Kuttab	Noun, plural	Writers
	Maktab	Noun, singular	Desk/office
	Makaatib	Noun, plural	Offices
	Maktaba	Noun singular	Library
	maktabaat	Noun, plural	libraries

In addition to the 10 derivational morphemes that come from the k-t-b root, the dictionary of MSA gives 32 different derivational words that belong to different lexical categories. These derivations are related to writing, letter, books, etc. Other terms applied to Arabic morphology are derivational or root and pattern morphology.

Another way of looking at the root and pattern in Arabic is the template. *Templates* concern roots and patterns arranged in a fixed order, with vocalism and consonant roots inserted into a skeleton to form different lexical categories (e.g. nouns, verbs, adjectives, etc.). Nonconcatenating templatic morphology (NTM) is a term used to describe languages that use consonant roots, patterns and templates to produce lexicon (words). NTM considers the template as the main unit in word production, dissimilar to derivational morphology, which considers roots to be the main part in producing a word.

Figure 2.3 explains the structure of the template according to Béland and Mimouni (2001). Common templates used in MSA are CaCaCa, nCaCaCa CiCaaC CaCCaCa, CuCCaaC, maCCaCa, muCaaCiC and CiCaaCii. Here, C represents the consonant of the root. These templates can be used with different roots to form the same category. For example, if we add the root /d.r.s/ to the template maCCaCa, it will present /mad.ra.sa/ which means 'school'. As another example, adding a different root √s.m.k to the same template maCCaCa will give /mas.ma.ka/ (which means 'fishery'). The template principle is called Wazen in Arabic.

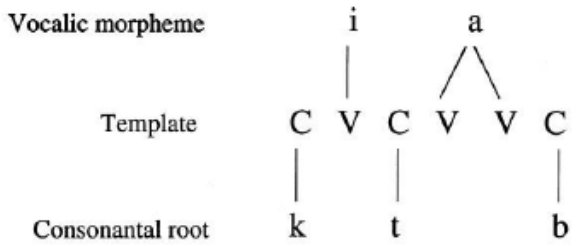

Figure 2.0.1. The consonant root, vocalic pattern and template (Béland and Mimouni, 2001, p. 84)

To summarize, there are two different accounts in terms of looking at the root in Arabic; a) derivational or root and pattern morphology, which considers that words are derived from the *root* in different lexical categories; b) NTM, which considers the *template* the main part in word formation. Each template performs a specific lexical function when the root and vocalic pattern are added to the template to form a word.

A recent study by Khater (2016) investigated the effects of roots and patterns on Gulf Arabic-speaking children aged 2–7 years using a NWR test developed by the researcher. The NWR test comprised different combinations of roots and patterns, as well as lengths of two and three syllables. Three types of root and pattern were developed in the NWR test. Type 1 consisted of root–non-pattern non-words, featuring items with real Arabic roots and non-existing patterns (e.g. the root /k.t.b/ and the pattern (a-u) forms the non-word /katub/). Type 2 consisted of non-root–pattern non-words, the items having a non-existing root and real pattern (e.g. the root /k.f.s/ and the pattern (a-a) forms the non-word /kafas/). Type 3 consisted of non-root–non-pattern non-words, entailing items with a non-existing root and a non-existing pattern (i.e. /dafuk/).

The results showed a significant effect of non-word type (root) and non-word length, i.e. two syllables vs. three syllables across all three types. The children performed more accurately (significantly higher) on type 1 than type 3, but no significant differences were found between type 1 and type 2 items or between type 2 and type 3 items. Thus, the different types of pattern

did not significantly affect children's performance on the NWR test. In addition, they performed more accurately on two-syllable items than three-syllable items. The root effects differ from word-likeness in other languages as the existing root consists of consonants that carry semantic information and is intertwined with vocalic patterns to produce the word. The participants' performance was sensitive to the type 1 consonant roots, even if the consonants were separated by non-patterns. These findings indicate that the semantic information the root holds seems to affect the participant's performance more than the vocalic pattern which carries morphological and syntactic information (Khater, 2016).

2.10 Comparison of scoring methods

The two main scoring methods used widely in NWR studies are the whole word correct (WWC) method and the percentage per phonemes correct (PPC) method. The WWC scoring method was used to score CNRep (Gathercole and Baddeley, 1996), with each item scored either correct or incorrect for the word as a whole. In contrast, the PPC method was used to score the NRT (Dollaghan and Campbell, 1998). This scoring focuses on the number of phonemes produced correctly by the participant on each item.

Estes *et al.* (2007) compared the WWC and PPC methods across 23 English studies with TD children and DLD children. They explored the effects of the scoring methods on NWR as the participants' responses were scored using both methods. They hypothesized that children with DLD would be more likely to make small errors in the PPC scoring method and produce smaller effect sizes in comparison with the WWC scoring method because the participants could receive credit even producing an error in each item. The findings of their analysis were contrary to their hypothesis. Although the WWC scoring method produced lower scores for both the DLD and TD groups compared with the PPC scoring method, they found that the effect size of both groups was lower for the WWC scoring method (d = .48) than for the PPC method (d = 1.17). These findings suggest that both groups tended either to get the whole word right or make multiple errors rather than just one phoneme being incorrect.

A further study by Deevy *et al.* (2010) found that the scoring methods did not influence TD and DLD group performance, i.e. the difference was minimal (d = 2.26 vs. d = 2.21). However, in Dispaldro *et al.*'s (2013) investigation of NWR with Italian TD and DLD children, the degree of group difference was greater under the WWC scoring method (d = 2.57) than the PPC scoring method (d = 1.38). A further Arabic study compared the two methods in Gulf Arabic-speaking children – 44 TD children and 15 children with DLD – aged 2–4 years (Khater, 2016). The study found that the scoring methods did not make any significant contribution to the group

results for NWR. However, when the two scoring methods were subjected to correlational and regression analysis with receptive and expressive vocabulary, the WWC scoring method showed a stronger correlation and higher predictive value between NWR and vocabulary tests than the PPC scoring method. The difference in regression analysis across the WWC and PPC scoring methods was minimal. These results showed similar results for the two methods on the NWR test. Further study is needed to investigate the effect of using different scoring methods in different languages and among different populations. Exploring the possible effect of using different scoring methods on Arabic NWR is warranted, especially due to the properties of Arabic phonology and morphology that set it apart from most European languages.

2.11 Summary

This chapter has provided a review of the existing literature regarding the concept of NWR and its significant role in vocabulary and language development. A review of studies regarding the association between NWR and vocabulary in TD and individuals with DS has been presented. Good vocabulary skills could be based on good NWR. English and Arabic studies hypothesize that being able to hold a sequence of sounds in phonological short-term memory helps the child store accurate representations in longer term memory. The NWR is thought to be important for the development of receptive vocabulary in English TD studies (Baddeley *et al.*, 1998; Briscoe *et al.*, 2001; Coady and Evans, 2008). Similarly, a strong correlation was found between NWR and vocabulary skills in an Arabic TD study conducted by Khater (2016). In addition, a significant correlation was found between NWR and vocabulary in an English study of individuals with DS (Laws, 1998; Laws and Bishop, 2003). In contrast, Bowey (2001) and Laws and Gunn (2004) found no evidence of a correlation between NWR and vocabulary in individuals with DS. The differing results between TD and DS children for NWR might be due to vocabulary size, or the estimate of how many words a child has in his mental lexicon; The relationship between NWR and vocabulary is thought to be interactive and reciprocal so that vocabulary aids NWR and vice versa. Additionally, the correlation was greater between NWR and vocabulary in TD individuals due to early stages of language development, so this may account for the discrepant findings. Theories of NWR and vocabulary development have also been discussed, in addition to outlining the process involved in NWR and the NWR tests commonly used in English studies. A further objective of this chapter has been to provide the rationale for studying NWR in Arabic, introducing the properties of the phonology and morphology of Gulf Arabic. The chapter concluded with the two scoring methods used in the literature for examining NWR in TD and language impairment studies.

Chapter 3. Phonological Awareness and Vocabulary

3.1 Introduction

Chapter 1 in this thesis looked at the main themes of the study, including providing an overview of DS, developmental trajectory, cognitive ability and language profiles among individuals with DS. It also provided the rationale for studying DS, the need for a control group and similarities to DLD. The chapter concluded by discussing the significance of the study. Chapter 2 defined phonological short-term memory in relation to NWR and specified its importance as a predictor of language learning, as well as looking at literature investigating the correlation with vocabulary knowledge in TD and DS populations. Theories of NWR and vocabulary understanding were also discussed. The rationale for studying Arabic participants and the phonology and morphology of Gulf Arabic were also reviewed. Finally, a comparison of scoring methods used for NWR was presented at the end of the chapter.

The literature considered in Chapter 2 emphasized the importance of phonological short-term memory to predict vocabulary development and language learning in both TD and DS studies. It was suggested that the relationship between phonological short-term memory and vocabulary knowledge is facilitated by phonological awareness and reflects participants' ability to segment spoken words (Masala and Walley, 1998). Therefore, the objective of this chapter is to investigate the importance of phonological awareness as playing a crucial role in the development of vocabulary and how vocabulary knowledge predicts phonological awareness in terms of the lexical restructuring model in both DS and TD populations. Further, it reviews studies that have investigated the correlation between short-term memory and phonological awareness in the context of TD.

The remainder of this chapter is as follows. It starts by defining phonological awareness and outlining phonological awareness levels and tasks for assessing phonological awareness. The development of phonological awareness in TD and DS studies is then addressed. Another objective of this chapter is to provide a theory that explains the relationship between vocabulary knowledge and phonological awareness (the lexical restructuring [LR] model). The crucial importance of vocabulary knowledge for phonological awareness and findings from TD and DS studies are also reviewed. A further objective of this chapter is to articulate the importance of correlation between working memory and phonological awareness based on TD studies. Finally, the research questions and hypotheses of this study are presented at the end of the chapter.

3.2 Phonological awareness

3.2.1 What is phonological awareness?

Phonological awareness can be defined as the awareness of sound structure, or the phonological structure of a spoken word (Gillon, 2012). Moreover, it represents the ability to perceive and manipulate the sounds of spoken words. It includes awareness of the smallest speech units (i.e. phoneme awareness), up to larger units (i.e. syllables, rhymes) (Goswami and Bryant, 1990). According to Anthony and Francis (2005) phonological awareness concerns an individual's degree of sensitivity to the sound structure of spoken language.

Phonological awareness skills consist of, but are not restricted to: the ability to understand similarities between words, e.g. identifying and producing words that rhyme/share the same common onset (initial sound of the word); awareness of the component segments of the word, such as phonemes and syllables, as well as the ability to carry out operations on words, including blending and segmenting words into their components (Alcock *et al.*, 2010). McBride-Chang (1995) provided a detailed explanation of phonological awareness. Four operations are required of individuals who participate in phonological awareness tasks. First, the individuals must recognize a speech segment. Afterwards, the speech segment must be held in memory (similar to the NWR task, which holds the sequence of sounds in memory before the process of repetition) long enough to perform an operation on it. Following this, the manipulation, blending, or identification of the speech segments must be carried out. In the last stage, the operation must be communicated, either through a verbal or non-verbal response. It is important to note that both phonological awareness and NWR involve working memory, which holds sequences of sounds in the memory before identifying or repeating the sounds.

During the 1970s and 1980s, there was much argument concerning whether phonological awareness was a prerequisite for literacy development (Stackhouse and Wells, 1997). To date, many studies have focused on the correlation between phonological awareness and literacy skills in individuals with DS, with more limited attention given to the relative contribution of vocabulary and working memory/short-term memory, each of these variables contributing to the process of learning to read (Scarborough, 1998).

3.2.2 Levels of phonological awareness

As mentioned previously, phonological awareness entails a multilevel skill of breaking down words into smaller units (Goswami and Bryant, 1990; Gillon, 2004). Three types of phonological unit have been most researched: (a) syllabic (identifying syllables in words), (b) intra-syllabic (identifying the initial consonant of the word [onset] and the vowels and any

remaining consonant of the word [rime]) and (c) phonemic (awareness of individual sounds/phonemes in the word) (Goswami and Bryant, 1990; Treiman and Zukowski, 1991). Phonological awareness skills do not just entail the ability to differentiate phonemes in words, but require a more complex act of processing that involves good receptive language skills and working memory (Castles and Coltheart, 2004). Several tasks can be used to measure these three levels of phonological awareness, examining the ability to manipulate and blend the unit at different stages (Burt, 1999). Anthony and Francis (2005) identified phonological awareness levels based on the unit of word structure, including whether syllables or smaller intra-syllabic units (i.e. onsets, rhymes) are the focus of the task. Many tests of phonological awareness have been administered to people of different ages, reading levels and languages.

With regard to English, it has been stated that if an individual has developed a level of phonological awareness, he/she will be able to understand that the word *basket* can be divided into two syllables: *(bas*), which is the initial syllable, and (*ket*), which is the final syllable, i.e. will have a degree of syllable awareness. At the next level of phonological awareness, each syllable can then be divided further into onset and rhyme: /b/ is the onset and /as/ is the rhyme in the initial syllable /bas/. At the final level, the individual understands that there are three phonemes (/b/, /a/, /s/) in the (bas) syllable (Al-Sulaihim, 2014). According to Bernhardt and Stoel-Gammon (1994, p. 126), a word is 'composed of a number of progressively smaller units, each with its own representational tier/level'. Gillon (2004) showed how the word (basket) could be presented in terms of a 'hierarchical structure', as illustrated in Figure 3.1.

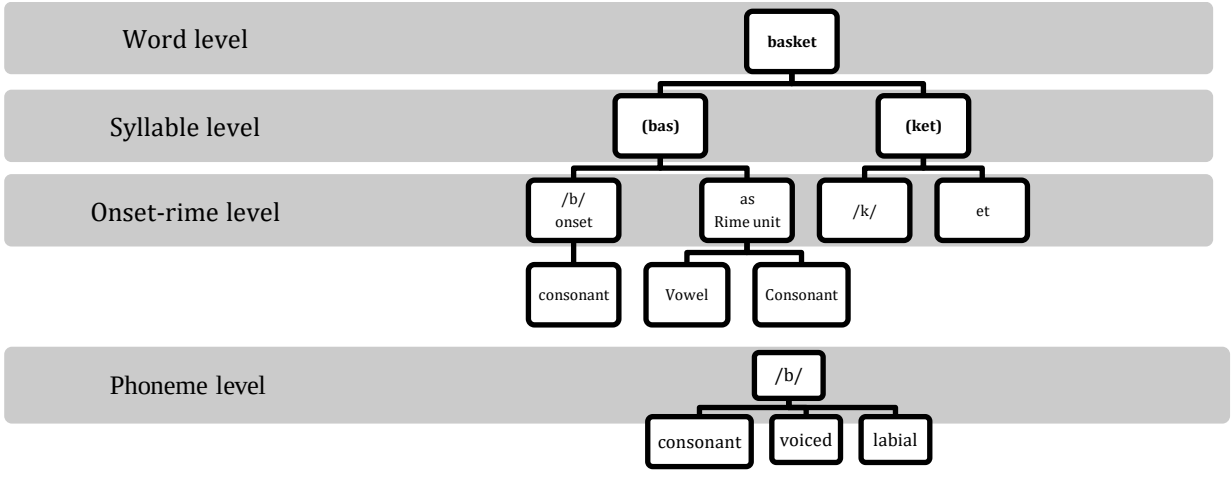

Figure 3.0.1. Hierarchical structure of the word basket (adapted by Gillon, 2004, from Bernhardt and Stoel-Gammon, 1994)

Moreover, Goswami and Bryant (1990) pointed out that during the early years of schooling, children progress through the hierarchical levels of phonological awareness, forming awareness

of syllables, then onset/rhyme, and finally phonemes/sounds of words. Therefore, it is important to investigate all levels of phonological awareness.

Stackhouse and Wells (1997) theorized that phonological awareness develops along a continuum from implicit to explicit awareness and this is the result of a combination of auditory, articulatory and reading experience. Figure 3.2 provides an illustration of this theory. As can be seen, phonological awareness becomes more reliant on reading capabilities as time goes on. Moreover, as children gain more schooling experience, through literacy training they learn how words are structured, including word/syllable/phoneme limits, which in turn enables more explicit phonological awareness.

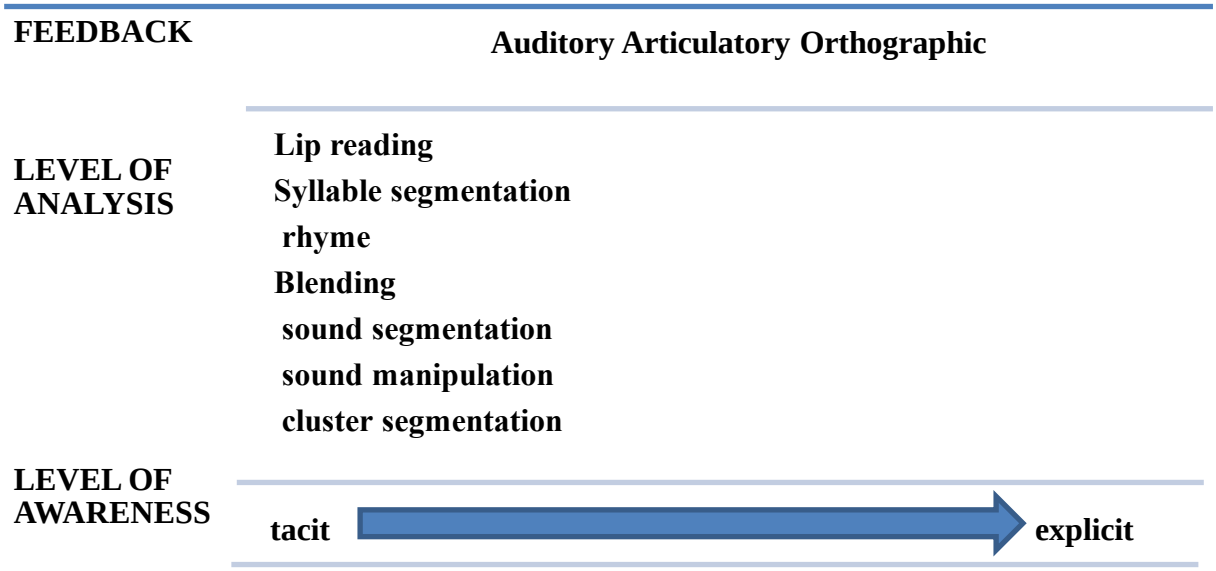

Figure 3.0.2. The development of phonological awareness skills (Stackhouse and Wells, 1997)

3.2.3 Tasks assessing phonological awareness

Phonological awareness has been investigated at different ages and among those with reading abilities through a range of different tasks and with different phonological unit sizes. Different stimuli have been used in phonological awareness studies: some stimuli are typically presented in a picture format or orally for real words and non-words. Participants' responses can be verbal, or pointing or tapping, depending on the task being performed. Vloedgraven and Verhoeven (2009) classified phonological awareness into several levels, as presented in Table 3.1.

Table 3.1. Classification of phonological awareness levels (Vloedgraven and Verhoeven, 2009)

Phonological awareness levels	Examples for each level
Word level	Involves word identification, which can be tested by dividing sentences into words and counting them (i.e. Examiner: *I am going to say a sentence and you must count words by pointing*. Points to 'The elephant is huge'. Participant should point to each word independently while the examiner says the word).
Syllable level	Involves syllable recognition (i.e. examiner: *Can you count the number of syllables in football?* The response could be given either verbally, or by clapping the hands. Syllable blending (i.e. *bas and ket would be basket*), syllable deletion (i.e. *basket without ket would be bas*).
Rhyme level	Involves rhyme identification (i.e. *Do fan and man rhyme?*). The response can be given either verbally, or by matching pictures of words that rhyme. Rhyme generation (i.e. *Could you produce a word like the ending of short, court?).*
Phoneme level	Involves phoneme addition (i.e. *adding /b/ to /all/ would produce /ball/*), phoneme deletion (i.e. *saying hat without /h/ is /at/*), phoneme substitution (substituting /s/ with /g/ in /sun/ would be /gun/), phoneme blending (i.e. *joining /c/, /a/ and /t/ would produce /cat/*).

Each type of task targets and assesses different levels of phonological awareness and degrees of complexity. For example, rhyme assessments target words which differ in their onsets. Thus, children must understand how the words are different in terms of onset and how they are similar in terms of rhymes. They must be able to recognize the similarities and differences in order to segment the word before making the decision whether two words rhyme or not. Furthermore, there are different tasks widely used to assess rhyme, such as rhyme identification (any of the two stimulus items rhyme, i.e. *Do fan and man rhyme?*) and rhyme production (participants have to produce a string of rhyming words, i.e. *Could you produce words similar to the ending of short, court?*) (Stackhouse and Wells, 1997). It is known that rhyme awareness and syllable awareness involve several cognitive processes, such as short-term memory, stimulus comparison, the comprehension of the instruction given for each task, as well as the level of phonological awareness being assessed (Stanovich *et al.*, 1984). Furthermore, McBride-Chang (1995) found that all phonological awareness tasks require cognitive ability and working memory. Therefore, it is important to investigate the correlation between working memory and phonological awareness in DS and TD individuals. Moreover, careful consideration is important to select the appropriate task for individuals with DS.

One of the phonological awareness tasks known to be very difficult and complex is the elision task. This involves the isolation and omission of one or more phonemes, which could be either consonants or vowels, in word production (Wagner *et al.*, 2013). The examiner requires the participant to say a compound word after taking off a syllable or string of phonemes (i.e. baseball without *base* is *ball*), or deleting one phoneme from a word (i.e. fan without the /f/ is an). Furthermore, removing the segment /foot/ from football can be considered removal of a

word from a compound word. In an elision task, the point is to remove a syllable, but a bisyllablic word turns into a word of one syllable. As a result, the task varies in complexity in terms of how the word must be segmented to form a new word. This can vary from targeting a single syllable (in words of more than one syllable) to more than one phoneme (in monosyllabic words) to the omission of single phoneme. Also, the deletion of a syllable or phoneme can be from the initial or final position of the word. This complex task has been excluded from this study, as it requires a high phonological working memory load (Jones *et al.*, 2009). Moreover, prior to reading acquisition, TD children find it difficult to complete this task, which requires access to the phonemic unit.

An example of the hierarchical manner of phonological awareness progression has been reported through a longitudinal study conducted by Treiman and Zukowski (1991). They found that 7-year-old children in the first grade were able to perform syllabic awareness tasks, onset–rhyme tasks and phoneme awareness tasks. For syllable awareness, a syllable comparison task was used in which the participant heard a pair of words and then identified whether two words shared a syllable at the beginning (e.g. tickle, ticket) or shared a syllable at the end (e.g. entire, retire). In terms of the onset–rhyme task, the investigators looked at the children's ability to compare onset and rhyme, given pairs of two words which shared a consonant onset at the beginning (e.g. plank, plea) and other pairs which shared a vowel–consonant rhyme (e.g. spit, fit). In the phoneme awareness task, the investigators assessed the children's ability to identify pairs of words that shared a phoneme at the beginning (e.g. plank, prove) and shared a phoneme at the end (e.g. split, flat). At the age of 6, the same children were able to perform only syllabic awareness tasks and rhyme tasks and at kindergarten, aged 5, only syllabic awareness tasks.

These findings indicate that the levels of phonological awareness develop hierarchically (each level builds upon the previous) over time, since with increased phonological awareness skills children become sensitive to smaller and more abstract phonological units, such as phonemes. In terms of the type of task presented to the participants, it is worth noting that individuals with DS are known to have limited memory capacity and thus it is recommended to use task with low memory demand to assess all phonological awareness. It is important to investigate phonological awareness in Arabic individuals with DS (children and adolescents) and compare them with TD children matched on non-verbal cognitive abilities to observe whether there is a sequence of development from larger units to smaller units in oral language.

It is also important to note that phonological awareness is considered a complex construct, not only because it is composed of different linguistic levels (i.e. word, rhyme, phoneme, syllable),

but also because the different tasks present varying demands depending on the level assessed. Therefore, task complexity and phonological awareness level are both important and should be considered when examining individuals with DS. For example, participants may be able to isolate a target but be unable to delete it (Hulme *et al.*, 2002). Many studies have suggested that the complexity of a task is related to the location of phonemes in the word. The identification of the initial and final phonemes within a word will be easier than identification of the medial phoneme (McBride-Chang, 1995; Carroll *et al.*, 2003). Consequently, in this study, when examining phonological awareness skills in individuals with DS and TD children of different ages and cognitive abilities, different linguistic levels and cognitive skills were the target of assessment and instruction. Such cognitive skills were examined using several linguistic tasks.

Although Anthony and Francis (2005) found that the general sequence of phonological awareness is universal across languages, the rate of phonological awareness development will be affected by the syllable structure of the language, as mentioned by Share and Blum (2005). The subdivision of syllables in Semitic languages, like Arabic and Hebrew, is different from English. For example, all syllables in Arabic start with a single consonant, which presents as the syllable onset (C), and this consonant is followed by a vowel (V). Therefore, the syllabic structure of Arabic is (CV), with (CVC) being the most predominant (Anthony and Francis, 2005). Moreover, in Hebrew, like Arabic, syllables are split into the body (CV) and the coda (C), producing a (CV-C) syllable structure. Some studies have found that Arabic and Hebrew readers who learn to read with this type of syllable structure containing body and coda may be more sensitive to it than onset–rhyme structure (Share and Blum, 2005).

In my view, the influence of syllable structure in Arabic is sufficiently similar to English as not to cause major differences in rate and characteristics of the development of phonological awareness. As mentioned previously in section 1.9, the Arabic language is characterized by a diglossic situation in which two forms of the same language are used in different situations. The spoken Arabic is used in daily communication, and the language of Arabic worldwide is read and write. My study tasks involved the language of Arabic worldwide read and write, and the influence of syllable structure was similar to English.

Although individuals with DS have limited literacy skills and the effect of orthography may be minimal, it should be noted that Arabic has a different orthographic system, differentiating it from English and other European languages. Arabic is considered to comprise a transparent (shallow) orthography in its vowelized form (using diacritic markers), whereas English has a

non-transparent (deep) orthography due to the lack of one-to-one correspondence between graphemes and phonemes.

3.2.4 Development of phonological awareness in English

As pointed out in 3.2.2, Bernhardt and Stoel-Gammon's (1994) model and many studies have hypothesized that phonological awareness develops from large units of syllables and onset–rhyme to smaller phonological units of phonemes (Bradley and Bryant, 1983a; Goswami and Bryant, 1990; Gillon, 2004). This pattern of developmental sequence in phonological awareness, in which syllable awareness develops prior to rhyme awareness, which develops prior to phoneme awareness, was assessed in an early study by Liberman *et al.* (1974), the outcomes of which supported the existence of a development sequence in phonological awareness in line with many other later studies (Bradley and Bryant, 1983b; Gillon, 2004).

Liberman *et al.* (1974) tested the hypothesis that the ability to segment words into large components (syllables) would be developed prior to the ability to segment words into smaller components (phonemes). To test this hypothesis, they examined children and categorized them into three age groups: preschool (chronological age: 4:9), kindergarten (chronological age: 5:8), and grade 1 (6:9). All the children in each level (preschool, kindergarten and grade1) were divided into two experimental groups, the first group tapping the number of phonemes in stimulus items, the second group tapping the number of syllables in stimulus items. The outcomes of this study showed a clear effect of both task and age, as illustrated in Figure 3.3. All the children in the different group levels found tapping syllables easier than tapping phonemes. Moreover, some children reached criterion level (six consecutive correct items) on the syllable task. As shown in the figure, 90% of grade 1 children were able to segment words into syllables, 48% of the children at the kindergarten level were able to do so and 46% of the children at the nursery level could. In terms of the ability to segment words into phonemes, 70% of grade 1 children were able to do so, only 17% of kindergarten children could, and none of the preschool children could. The results of this study indicate two significant findings: first, syllable awareness skills develop prior to phoneme awareness skills; second, phoneme awareness develops once formal literacy training has started as none of the preschool children were able to segment words into phonemes. However, it is not necessary to develop phoneme awareness through literacy training as some of the individuals with DS were able to perform on the phoneme awareness task with a lack of literacy skills.

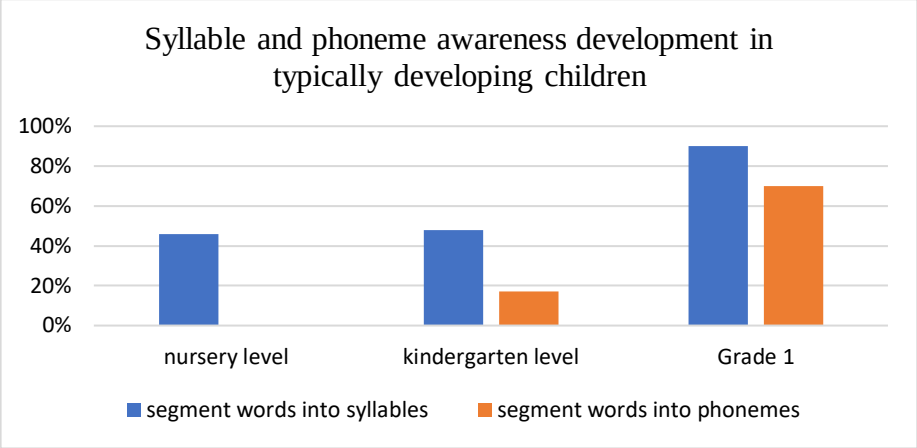

Figure 3.0.3 The development of syllables and phonemes (Liberman et al., 1974)

Anthony and Francis (2005) found that the general sequence of phonological awareness development is universal across languages and ages. This was based on cross-linguistics studies. The awareness of larger units, such as syllables, is usually present by age three in the early stage (Goswami, 2002) and the higher level of phonological awareness (i.e. phoneme manipulation) is generally attainable once formal literacy training is introduced; by the end of grade 1, children should be able to count the phonemes in the word or syllable. Therefore, the relationship between reading and the development of phonological awareness may be a reciprocal and causal one which continues to develop into the ability to segment phonemes in words or syllables by the time children have started their formal education.

Two overlapping patterns of development are evident. First, children become more sensitive to smaller units of the word as they increase in age; they can detect syllables before they can detect onset–rhyme. Second, they can detect onset–rhyme before they can detect individual phonemes within a word unit. Third, they can detect the initial and final phonemes within words before they can detect the medial phoneme. Finally, children refine their existing phonological awareness skills while learning new ones (McBride-Chang, 1995; Anthony and Francis, 2005).

A further study by Carroll *et al.* (2003) examined the development of phonological awareness in a longitudinal study in which they examined 67 preschool age children three times in one year on measures of syllables, rhymes and phonemes. The results indicated that the development of phonological awareness follows the general sequence from the identification of large units to small units. In other words, the participants tended first to demonstrate awareness of syllables and rhymes and then awareness of phonemes.

As found in previous studies, the development of phonological awareness occurs in stages and the tasks requiring children to segment words into phonemes are difficult for many preschool

children (under the age of 4 years). Fowler *et al.* (1991) propose that during the preschool period, a child's phonological awareness undergoes constant reorganization because of the increase in vocabulary capacity, which is completed at approximately the age of 7 years. Therefore, it is important to investigate whether there is a relationship between phonological awareness and vocabulary knowledge in individuals with DS and whether the relationship is similar to that of TD children. According to Fowler and colleagues, the capability to segment syllables into phonemes appears to mirror both a growth in the phonological system and the impetus provided by exposure to reading instruction. As previously mentioned, reading plays a vital role in the development of phonological awareness, with which it enjoys a reciprocal causal relationship (De Manrique and Signorini, 1998; Hogan *et al.*, 2005). De Manrique and Signorini refer to this reciprocity as two levels of phonological awareness. The first concerns basic methodological skills (including rhyming, syllable awareness and sound matching), which children learn indirectly while mastering speech sounds and exposure to songs and word games. The second level is acquired with formal literacy instruction and relates to segmental awareness skills, such as phoneme identification, blending and segmentation, spelling and reading (Lafrance and Gottardo, 2005). However, this was not the case for the individuals with DS in this study as most of the participants were unable to read but were able to master all phonological awareness levels.

As mentioned above, studies in the English-speaking context clearly indicate that phonological awareness develops gradually along a certain continuum over time and that the pattern of phonological awareness development is similar across languages.

3.2.5 Development of phonological awareness in Arabic TD children

To my knowledge, few studies are available on the development of phonological awareness in Arabic, although the results support the proposal that there is a sequential development of phonological awareness skills in alphabetic languages.

Tibi (2010) investigated the development of phonological awareness skills in a group of 140 TD children aged 6–8 years. The children were divided into 3 groups: group 1 = 6 years, group 2 = 7 years and group 3 = 8 years. All the groups were examined on three Arabic phonological awareness tasks, including syllable deletion, rhyme oddity and identification of the initial phoneme. The results indicated a developmental progression in phonological awareness tasks across the three groups; scores for the phoneme task were lower than for the syllable and rhyme tasks. This is in line with the hierarchical development of phonological awareness in English studies.

A recent longitudinal study by Al-Sulaihim and Marinis (2017) examined the development of Arabic phonological awareness skills and the correlation between phonological awareness and reading skills in 30 TD children within a mean age of 6 years old from Kuwait. The children were examined at the beginning and end of the grade 1 school year on syllable, rhyme and phoneme level, as well as a single word reading task. It was found that the children's performance for syllables was significantly higher than for rhyme, which significantly improved at the end of grade 1 when the scores were compared to those from the beginning of the school year. The authors thus showed that phonological awareness improved over time when the children were exposed to literacy training from the beginning of the school year. Further findings showed a significant correlation between phonological awareness and reading task. Moreover, performance on the syllable and rhyme tasks was significantly higher than on the phoneme awareness tasks. These outcomes provide important insights into the development of phonological awareness in Arabic among early readers. Saiegh-Haddad (2007) reported that phonemes are more challenging to learn than larger syllables.

3.2.6 Development of phonological awareness in DS studies

One of the first studies to investigate phonological awareness in individuals with DS was that of Cossu *et al.* (1993). They tested phoneme segmentation, phoneme blending and onset deletion in 10 children and adolescents with DS aged 8–15 years and 10 TD children aged 6–7 years matched on reading skills. It was found that individuals with DS performed significantly lower than TD children on all phonological awareness tasks. From these outcomes, Cossu and colleagues argued that phonological awareness is not a prerequisite for learning to read. However, Cardoso-Martins and Frith (2001) contended that the tasks used by Cossu and colleagues were very cognitively demanding, with heavy memory demands. For example, the phoneme blending task included items with six phonemes. As individuals with DS have short memory spans, typically lower than six (Bird and Chapman, 1994), it is perhaps unsurprising that they would face difficulty in this task and perform poorly in the phonological awareness tasks. It seems that early studies into the phonological awareness skills of children with DS reached prematurely negative conclusions due to methodological flaws, namely high cognitive demands. It is therefore anticipated that these tasks might have interfered with their abilities to understand the phonological awareness tests. More studies have illustrated that individuals with DS can indeed show measurable levels of phonological awareness, as discussed in the coming paragraphs.

Another study, conducted by Kennedy and Flynn (2003), investigated the development of phonological awareness in younger children – a group of 9 children with DS from New Zealand

aged 5–8 years. A series of measures was used to assess the phonological processing skills of the children: rhyme detection (participants were presented with three pictures, two depicting words that rhymed), alliteration detection, initial phoneme isolation and phoneme blending. All task responses required a multiple-choice non-verbal response to overcome speech intelligibility problems and they used pictures to increase motivation. In terms of the children's performance in the phonological awareness tasks, some scored above chance on all tasks, whereas others did not. It is worth noting that the children with DS performed significantly higher in the rhyme task than the phoneme isolation task, which indicates the same developmental pattern as TD children. Even though this study only assessed nine children, it showed that individuals with DS could perform above chance on phonological awareness tasks.

Another study which investigated this phenomenon was that of Cardoso-Martins and Frith (2001). They examined phonological awareness skills and reading accuracy in 33 children and adolescents with DS aged 10–49 years and compared them with 33 TD children aged 6–9 years, matched on reading accuracy. It was found that the TD children performed significantly better on an initial phoneme deletion task; however, both groups performed similarly close to the ceiling on an initial phoneme detection task. According to these findings, it seems that some elements of phonological awareness are less well developed in individuals with DS in comparison to reading accuracy, while others may be in line. This suggests that individuals with DS may learn to read in the absence of phonological awareness (Cossu *et al.*, 1993; Evans, 1994). It is worth noting that the large age range of the individuals with DS was likely to result in great variation in performance based on schooling experience, literacy skills and experience more broadly.

Snowling *et al.* (2002) compared individuals with DS to TD children matched on reading accuracy using measures of syllable segmentation and phoneme detection. It was found that individuals with DS performed more poorly in phonological awareness tasks than the TD control group. However, when receptive vocabulary was used as a control variable for both groups in the second experiment, the two groups performed similarly on the initial phoneme detection task but not on the final phoneme detection task. Further to this, it is worth noting that the children with DS were better readers than the TD children in the second experiment. This study suggested that vocabulary level influences phonological awareness performance in individuals with DS. This is in line with Zens *et al.* (2009), who suggested that when children learn words, their learning ability depends on the ability to listen and analyse the phonological forms of words, which can be stored in the lexicon (Zens *et al.*, 2009). However, no significant correlation was found between reading and phonological awareness. A study by Roch and

Jarrold (2008) examined whether there was any observed relationship between phonological awareness and reading ability in 12 children and young adults with DS and compared them to a control group of 14 TD children aged 6–7 years old matched on word reading abilities. The results showed that although the TD group performed better on measures of phoneme deletion than reading skills, the same relationship was found between phonological awareness and reading in individuals with DS and the TD group.

The divergence of findings may be due to the various phonological awareness measures used by different studies, as tasks can vary in their degree of complexity. There are simple tasks known to impose low cognitive demands, such as phoneme matching, and individuals with DS perform similarly to reading matched TD groups on such tasks (Cardoso-Martins and Frith, 2001; Fletcher and Buckley, 2002; Snowling *et al.*, 2002; Roch and Jarrold, 2008). DS performance on tasks imposing high cognitive demands, such as blending and segmentation, presents conflicting results (Cossu *et al.*, 1993; Boudreau, 2002; Fletcher and Buckley, 2002). However, difficulties with more complex tasks, which place a greater load on working memory, such as phoneme deletion, have regularly been found (Cossu *et al.*, 1993; Cardoso-Martins and Frith, 2001; Roch and Jarrold, 2008), Consequently it appears that individuals with DS may have lower levels of phonological skills matched with their reading accuracy and tasks requiring a greater degree of manipulation are more challenging.

In another study, Snowling *et al.* (2002) designed and administered alliteration and rhyme tasks that had low cognitive and memory demands. Children with DS performed above chance in the alliteration task, whereas the TD children matched on reading accuracy scored above chance in both tasks. This particular deficit in rhyme tasks has been replicated in other studies (Cardoso-Martins *et al.*, 2002) and suggests that children with DS may be biased towards the initial sounds of words, with more relative weaknesses found for final phonemes (Snowling *et al.*, 2002). Individuals with DS have lower mental ages than reading accuracy-matched TD control groups and this may result in more difficulty understanding task demands as a reading accuracy measure cannot identify participants' cognitive or vocabulary abilities. Therefore, phonological awareness in individuals with DS has been found to correlate with cognitive abilities and vocabulary abilities due to task complexity rather than the phonological awareness task itself. However, in their study, the reading level was not correlated with the phonological awareness level. It is important to note that this relationship is different from that found for the TD participants. Therefore, it is recommended to compare the phonological awareness skills, cognitive abilities and vocabulary skills of individuals with DS, and also to make a comparison with individuals with TD, and examine whether the same correlation exists between the groups.

Boudreau (2002) administered a large test battery of phonological awareness skills to 20 children with DS aged 5–17 years and 20 TD children aged 3–5 years matched on non-verbal cognitive ability. The results showed that children and adolescents with DS performed at a similar level to non-verbal ability-matched TD children on syllable segmentation and blending tasks. However, the TD children performed significantly better on rhyme and alliteration judgment tasks. This study recommends using mental age as a control variable and considers that the difficulties with phonological awareness tasks seen in individuals with DS are not wholly due to their lower cognitive abilities.

3.3 Theory concerning phonological awareness and vocabulary knowledge

Understanding the relationship between phonological awareness and vocabulary knowledge is the first step in understanding phonological awareness and its correlation with speech and language development. One of the theories that explains the relationship of phonological awareness development with vocabulary knowledge is the lexical restructuring (LR) model.

The LR model can be defined as positing that vocabulary development promotes phonological awareness development through the reorganization of the lexicon (Walley, 1993; Metsala and Walley, 1998). It has been recommended that word production be represented holistically. More precisely, children can segment large units (i.e. whole words) before being able to recognize smaller units (i.e. syllabic, intra-syllabic and phonemic levels), especially in preschool and school age years. The factor that helps children understand the representation of phonemes within words is vocabulary development and therefore it is hypothesized that the more vocabulary knowledge the child has, the higher the scores for phonological awareness development the child would attain. In line with this hypothesis, vocabulary is positively associated with phonological sensitivity (Chiappe *et al.*, 2004). For example, receptive and expressive vocabulary tend to be significantly correlated with blending and phoneme deletion tasks examined with a group of TD children.

The power of the LR model has been confirmed by a longitudinal study (from kindergarten to grade 2) conducted by Cooper *et al.* (2002). They investigated TD children aged 5:2–6:3 years and examined whether vocabulary development (receptive and expressive) and background factors (e.g. parents' education, SES) would predict phonological awareness development (blending and elision tasks). The results strongly indicated that both vocabulary skills were significant predictors of phonological awareness task achievement. However, the effects of the background factors on phonological awareness were not significant.

Carroll *et al.* (2003) investigated the correlation between receptive vocabulary and phonological awareness tasks in 67 TD children aged 3:2–4:5 years old. They found a significant association between phonological awareness and receptive vocabulary. The results of this study provide evidence for the LR model; however, this study made no predictions for when children grow older.

3.4 Phonological awareness and vocabulary in TD groups

As explained in 3.3.1, it is well documented that there is a positive correlation between vocabulary knowledge and phonological awareness in TD children (Metsala, 1999; Carroll *et al.*, 2003; De Cara and Goswami, 2003; Lund *et al.*, 2015). The LR model claims that when children's vocabulary develops, their ability to reorganize words increases. Metsala and Walley (1998) identified four factors that affect these representations: phoneme similarity among words stored in the participant's lexicon, age of acquisition, word familiarity and vocabulary size.

Metsala (1999) investigated phonological awareness skills in TD children aged 4–6 years at the intra-syllabic and phonemic levels using familiar spoken words (i.e. real words) and unfamiliar words (i.e. non-words) and receptive vocabulary skills. They investigated the correlation between phonological awareness tasks and receptive vocabulary. They found that both levels of phonological awareness were significantly correlated with receptive vocabulary in all children. Moreover, the older children performed significantly higher than the younger children in all phonological awareness and vocabulary tasks. These outcomes may be explained by the argument that phonological awareness skills develop gradually at younger ages because of the growth in receptive vocabulary. Namely, knowing many words promotes the child's phonological system to be more aware of phoneme differences between spoken words. In addition, children's performance on the phonological awareness tasks that used real words was significantly higher than for non-words. These findings stress the importance of growth in vocabulary knowledge for prompting phonological awareness development.

In a further recent study that endeavoured to clarify the relationship between phonological awareness and lexical abilities, Lund *et al.* (2015) studied the correlation between phonological awareness skills and vocabulary knowledge. They compared the performance of TD monolinguals and bilinguals with and without hearing loss within an age range of 3–5 years. There were 9 monolinguals with normal hearing, 9 monolinguals with hearing loss, 10 bilinguals with normal hearing, and 9 bilinguals with hearing loss. Rhyme awareness tasks and initial phoneme tasks were used to measure phonological awareness. A significant correlation

between vocabulary and phonological awareness was found in the groups with normal hearing. The outcomes support the LR model of phonological awareness development. However, there was no correlation between vocabulary and phonological awareness in groups with hearing loss. The researchers offered three possible explanations for these outcomes. First, the LR model is only valid for children with normal hearing and does not address how children with hearing impairment acquire phonological awareness. Second, they proposed that if patterns of phonological awareness development in children with hearing loss differ from TD children with normal hearing, it might be that a different way of developing causes differences in phonological awareness. Third, the vocabulary measures used in this study led to a weak correlation between phonological awareness and receptive vocabulary. Moreover, the bilingual groups with and without hearing loss and monolingual group with normal hearing performed better than the monolingual group with hearing loss. This shows an advantage for bilingualism in phonological awareness with hearing loss. One explanation for the benefits of bilingualism is that bilingual children have greater phonological awareness compared with monolingual children because they are learning two separate language codes (Chen *et al.*, 2004).

Furthermore, several studies have found both receptive and expressive vocabulary to be predictors of phonological awareness (Silvén *et al.*, 2002; Sénéchal *et al.*, 2006). Silven and colleagues (2002) reported on longitudinal data from 66 children in an investigation of how phonological awareness is affected by mother–child interaction and child language development. The children were videotaped at 12 and 24 months of age with their mothers to assess mother–child interaction sensitivity and children's vocabulary. Phonological awareness was assessed using the detection of words at 36 and 48 months of age. The results indicated a significant association between interaction sensitivity and later phonological awareness development. Further correlations were found between vocabulary (receptive and expressive) and phonological awareness. These outcomes might indicate that mother–child interaction is one of the predictors that may affect the child's ability to differentiate sound patterns in words as early as 36 months. The researchers concluded that children who interact highly with their mothers during free play in the first years of life tend to have higher awareness of sound patterns in words and their receptive vocabulary seems to determine the development of awareness. Therefore, there is an association between phonological awareness and vocabulary development in that early vocabulary supports later phonological awareness development, as well the early maternal interaction sensitivity supporting later phonological awareness development.

Although several studies have assumed that vocabulary knowledge is associated with phonological awareness development, it is worth noting that some studies have found no significant association (Gathercole and Baddeley, 1990; Garlock *et al.*, 2001). For example, Garlock and colleagues (2001) aimed to test the effect of lexical factors associated with vocabulary development (age acquisition) on spoken word recognition. The participants were 46 preschool children, 46 elementary school children and 46 adults. All the participants were tested on receptive vocabulary, phonological awareness (phoneme isolation task) and word repetition. The findings showed a small effect of word frequency in word repetition, whereas age had an effect for all groups. However, the findings suggested that although vocabulary predicted word reading, it did not predict phonological awareness. This study showed no correlation between participants developing phonological skills and vocabulary development. To date, many studies have focused on the correlation between phonological awareness and literacy skills in individuals with DS, with more limited attention paid to the relative contribution of the development of phonological awareness in relation to chronological age/cognitive abilities.

3.5 Phonological awareness and vocabulary in DS groups

Since vocabulary knowledge is correlated with phonological awareness in TD studies, it follows that vocabulary development is associated with phonological awareness in individuals with DS (Morais *et al.*, 1979; Bird *et al.*, 2000; Cupples and Iacono, 2000). Also, difficulties in oral language skills have been found to correlate to phonological awareness (Byrne *et al.*, 2002; Laws and Gunn, 2002; Verucci *et al.*, 2006).

The validity of the LR model has been confirmed by empirical study of the role of vocabulary development in the progression of phonological awareness in individuals with DS. For example, Laws and Gunn (2002) examined 30 children and adolescents with DS aged 10–24 years. They were divided into groups of 16 readers and 14 non-readers. The readers were classified as those who were able to produce one word on the reading test. All participants were examined for receptive vocabulary (on the BPVS), NWR and phonological awareness skills (identification of rhyme and onset) and the correlation between them was assessed. The reader group performed significantly higher than the non-reader group on all the variables. This showed a clear advantage in vocabulary comprehension for the reader group. The correlation was investigated for the reader group only to determine whether phonological awareness and vocabulary and reading were correlated with each other. A significant correlation was found between NWR and phonological awareness for the reader group only ($r = .79$). Moreover, phonological awareness was significantly correlated with receptive vocabulary skills ($r = .60$).

It would be useful to examine whether a similar correlation exists in the non-reader group. The non-reader group had only 4 participants when they were examined at time 2 after 5 years in a follow-up study and due to the small number of participants, the correlation was not tested. Furthermore, no control group was matched with the DS group. It is recommended to add a control group matched either on cognitive abilities or vocabulary skills. Thus, when task performance in the clinical group is below or above the control group, it can be considered to represent an atypical cognitive strength or weakness when compared with the control group. Although this study attempted to study literacy skills in individuals with DS during the pilot study, most of the participants faced difficulty in the single word reading task and with letter knowledge, in addition to there being time constraints that might have affecting their cooperation in other assessments.

To summarize, the validity of the LR model has been supported by some experimental studies of the role of vocabulary development in the progression of phonological awareness in TD and DS groups. However, other studies have found no significant correlations between vocabulary and phonological awareness in TD groups. These study outcomes present disagreement between the studies. The main argument for the divergent findings was the way vocabulary is measured, which might have an effect on the correlation with phonological awareness. It was found that the studies which used a vocabulary of high-frequency words, had a strong correlation with PA; on the other hand, the studies which used a vocabulary of low frequency words had a weak correlation with PA.

3.6 Receptive and expressive vocabulary in DS

Vocabulary knowledge in TD children has been found to be a predictor of verbal comprehension (Silva and Cain, 2015) and reading comprehension (Clegg *et al.*, 2015). Similar relationships have been identified in individuals with DS, with receptive vocabulary being a predictor of academic skills, including reading and spelling (Laws and Gunn, 2002), as well as social skills (Hippolyte *et al.*, 2010). In addition, vocabulary has been found to be necessary for syntactic development in individuals with DS (van der Schuit *et al.*, 2011).

Different measures can be used to assess receptive and expressive vocabulary skills. Expressive vocabulary can be measured using one-word picture vocabulary tests or by calculating the total number of words produced in speech through free conversation or picture description. Expressive vocabulary can also be measured using definition tasks, but this method is not widely used with individuals with DS due to the likely impact of expressive language difficulties. Receptive vocabulary is commonly measured using receptive one-word picture

vocabulary tests in which the participant is required to choose a picture which matches a word on a multiple-choice task.

The early development and onset of vocabulary was investigated by Berglund *et al.* (2001) through a parental questionnaire in a large cross-sectional study of Swedish children with DS age 1–5 years, compared to TD children aged 1.4–2.4. It was found that 10% of the children produced their first word at one year and 80% uttered their first word by two years, although there was a large amount of variability. Some of the infants with DS started to produce their first word at the same age as TD children, implying that first word production is not necessarily delayed. Notwithstanding the slower rate of acquisition, at four years old, children with DS were performing similarly to TD children aged eighteen months. Further investigation for this study entailed whether there was an effect of gender on vocabulary performance in children with DS and it was found that girls scored higher than boys in vocabulary skills. However, Berglund and Eriksson (2000) found no gender effect on wider language skills.

In terms of expressive vocabulary among adolescents with DS, Laws and Bishop (2003) suggested that their expressive vocabularies are like those of younger TD children matched for non-verbal mental age. However, other studies have reported that children with DS score lower on expressive vocabulary than TD children matched for mental age (Hick *et al.*, 2005; Price *et al.*, 2007; Roberts *et al.*, 2007; Caselli *et al.*, 2008). Furthermore, it has been reported that children and adolescents with DS aged 5–20 years produce fewer words in connected speech during free conversation and narration than TD children matched for non-verbal metal age.

Articulation difficulties are common in individuals with DS (Kumin, 1996), thus making it challenging and difficult to assess the production of words. To avoid this, whilst stringently assessing the quality of phonological representation, Jarrold *et al.* (2009) investigated phonological learning using a receptive multiple choice task rather than an expressive/production task. This required participants to choose the word they had learnt and ignore distractor words that were phonetically similar to the target non-word. The study included individuals with DS aged 14–29 years and TD children aged 5–8 years. The DS participants were found to be impaired on this task compared to the TD children matched for non-verbal ability. Moss and Jarrold (2011) extended this work using a similar training method but requiring a spoken response in three experiments conducted with individuals with DS aged 9–30 years and TD children aged 4–6 years. In contrast to Jarrold *et al.* (2009), there were no differences in phonological learning between the DS and TD participants. It was argued that

this conflicting result might be because the target item appeared more frequently than the distractors. In addition, the assessment was only administered immediately after training and not over the longer term (Moss and Jarrold, 2011; Mengoni *et al.*, 2013). It should be noted that vocabulary learning was better than might be expected given phonological memory difficulties in DS and that it could indicate multiple routes to vocabulary acquisition, including the benefits of orthography.

Cleland *et al.* (2010) investigated the relationship between receptive vocabulary, expressive vocabulary and receptive and expressive language to non-verbal ability in children and adolescents with DS aged 9–18 years. They found receptive and expressive vocabulary not to be highly correlated with non-verbal ability, but they found receptive vocabulary was superior to expressive and receptive language measured through the Clinical Evaluation of Language Fundamentals – Preschool (CELF-P). A justification for these findings is that many participants were unintelligible and the assessment of expressive language was difficult for them; thus, the discrepancy was the consequence of testing difficulties rather than an actual difference. These findings suggest that language impairment in DS is not simply a result of poor cognitive ability but due to some other factors, such as similar language profiles to DLD. Clinically this is useful because it suggests that language therapy may be necessary in people with DS who present with a difference between language and cognition. It is worthwhile investigating the development of vocabulary (receptive and expressive) in relation to mental age in Arabic individuals with DS and how this development differs from TD individuals matched on mental age.

The development of vocabulary was further investigated cross-linguistically and longitudinally by Galeote *et al.* (2011) through parent reports using the MacArthur-Bates Communicative Development Inventories (MB-CDIs) in a large cross-sectional study of 186 Spanish children with DS and 186 TD matched on mental age of 8–29 months. No significant differences were found between the DS and TD groups in terms of expressive vocabulary and both groups performed significantly higher in vocabulary comprehension compared to expressive vocabulary. The study results support a specific association between cognition and vocabulary development and confirm that vocabulary levels are similar for DS and TD groups when controlling for mental age. The study findings also support the results of other research which has suggested that the receptive vocabulary of individuals with DS does not differ from mental age-matched TD participants, including children, adolescents and young adults (Abbeduto *et*

al., 2003; Laws and Bishop, 2003). In addition, the development of receptive vocabulary has been found to continue in later adolescence and early adulthood; this might be because of greater life experience due to greater chronological age (Chapman *et al.*, 1998) However, Roberts *et al.* (2007) found that children with DS performed significantly lower than TD children matched on non-verbal mental age for receptive vocabulary. The discrepancy in findings for vocabulary comprehension and production may be due several factors: sample sizes and the chronological age of groups, different methods used and different statistical analyses (Galeote *et al.*, 2011)

3.7 Phonological awareness and non-word repetition (NWR)

It has been suggested that there is a relationship between phonological awareness and vocabulary development (Metsala, 1999; Carroll *et al.*, 2003; De Cara and Goswami, 2003; Lund *et al.*, 2015). The increase in vocabulary capacity in children in early age is reflected in the identification of syllables, rhymes and phonemes in TD children (Carroll *et al.*, 2003; Lund *et al.*, 2015). More precisely, when a child learns a word, the child relies on the ability to listen and analyse the phonological forms of the word, which can be kept in the existing lexicon (Zens *et al.*, 2009). Studies of TD children also show a correlation between NWR and vocabulary development (Baddeley *et al.*, 1998; Briscoe *et al.*, 2001; Coady and Evans, 2008; Khater, 2016). It has been suggested that this association depends on phonological awareness and reflects participants' ability to segment spoken words (Metsala, 1999). In TD children, vocabulary growth drives a process of restructuring the representation of spoken/heard words leading to phonemic representation. These representations can be drawn on to facilitate NWR performance. There is an additional suggestion that highlights the correlation between phonological awareness and working memory. As previously mentioned (see 2.5.3), in the phonological processing account – one of the theories that explains the relationship between NWR and vocabulary – phonological awareness, lexical knowledge and speech perception are included as factors that play a role in NWR (Snowling *et al.*, 1991). Phonological awareness assessment requires three operations: hearing, acting and responding. The participant must first hear the spoken item, second perform an operation on this speech segment (e.g. say the first phoneme of this word) and third respond verbally. This process uses phonological short-term memory and general cognitive ability (Colom *et al.*, 2004), both of which have also been identified as strong predictors of phonological awareness (McBride-Chang, 1995; Oakhill and Kyle, 2000).

As one aim of this research was to examine the correlation between NWR and phonological awareness, several studies in this area were examined. Although TD studies have been

conducted investigating the correlation between phonological awareness and NWR, the correlation between phonological awareness and NWR remains largely unexplored in Arabic individuals with DS. To the best of my knowledge, no current or previous study has examined the correlation between phonological short-term memory (NWR) and phonological awareness in Gulf Arabic individuals with DS. Arabic is typologically different from the languages previously studied (most often English) and thus it is necessary to test whether the phenomenon previously identified could be generalized. All the studies discussed below were undertaken among TD populations and TD individuals with dyslexia.

A study conducted by Oakhill and Kyle (2000) in the UK investigated the relationship between working memory and phonological awareness in 58 TD children aged 7–8 years. The memory tasks involved the following: a word span task (i.e. verbally listing words with different complexities of syllable length and asking the participant to remember a sequence of four words out of 24); a sentence span task (i.e. producing a simple and short sentence verbally with a missing final word and asking the participant to complete the sentence with a final short word, e.g. 'a cat has four ___'). The researchers compared the predictive power of both memory tasks on two assessments of phonological awareness: the sound categorization task to assess the awareness of onset and rime; the phoneme deletion task to assess awareness at the phoneme level. A non-verbal cognitive assessment was not included in the study. The data were analysed through correlational and multiple regression analysis and it was found that the sound categorization task entailed a higher working memory demand than the phoneme deletion task. The sentence span task was one determinant of performance on the sound categorization task only. In contrast, the word span task did not significantly predict performance on any of the phonological awareness tasks. Performance on the phoneme deletion task was not related to the sentence span task; this conflicts with data from Leather and Henry (1994), who found strong correlations in measures of working memory and phoneme deletion tasks. Neither the word span memory task nor the sentence span memory task could be expected to provide a pure assessment of phonological skills as phonological awareness tasks impose different memory processing demands and the sound categorization task especially placed a heavier demand on the central executive. This may be due to the large memory component of the sound categorization task. This task simultaneously has processing and storage weights as the words need to be sorted in memory and simultaneously compared for phonological similarity, which is not adequately assessed by short-term memory.

Alloway *et al.* (2005) also investigated the predictive value of working memory and phonological awareness skills in relation to teacher ratings of 194 children's progress towards

learning goals at 4–5 years old. The outcomes showed a relationship between working memory, short-term memory, phonological awareness and non-verbal ability. Non-verbal ability was measured by the Wechsler preschool and primary school scale of intelligence, short-term memory was measured by NWR, digit recall and word recall tasks, and working memory was measured by backwards digit recall, counting recall and listening recall. Phonological awareness was measured using a rime detection task and an initial consonant deletion task. The results showed a significant correlation between working memory and phonological awareness, which supports earlier contentions that the processing component of the central executive is involved in storing phonemes in phonological awareness tasks (Hecht *et al.*, 2001). Alloway *et al.*'s (2005) outcomes support the posited difference between the phonological loop (working memory) and phonological awareness, consistent with Gathercole *et al.* (1991), who proposed that even if these processes are controlled by the efficiency of phonological processing, they reflect distinct cognitive systems. In addition, the specific role of the phonological loop in supporting long-term learning of the phonological forms of new words in vocabulary acquisition was reinforced by these outcomes (Baddeley *et al.*, 1998).

The correlation between phonological awareness and working memory has been identified in the English context with TD children. In the Arabic context, a recent study by Zayed *et al.* (2013) investigated the correlation between phonological awareness and working memory in a group of Egyptian Arabic preschool children with and without dyslexia (reading and spelling difficulties). The participants were aged 5–6 years and categorized in two groups: a) at risk of dyslexia (n = 20); b) without risk of dyslexia (n = 20). The tests used to assess phonological awareness were as follows: a syllable blending task, a rhyme detection task, a phoneme isolation task and a phoneme blending task. The working memory tasks comprised a backwards digit recall test and a listening recall task. The results indicated that children at risk of dyslexia performed significantly worse in both phonological awareness and working memory tasks than the TD cohort due to poor phonological awareness skills and working memory associated with dyslexia (Jeffries and Everatt, 2003; Alloway *et al.*, 2004; Jeffries and Everatt, 2004; Alloway *et al.*, 2005). These findings indicate that children at a high risk of dyslexia suffer impairments in both phonological awareness and working memory. Further findings indicated a strong correlation between phonological awareness and working memory for all participants using Pearson correlations, but the study did not compare the strength of the correlations between the groups.

The correlation between phonological awareness and NWR has been also identified in English DS populations. Laws and Gunn (2002) found a high and significant correlation between

phonological awareness (rhyme awareness level) and NWR (r = .79) in readers with DS with controls for chronological age and non-verbal ability. However, no correlation was found for non-reader individuals with DS and it is worth investigating how the correlation differs from that of TD individuals matched on mental age.

In summary, a relationship between working memory and phonological awareness has been identified and there is further evidence to support the claim that working memory is a cognitive mechanism underpinning phonological awareness. This study aimed to extend these findings to the Kuwaiti Arabic context, specifically one including both DS and TD participants.

It is evident from the above discussion that both working memory and phonological awareness are highly correlated (Oakhill and Kyle, 2000; Gathercole *et al.*, 2004; Zayed *et al.*, 2013). It is also apparent that recent studies addressing the relationship between these two predictors are limited, although data on the correlation between phonological short-term memory components (Alloway *et al.*, 2006) and between phonological awareness components (Anthony and Francis, 2005) are available. To my knowledge, no presently published study has investigated the relationship between phonological short-term memory and phonological awareness in the Gulf Arabic context, specifically focusing on a comparison between TD and DS groups, thus providing the rationale for this study. As discussed earlier, DS may affect phonological awareness levels and possibly phonological short-term memory. This study therefore attempted to identify any differences in performance on working memory and phonological awareness between the DS and TD groups, investigating the correlation between working memory and phonological awareness in DS and TD children to identify possible differences. Further investigation would be warranted to investigate whether NWR might predict phonological awareness in a similar way across DS and TD groups.

3.8 Summary

This chapter has provided an overview of phonological awareness development and the literature regarding the relationship between phonological awareness and vocabulary development in English and Arabic studies, as well as presenting English DS studies. English and Arabic studies share the same view that vocabulary knowledge plays an important role in the development of phonological awareness. The outcomes of these studies support the LR model, which states that vocabulary development promotes phonological awareness development through the reorganization of the lexicon. A further objective of this chapter has been to explore the correlation between phonological awareness and working memory in English and Arabic studies of TD participants. There is additional evidence that highlights the

correlation between phonological awareness and working memory. Working memory plays an important role in the development of phonological awareness according to the theories of working memory. It is clear from the research reviewed that few studies of English have examined the correlation between phonological awareness and vocabulary in individuals with DS. So far, little attention has been paid to matching DS participants with a control group on mental age and investigating how the DS group differs from the TD group in terms of the correlation between vocabulary knowledge and phonological awareness. Consequently, there are number of unsolved questions in terms of the correlation between phonological awareness and vocabulary knowledge, as well as the correlation between phonological awareness and working memory in individuals with DS and TD matched on mental age and whether this correlation differs between the groups, as well as the issue of cognition raised in Chapter 1. This indicates a need for more understanding of the correlation between vocabulary knowledge and phonological awareness in individuals with DS and how they differ from TD participants matched on mental age.

3.9 Research questions and hypotheses

This study had several aims. First, it sought to investigate the developmental trajectory of vocabulary (APVT, AEVT), phonological short-term memory (NWR) and phonological awareness (syllable, rhyme, phoneme) across non-verbal mental ability, measured by the RCPM scores in individuals with DS and TD children. Second, it aimed to compare the rate of development of vocabulary, NWR and phonological awareness across non-verbal mental abilities in individuals with DS and TD. Third, it sought to investigate the relationship between NWR, vocabulary development and phonological awareness in Arabic-speaking DS and TD individuals matched on non-verbal cognitive abilities. The research aimed to add cross-linguistic evidence from the Arabic context to the existing literature on the role of non-verbal mental abilities (RCPM), phonological awareness, NWR and vocabulary knowledge for DS children matched with TD individuals on non-verbal cognitive abilities.

Research questions

1. Are the developmental trajectories of vocabulary, non-word repetition (NWR) and phonological awareness across non-verbal mental ability in individuals with Down syndrome (DS) similar to those of typically developing (TD) children in terms of onset and the rate of the development?
2. Does non-word repetition (NWR) performance predict vocabulary (APVT, AEVT) to the same extent across Down syndrome (DS) and typically developing (TD) groups?

3. Does vocabulary (APVT, AEVT) predict phonological awareness to the same extent across Down syndrome (DS) and typically developing (TD) groups?
4. Does non-word repetition (NWR) predict phonological awareness to the same extent across Down syndrome (DS) and typically developing (TD) groups?

Hypotheses

1. The developmental trajectories of vocabulary, non-word repetition (NWR) and phonological awareness across non-verbal mental ability will be similar in Down syndrome (DS) and typically developing (TD) groups in terms of onset/intercept and the rate of development.
2. Scores for non-word repetition (NWR) will be significantly correlated with scores on the Arabic Picture Vocabulary Test (APVT) and Arabic Expressive Vocabulary Test (AEVT) for the Down syndrome (DS) and typically developing (TD) groups and the slope will be steeper in the TD group than the DS group as measured by the interaction effect similar to Laws and Bishop (2003) (see 2.4).
3. Scores for vocabulary (Arabic Picture Vocabulary Test [APVT], Arabic Expressive Vocabulary Test [AEVT]) will be significantly correlated with scores for phonological awareness for the Down syndrome (DS) and typically developing (TD) groups and the slope will be steeper in the TD group than the DS group.
4. Scores for non-word repetition (NWR) will be significantly correlated with scores for phonological awareness for the Down syndrome (DS) and typically developing (TD) groups and the slope will be steeper in the TD group than the DS group.

The methods used to answer the research questions and interrogate the hypotheses are presented in the following chapter.

Chapter 4. Methodology

4.1 Introduction

This chapter explains the research methods used in this study. It begins with a description of the study design, followed by information on the DS and TD groups and then an outline of the methods and procedures used in this study. The pilot study and ethical issues are also addressed.

4.2 Study design

The design of the study was a cross-sectional, experimental developmental trajectory approach (Thomas *et al.,* 2009) undertaken with two groups: DS and TD. Following this approach, and before collecting the data, a pilot study was carried out in December 2015 to check whether participants were able to understand the assessments procedure. For the main study, data are collected at a single point of measurement for the TD and clinical groups, which vary in age. In addition a group matching/comparison of the DS and TD groups is applied during recruitment. TD children whose RCPM scores matched those in the DS group were recruited. Individuals with DS and TD had a similar range of developmental scores for non-verbal mental abilities and to ensure a spread of mental ages, those in the DS group had a chronological age of 6–20 years and those in the TD group had a chronological age of 3–10 years. Once the groups had been matched on NVMA, I investigated and compared the developmental trajectories of the dependent variables (vocabulary, NWR, phonological awareness) in terms of onset and rate of development across NVMA. Thus, the developmental trajectory approach involved matching the groups' performance on language skills at one point in time (see 5.4). The rationale for using some sort of group matching based on NVMA was that it would enable group comprisons for the dependentt variables. This might indicate whether the DS group was impaired as a whole compared to the mental age-matched TD group. An additional advantage of the developmental trajectory approach is that it is more sensitive to individual variability in skills than other approaches and can inform more clearly on whether relationships look different between groups at higher or lower mental ages (and therefore, by implication, whether those skills develop in a similar way over time across groups).

4.3 Participants

Two groups were recruited for the study. The DS, confirmed trisomy 21, group consisted of 48 individuals (17 males and 31 females), ranging in age from 6.02 to 20.05 years. The TD/control group consisted of 44 individuals (19 males and 25 females), ranging in age from 3.05 to 10.05 years. The control group was matched on RCPM (Raven, 2003) raw scores (within 3 points above or lower) to individuals with DS (for further detail, see 4.4.1). This was similar to a study

conducted by Laws and Bishop (2003), who matched individuals with DS to a TD control group on gender and RCPM within one point. However, it was challenging to match all participants of both groups within one point.

The rationale for using RCPM, which represents non-verbal cognitive abilities, rather than other tasks, is as follows. First, this task is a visuo-spatial task, requiring participants to reason the relations between visual items in order to select the target item completing a logically constructed pattern. It is a test of analogical reasoning implemented in a visuo-spatial and therefore is relatively independent of language ability (Gunn and Jarrold, 2004). Second, no speech production is required from the DS participants to respond to the task; they can respond by pointing. This suits individuals with DS, who display strength in visual ability and learning, but experience difficulties in speech production and motor processes (Chapman and Hesketh, 2000; Jarrold *et al.,* 2002). It is possible to ensure that their performance is not affected by confounding factors. Third, the instructions/tasks are very simple. This overcomes potential difficulties in explaining the tasks to individuals with low verbal abilities, or in translating the instructions across languages. Fourth, RCPM uses a single task (visual analogical reasoning via picture selection), the degree of difficulty of which may easily be manipulated and varied. This means that the same task can be used across a wide range of ages. Standardized IQ tests often introduce different tests at different ages, which makes it difficult to plot genuine developmental trajectories across a wide age range using standardized tests. In addition, other studies have used this method, ensuring that the results are comparable across studies (Vicari *et al.*, 2000; Fidler *et al.*, 2006).

The TD children were recruited through family, friends and summer clubs (the administration of which were willing to distribute letters to parents). The DS participants were recruited through five special education schools for special needs run by the Ministry of Special Education for Special Needs in Kuwait and the Kuwaiti DS society whose members were enrolled in one of these schools.

An official procedure was required to recruit individuals with DS from the special education schools for special needs in Kuwait. I submitted a letter of request to the Ministry of Education, specifically ‘The Public Administration for Private Education’. Once consent was given in October 2016, the Ministry sent a letter in November 2016 entitled ‘facilitate task’ for all schools with special needs in Kuwait to ease access to the school administration and make it possible for me to recruit and work with participants. Once I had received consent forms from

the participants' parents and from the participants themselves, either verbally or by signing, I started collecting data.

The DS group comprised 22 children and 26 adolescents, giving a total of 48 participants. Only 2 participants were excluded from the study and not counted due to poor performance on the non-verbal reasoning test (RCPM) and not cooperating in continuing the test. A liberal definition of adolescence was used in this study following Arnone (2014), who proposed that adolescence continues beyond 18 years. In this study, 2 individuals with DS were older, at 20 years. For readability, the participants are termed 'children' and 'adolescents'.

The DS participants came from different socio-economic backgrounds and from the capital of Kuwait and met the following inclusion criteria, quite similar to Næss *et al.* (2011):

- Their mode of communication was verbal and they used sentences of three or more words.
- Their first and dominant language was Arabic and the Kuwaiti dialect.
- They were able to understand and complete a non-verbal reasoning test (RCPM).
- They did not have a co-morbid diagnosis of another developmental disorder (e.g. autism).
- They had no current hearing infection or severe sensory-neural hearing loss according to their last hearing screening test in the previous 6 months recorded in their school reports.
- They were able to pass an articulation screening test (see Shaalan, 2010).
- DS participants should be below 23 years old due to the potential for decline in language and memory performance in young adults and signs of dementia in early adulthood (Laws and Bishop, 2003).
- There was signed parental consent form for all DS participants, non-reader participants consented verbally and the participants who could read signed for themselves.

In the TD group there were 44 children, matched on the DS RCPM scores, within three points above or below (Raven, 2003) and they came from similar socio-economic backgrounds (based on school reports), were from the capital governorate region and met the following inclusion criteria:

- Parents signed a consent form, non-reader children consented verbally and readers signed for themselves.

- They had no suspected or confirmed hearing, speech and language, or learning difficulties.
- Their first and dominant spoken language was Arabic and the Kuwaiti dialect.

A summary of the participants' characteristics is provided in Table 4.1.

Table 4.1 Summary of participants' characteristics

Participants	**DS Group**	**TD Group**
Number of participants (male:female)	48 (17:31)	44 (19:25)
Mean age in months (years)	156 (13:0)	75 (6:3)
Range in months (years)	75–247 (6:2–20:5)	43–127 (3:5–10:5)

4.4 Language and cognitive measures

Before testing the language measures and RCPM test, a pilot study was applied with TD participants and individuals with DS. Then, individuals in both groups were assessed over two sessions within the same week. Each session was held individually in a quiet room at their school, or at their homes. A few participants were tested in a quiet room at the Kuwaiti DS society. Each session lasted approximately 45 minutes with a break of 5–10 minutes between tasks. The presentation of the tasks for all participants was in Kuwaiti dialect. Participants' responses were scored manually at the time of testing. The tasks were administered in each session as follows (see Table 4.2):

- *Session 1:* RCPM (Raven, 2003); articulation screening test (Shaalan, 2010); NWR (Shaalan, 2010); AEVT (Khater, 2016).

  Note. The expressive vocabulary test was administered in the first session, so the participants would not hear the words and use them in the expressive vocabulary test.
- *Session 2*: Rhyme awareness task; syllable awareness test and phoneme isolation test (Al-Sulaihim, 2014); APVT (Shaalan, 2010).

Table 4.2 RCPM and language measures

Tasks	Test name
Non-verbal mental age	RCPM (Raven, 2003)
Phonological short-term memory	NWR (see Shaalan, 2010)
Vocabulary	APVT (see Shaalan, 2010) AEVT (see Khater, 2016)
Phonological awareness	Syllable awareness (Al-Sulaihim, 2014) Rhyme awareness Phoneme awareness (Al-Sulaihim, 2014)

4.4.1 Raven's Coloured Progressive Matrices (RCPM)

Non-verbal mental abilities/cognitive ability were assessed using the RCPM (Raven, 2003). This measure comprises 36 items divided into three sets of 12 each (A, AB and B) in which items are ordered by increasing difficulty. Each item is presented as a coloured pattern with a missing portion and there are 6 options to choose from to fill in the missing element. The 36 items were all administered in the order prescribed in the manual with no time limits set. This was the first task carried out with all participants in both groups and was conducted in a quiet room situated near the participant's classroom or a quiet room at home. The raw scores were used as a matching variable. The test was originally conducted with 50 TD children; 6 TD children were excluded as their scores were not within 3 points of an equivalent DS participant and the requirement for matching was to score a maximum of 3 points plus or minus the total raw scores of the DS scores. Raw scores were used to match samples and as a measure of non-verbal cognitive abilities in the analyses. Raw scores have also been used in other studies using a similar design of matched groups (Næss *et al.*, 2015; Facon *et al.*, 2016; Polišenská *et al.*, 2018). The rationale behind the usage of RCPM raw scores is that there is no normative data on RCPM in the Kuwaiti population.

The rationale for selecting the RCPM rather than another non-verbal ability test was the simplicity and speed of its administration (15–20 min). It has been used extensively to assess intelligence among typical and clinical populations of individuals with DLD (Cotton *et al.*, 2005). In addition, a verbal task would not have been suitable as I was evaluating language abilities and comparing these with non-verbal cognitive abilities. In addition, a non-verbal task might be preferable as a measure of the general level of cognitive ability with individuals with DS due to their difficulty in verbal ability. The item difficulty in RCPM has been shown to be highly similar for individuals with DS and TD participants (Facon and Nuchadee, 2010). The RCPM has been used widely with samples of individuals with DS (Laws *et al.*, 1995; Laws *et al.*, 1996; Laws, 2002; Natsopoulos *et al.*, 2002) as an index of non-verbal cognitive ability up to 30 years old. Table 4.3 shows the descriptive statistics for the RCPM in both the DS and TD groups.

Table 4.3. Descriptive statistics for RCPM scores in the DS and TD groups

	Down syndrome	Typically developing	Sig.
RCPM (raw scores)			
Mean	17.19	18.75	
SD	4.93	5.89	.17
Range	7–30	11–34	

t(90)= -1.38, p =.17 >.05 Note. RCPM = Raven's Coloured Progressive Matrices

An independent-sample t-test was run to determine if there were differences between the groups on the RCPM. The results of the t-test confirmed that the mean raw scores for the RCPM were not statistically different between the DS and the TD groups, as required to match the DS participants with the TD control on non-verbal cognitive/mental abilities.

4.4.2 Arabic Picture Vocabulary Test (APVT)

The APVT, adopted from (Shaalan, 2010), was based on the existing British Picture Vocabulary Test (BPVT) (Dunn *et al.*, 1997) and no changes were made to the test items or pictures. The test is non-standardized and consists of 132 items arranged in terms of difficulty into 10 groups, with 12 items per group. All items were in a booklet comprising 134 pages; 2 pages contained practice items and the other 132 test items. Each page showed four pictures, mostly taken from either the BPVT (Dunn *et al.*, 1997) or from non-copyrighted material (free clip art). Moreover, all four pictures on the page were taken from the same source so that no single picture would stand out and all the answers were transferred to a record form (see Shaalan, 2010). The test is administered individually and takes approximately 15–20 minutes to complete. The APVT was administered by Shaalan to 107 Gulf Arabic-speaking children in Qatar ranging in age from 4 to 9 years old. Some of the participants were TD children and some were diagnosed with DLD. In addition, this test was used by Khater (2016) with TD and DLD Gulf Arabic-speaking children.

The test was administered in the second session, so the participants would not hear the words and use them in the expressive vocabulary test, thus avoiding a learning effect. The participants were given the following instructions in Arabic: 'As you can see, this is a picture book, I will name one of the pictures and I want you to point with your finger to the picture I mentioned. Let's now practise a couple of pages.' This was followed by two practice items (*shoe* and *fish*). The children were presented with four pictures on each page and they were required to point to the correct response. None of the participants had difficulty understanding the instructions for the test. A ceiling criterion was employed because of the large number of stimuli to reduce fatigue. The ceiling criterion used was similar to that in Shaalan's (2010) study, eight errors in one group, at which point the test was stopped. The rationale for the ceiling criterion was that it was similar to that used in the BPVT (Dunn *et al.*, 1997). If the children seemed interested in the test, they were encouraged to continue even when the ceiling was reached, but scoring stopped at the ceiling item for many participants. All responses were recorded on a score sheet, with children receiving (1) for correct responses and (0) for incorrect responses or no response. The total raw scores were computed by subtracting the number of errors the participant made

from the last ceiling item. For example, a participant who stopped at item 60 and 15 errors in total would have a raw score of 45.

4.4.3 Arabic Expressive Vocabulary Test (AEVT)

This AEVT was developed by Khater (2016). It is an adapted version of the Expressive One-Word Picture Vocabulary Test (EOWPVT) (Brownell, 2000) and was designed to be administered with TD and DLD Gulf Arabic-speaking children. The EOWPVT is an English standardized test that provides an assessment of expressive vocabulary for all ages, starting at 2-year-old children to adults over 80 years old. The AEVT follows the same principles of picture display, scoring and organizing the stimuli in groups according to age bands. The bands were 11 months for each group and there were 8 groups. The test consists of 68 items and Khater's age groups started from 2:0–2:11 and went up to 9:0–9:11. There were 4 pages for practice items and 64 pages for test items. Each page contained one coloured picture taken from non-copyrighted material (free clip art). The criteria used to select the words and pictures for the AEVT were as follows: (i) item category, with each item relating to different groups (actions or verbs, singular and plural nouns in different categories – households, animals, food, toys, and clothes); (ii) item difficulty, established based on two methods, representative speech samples collected by Khater and Shaalan (2007) from 56 Gulf Arabian children aged 2:0–6:0 years, with the items used in the test for each age band selected from the speech sample of a similar age group, and a familiarity rating collected from 24 Gulf Arabic-speaking adults for 600 words (Shaalan, 2010).

This test was administered in the first session. The participants were given instructions in Kuwaiti Arabic: 'As you can see, we have on each page different pictures. I want you to name the picture you can see. Let's now practise a couple of pages.' This was followed by four practice items. None of the participants had difficulty understanding the instructions for the test. A ceiling criterion was employed because of the large number of the stimuli to reduce fatigue, especially with preschool age children. The ceiling criterion used was 6 errors in one group before stopping the test. All responses were recorded on a score sheet and the children received (1) for correct responses and (0) for incorrect responses or no response. The total raw scores were computed by subtracting the number of errors the child made from the last ceiling item. For example, a participant who stopped at item 60 and had 15 errors in total would have a raw score of 45. All the answers were transferred to a record form (see Khater, 2016).

4.4.4 Arabic NWR test

The Arabic NWR test was developed by Shaalan (2010). It was designed to compare the effects of phonological storage (as measured by syllable length) and the effects of phonological complexity (as measured by consonant clusters). Participants repeat a series of words of increasing length and phonological complexity. Careful consideration was paid to controlling other variables that have been found to influence NWR. These include: articulatory complexity (i.e. early developing sounds), lexicality effects, respecting the phonotactic rules of Arabic, morphological information, syllable number, and word likeness.

The NWR test consists of 56 non-words. These were presented orally by me, sitting behind the participant so the participant could not see my lip movements. The participants' responses were audio recorded. The instruction for each participant was equivalent to the following sentence given in Arabic: 'You will now listen to funny words and I want you to repeat them exactly the same way as you hear them.' The participants were required to repeat each non-word immediately following the prompt. The standard procedure used in this test is to present the words on audiotape, so the quality of the sounds presented is similar across participants. However, participants with learning difficulties are easily distracted and may need time to pause between test items, so it is easier and more practical to administer the test 'live'; the decision to present the items live follows a number of studies (Chiat and Roy, 2007; Chiat and Roy, 2008; Khater, 2016), based on the rationale that this method can increase the cooperation of the youngest participants. The same instruction was given for each participant in Arabic, specifically Kuwaiti. All responses were audiotaped through a voice recorder and analysed later. Most of the participants enjoyed the experiment and found it fun. No repetition of the stimuli was allowed. All participants' responses were scored using the whole word correct (WWC) scoring method, with each response or repetition scored either correct (1) or incorrect (0). The rationale for using this scoring method was its simplicity and similarity to the approach adopted in studies by Bishop *et al.* (1996) and Laws (1998).

Reliability was examined to ensure that changes in test scores were only due to a change in the variable being measured. Inter-rater reliability is a method used to assess test reliability by measuring the correlation between the scores of two different raters. A second examiner with experience in scoring tests was asked to score 10% of the participants' responses using the WWC scoring method in NWR test. There was high inter-rater agreement ($\alpha = .90$).

4.4.5 Arabic phoneme isolation task

The Arabic phoneme isolation task was developed by Al-Sulaihim (2014) and is an adapted subtest of the Preschool and Primary Inventory of Phonological Awareness (PIPA) (Dodd *et al.,* 2000). This task assesses the participant's ability to recognize onsets and to produce them as isolated sounds when the investigator presents them with a spoken word. I, as the investigator, presented the stimuli orally and the participants were shown a picture of the spoken words; this requires low memory, especially for individuals with DS. The participant sees the picture and hears the word and is required to produce the first sound of each word (e.g. 'As you can see, this is a car, what is the first sound of /kar/?' /k/). The task included 1 demonstration item, 2 practice items and 12 test items. All test items began with single consonant sounds, vowels or a consonant cluster. Participants scored either 1 point for correct responses, or 0 for incorrect (0 point) for incorrect productions of the initial phoneme of the word, as well as for non-responses. Raw scores were calculated based on the number of correct items. The rationale for selecting the phoneme isolation task rather than other phoneme awareness tasks, such as blending and deletion tasks, was that Stahl and Murray (1994) found the isolation of phonemes to be easier than blending and deletion.

4.4.6 Arabic syllable awareness task

The Arabic syllable awareness task was also developed by Al-Sulaihim (2014). It is an adapted subtest of the PIPA (Dodd *et al.,* 2000). This task assessed each participant's ability to process words and to segment words into syllables. The participants were presented with 4 practice items and 12 test items, spoken by me. They were shown a picture of 5 drums and asked to tap out the parts of the words as drumbeats or to clap the syllables while also segmenting the words into syllables. The task consisted of three 2-syllable words, three 3-syllable words, three 4-syllable words and three 5-syllable words. For example, the word 'pencil' would be segmented into two syllables, /pen/ and /cel/. The participants heard the word (pencil) and they were required to either tap or clap their hands for the number of syllables heard. They were given a score of 1 point for correct tapping or clapping and 0 for incorrect tapping/clapping or no response. Raw scores were calculated based on the number of correct items.

4.4.7 Arabic rhyme judgment awareness task

I developed this task based on the English rhyme judgment awareness test developed by Cupples and Iacono (2000) and designed for individuals with DS. The selection of the vocabulary used for this test was similar to that used for the rhyme awareness task developed by Al-Sulaihim (2014). In this task, the examiner first asks the participants whether they know any nursery rhymes (standard rhyming songs used with children). The examiner says the first

two lines of the nursery rhyme, leaving the participant to complete it. All participants completed the rhyme with no hesitation. I encouraged the participants by praising them and emphasizing the rhyming words (‘dad and sad, they rhyme, don’t they?’ ‘Yes, they do’). The participants were then told that they were going to play a game with rhyming words. The task was to select from two pictures (non-copyright free clip art) the picture of the word that rhymed with a word spoken by me as the examiner; the position of the target words, left or right, was exchanged randomly.

For example, pictures of a lock and a knot were presented with the instruction: ‘This is a lock and this is a knot; show me the one that rhymes with clock.’ The answer would be pointing to the picture of the lock (see Appendix K).

When children responded correctly to the practice items, their response was reinforced with a statement like ‘Yes, good job. Let’s do more’. However, if the participant’s response was incorrect, they were provided with corrective feedback and encouraged to think again. No feedback was provided for the test items. Raw scores were calculated based on the number of correct items. Because I developed this test and it had not been tested by others, extra steps were taken further to ensure the test’s reliability and validity.

Test-retest reliability. To examine the test-retest reliability of the rhyme judgment test, 10 children were tested again one week after they took the test the first time. This group consisted of five individuals with DS and five TD children. The results showed a Pearson correlation coefficient of $r = .94$ ($p = .00$), indicating the test was stable over time.

Concurrent validity. To assess the concurrent validity of the rhyme awareness judgment task, it was compared to tests developed by others, such as phonological awareness (e.g. syllable awareness, phoneme awareness) tests and vocabulary tests (e.g. APVT, AEVT). The results of the Pearson correlation revealed significant correlations ($p < .01$) between the rhyme judgment awareness task and all these measures, as illustrated in Table 5.2 in Chapter 5.

Although I administered and scored all the assessments, inter-rater reliability statistics were calculated for 10% of the assessments by Fathiya Al Rahbi based on scoring of the vocabulary, NWR and phonological awareness tests by a second researcher to check reliability and consistency.

4.4.8 Articulation screening test

Before applying tests, all individuals with DS and the TD children were required to participate in an articulation screening test developed by Shaalan (2010) to rule out any severe

phonological disorders. In this screening test, participants were asked to repeat 30 words that started with as many Gulf Arabic consonants. These 30 words were selected to include late developing sounds in medial and final word positions.

4.4.9 Other tests used only in the pilot study

Two tasks were used as measures of reading ability in the pilot study. The first was a letter knowledge task, in which participants were shown 28 letters in Arabic and asked to produce either the name or the sound of the letter. Either of those two answers would be marked as correct. The second test was the single word reading test, developed by Al-Sulaihim (2014) and paralleled with the reading subtest of the Wechsler objective reading dimension test. This test consists of 75 items. For items 1–4, participants were required to look at a picture and point to the word beginning or ending with the same sound as the word in the picture. They were asked to select from a list of 4 option words. For items 5–7, participants were asked to select from a word list of four words the one matching the picture. The remaining items for this test assessed single word reading without any visual cues. The test was stopped after 6 consecutive errors. A score of 1 was given for correct responses and 0 for incorrect responses or no response. These literacy tests were excluded from the main study as they were time consuming, the participants lost motivation to continue with the other tests and it was difficult for most of the DS participants to digest the task in the pilot study.

4.5 Pilot study procedure

The pilot study was carried out in December 2015, before collecting the data for the main study,to check whether participants were able to understand the assessments procedure, to find out how long the tests would take to deliver and to gain information about time management. Twelve participants participated in the initial pilot study. Ten individuals with DS were recruited from special education schools for special needs. Two TD children were recruited from family members.

The results of the pilot study showed that all participants were able to understand all the tests, except the letter knowledge and single word reading test. Some of the TD children were unable to read as they had not started school. Some children and adolescents with DS faced difficulty reading the letters and words of the literacy tests, in addition to these being time consuming. Thus, it was decided to exclude literacy assessments (the letter knowledge test and the single word reading test test) from the main study. Furthermore, the time spent on applying these tests meant that the total time per session came to 2 hours, with a 5–10 min break between the tasks. Presenting the NWR task via audio recording in the pilot study proved distracting for young

TD participants as well as for those with DS and they did not respond to the task. Therefore, it was decided to abandon the recorded stimuli in favour of live stimuli that would be natural and spontaneous. The data collected and analysed for the main study were therefore different from those in the pilot study.

Data collection took place in November 2016. The participants took part in two testing sessions; the first assessed the RCPM (see 4.4.1), the expressive vocabulary test (see 4.4.3), the articulation-screening test (see 4.4.8), the phoneme isolation test (see 4.4.5), and the NWR test (see 4.4.4) presented through an audio recording; the second session assessed the receptive vocabulary test (see 4.4.2), the rhyme awareness test (see 4.4.7), the syllable awareness test (see 4.4.6), the letter knowledge test and the single word reading test (see 4.4.9) for readers.

4.6 Ethical implications

Before the participants were recruited, the Newcastle University research ethics committee reviewed the project and it received a favourable ethical opinion. All the parents of the TD children and individuals with DS were given an information sheet (see Appendix A and Appendix B), which briefly described the study aims. If they agreed to their child participating in the study, a consent form was provided for them to sign (see Appendix C). A further information sheet was given to participants able to read (see Appendix D) and another information sheet for non-reader participants (see Appendix E). Another consent form was given to reader participants to sign (see Appendix F). For the non-reader participants, those willing and motivated to participate were only involved in the study if a consent form was received from their parents. After obtaining informed consent from the parents and reader participants, parents were asked to complete a simple questionnaire and return it. Different questionnaires were developed for the parents in the DS and TD groups. The background questionnaire given to the parents in the TD group (see Appendix G) involved general health information and participants' developmental milestones. In the background questionnaire given to parents in the DS group (see Appendix H), the type of DS was also included. At the end of participation, a debriefing sheet was given to parents (see Appendix I) and another was given to the participants able to read (see Appendix J). In addition, parents and participants in both groups were told before giving written consent that they were taking part in a project about how TD children might differ from individuals with DS in terms of vocabulary, memory and phonological awareness. They were informed that their answers, responses and information would be stored anonymously. The tasks had nothing to do with anything they did at school and they could withdraw at any time.

4.7 Data management

Data collection was undertaken between November 2016 and June 2017. All test scores and materials were kept solely in my possession to ensure the proper storage and confidentiality of information. The data were managed using Microsoft Office Excel and IBM SPSS version 24. All data collection materials, such as scored record sheets, questionnaires and signed consent forms, were stored safely in a locked filing cabinet. To guarantee privacy, each participant was given an identification number based on the group to which they belonged and all names and other identifying materials were removed from score sheets and electronic spreadsheets (Excel and SPSS). Moreover, only I had access to the participants' personal information.

4.8 Data analysis

Several methods were used to analyse the data. First, scatter plots were drawn for all language measures over chronological age and mental age separately for the DS and TD groups to visually examine linearity. No clear nonlinear trends were found for the TD group. To answer RQ1, concerning whether RCPM would predict language measures similarly in the DS and TD groups, separate univariate regression analyses/ANCOVA were used to examine the developmental trajectories for the DS and TD groups in relation to RCPM. Further univariate regression analysis was applied to form a between-group comparison of the two developmental trajectories for the APVT, AEVT, NWR and phonological awareness tasks. For RQ2, addressing whether NWR would predict vocabulary to a similar extent across the DS and TD groups, univariate regressions were performed. For RQ3, addressing whether vocabulary knowledge would predict phonological awareness to a similar extent across the DS and TD groups, two separate univariate regression analyses were performed for APVT and AEVT to predict phonological awareness. For RQ4, concerning whether NWR would predict phonological awareness to a similar extent across the DS and TD groups, univariate regression analysis was performed. In addition, to determine whether there were significant differences in the means of language measures in the DS and TD groups, an independent sample t-test was used.

4.9 Summary

This chapter has discussed the methods and procedures used in the study. Information regarding the participants' sample and study design has been provided. All the methods used in this study have been explained in detail. This chapter has further discussed the ethical implications and pilot study procedure, in addition to the data analysis undertaken to answer the research questions. The next chapter will discuss the results of the study in detail.

Chapter 5. Results

5.1 Introduction

An initial scan process was conducted using IBM SPSS 24 to explore descriptive statistics, missing data, and the normality and multicollinearity of data separately for the DS and TD groups. Raw scores were calculated for the RCPM, vocabulary tests (APVT, AEVT), phonological awareness tasks (syllable, rhyme, phoneme), and NWR. Descriptive statistics were used to present information (mean, standard deviation, range) on all tests administered to all participants in both groups, in addition to using parametric tests to investigate whether the groups differed in their performance on language measures. To examine performance on language measures in relation to chronological age/raw RCPM scores, the developmental trajectory approach was applied as previously described in 1.3. This approach adopts the analysis of covariance (ANCOVA) function, in other words separate univariate regression analysis.

Before carrying out the cross-sectional developmental trajectory analysis, scatter plots for all language measures over chronological age and mental age were created for the DS and TD groups to visually examine linearity. No clear nonlinear trends were found. The other research questions were analysed further using correlations to explore relationships between variables and ANCOVA to make group comparisons.

5.2 Characteristics of the participants

This study comprised 48 individuals with DS (52.17%) and 44 (47.82%) TD children matched on RCPM raw scores within 3 points plus or minus. (See Chapter 4: Methodology for more details.)

5.3 Results and analysis

This chapter aims to answer the following research questions:

1. Are the developmental trajectories of vocabulary, non-word repetition (NWR) and phonological awareness across non-verbal mental age in individuals with Down syndrome (DS) like those of typically developing (TD) children matched on non-verbal mental age in terms of onset and the rate of the development?
2. Does NWR performance predict vocabulary (APVT, AEVT) to a similar extent across DS and TD groups?
3. Does vocabulary (APVT, AEVT) predict phonological awareness to a similar extent across DS and TD groups?

4. Does NWR predict phonological awareness to a similar extent across DS and TD groups?

The *first question* in this study aimed to investigate the developmental trajectories of vocabulary (APVT, AEVT), phonological short-term memory (NWR), and phonological awareness (syllable, rhyme, phoneme) in individuals with DS and compare them to those of TD children matched on mental age across non-verbal mental age. A further aim was to investigate whether the development of vocabulary, NWR and phonological awareness differed between the groups in relation to NVMA. The *second question* aimed to evaluate whether NWR predicts vocabulary knowledge based on receptive and expressive vocabulary tests. The *third question* aimed to evaluate whether vocabulary knowledge predicts phonological awareness. The *fourth question* aimed to evaluate whether NWR predicts phonological awareness.

Before attempting to answer the research questions, descriptive statistics and correlations are presented separately for the DS and TD groups. An independent t-test was applied to investigate whether significant differences were indicated between the groups on vocabulary skills, phonological awareness and NWR. Fisher-z transformation was applied to investigate whether there were significant differences in the correlation coefficients between correlations for the DS and TD groups.

5.4 Comparisons of group performance

Table 5.1 presents the means, standard deviations, and ranges for the DS and TD groups for language measures (receptive vocabulary, expressive vocabulary, NWR, phonological awareness). An independent t-test was applied, and significant differences were found between the groups on all language measures, as illustrated in Table 5.1.

Table 5.1. Descriptive statistics and group difference on all language measures

	Down syndrome (DS) (n = 48)	Typically developing (TD) (n = 44)	Group difference t (90)	Sig.
Receptive vocabulary (APVT)			-3.17	
Mean	46.70	60.04		**
SD	4.93	5.89		
Range	7–30	11–34		
Expressive vocabulary (AEVT)			-3.27	
Mean	28.52	35.29		
SD	8.66	11.12		**
Range	13–54	13–58		
Non-word repetition (NWR)			-8.32	
Mean	46.72	86.89		
SD	20.72	13.04		**
Range	3.58–96.66	35.71–100		
Syllable awareness task			-2.31	
Mean	7.56	8.68		*
SD	2.12	2.50		
Range	3–12	3–12		
Rhyme awareness task			-3.09	
Mean	7.56	9.14		**
SD	2.20	2.67		
Range	2-11	3-12		
Phoneme isolation task			-4.81	
Mean	6.0	9.39		
SD	3.29	3.46		**
Range	0-12	2-12		

* $p < 0.05$, ** $p < 0.01$. *Note. All the language test scores are raw scores, except for the NWR (scores presented as percentages), and used the whole word correct scoring (WWC) method.*

A visual inspection of the mean scores in Table 5.1 shows that the TD group scored higher on all language tasks.

5.4 Correlational analysis

The next section, as illustrated in Table 5.2, examines the relationships between the RCPM, receptive vocabulary (APVT), expressive vocabulary (AEVT), NWR and phonological awareness, including syllable awareness, rhyme awareness and phoneme awareness, separately for the DS and TD groups using product-moment Pearson correlation coefficients.

Table 5.2. Product-moment Pearson correlations (r) between non-verbal mental age and all language measures in the DS and TD groups

	RCPM	APVT	AEVT	Syllable	Rhyme	Phoneme	NWR
RCPM		**.527**** *.630***	**.529**** *.762***	**.510**** *.670***	**.414**** *.593***	**.512**** *.547***	**.014** *.540***
APVT			**.698**** *.822***	**.327*** *.603***	**.498**** *.692***	**.631**** *.634***	**.059** *.557***
AEVT				.360* *.597***	**.495**** *.698***	**.698**** *.606***	**.106** *.587***
Syllable					**.714**** *.608***	**.430**** *.648***	**.256** *.608***
Rhyme						**.594**** *.824***	**.309*** *.704***
Phoneme							**.296*** *.780***

Notes. Correlations for DS participants are reported in bold. Correlations for TD participants are reported in *italics*.
RCPM = Raven's Coloured Progressive Matrices: APVT = Arabic Picture Vocabulary Test; AEVT = Arabic Expressive Vocabulary Test; NWR = Non-word repetition. * $p < 0.05$, ** $p < 0.01$

As can be observed in Table 5.2, all the language measures, including vocabulary measures (APVT, AEVT), phonological awareness tasks (syllable, rhyme, phoneme) and NWR, were significantly correlated with each other in the TD group, in addition to significant correlations with RCPM. In contrast, for the DS group, NWR was not significantly correlated with either RCPM, vocabulary test (APVT, AEVT) or syllable awareness. This was not expected for the DS group.

To investigate whether there were significant differences between the correlations for the DS and TD groups, the Fisher-z transformation and hypothesis testing were applied to convert the Pearson correlation coefficient (r) into a z score, then determine the significance of any differences (Rosenthal and Rosnow, 1991). Table 5.3 presents only the significant differences in correlations between the DS and TD groups; non-significant differences in correlations are not reported.

Table 5.3. Fisher-z transformation and hypothesis testing

Measures	DS r	TD r	z
RCPM – NWR	-.256	.540	-2.73**
NWR – APVT	.059	.557	-2.64**
NWR – AEVT	.106	.587	-2.62**
NWR – Syllable	.256	.608	-2.06*
NWR – Rhyme	.309	.704	-2.57**
NWR – Phoneme	.296	.780	-3.43**

Notes. RCPM = Raven's Coloured Progressive Matrices; APVT = Arabic Picture Vocabulary Test; AEVT = Arabic Expressive Vocabulary Test; NWR = non-word repetition. * $p < 0.05$, ** $p < 0.01$

As illustrated in Table 5.3, the negative z-scores indicate that the correlations were significantly stronger in the TD group than in the DS group. This is also presented visually in a scatter plot in Appendix L.

5.5 Results for RQ1

Are the developmental trajectories of vocabulary, NWR and phonological awareness across RCPM in individuals with DS like those of TD children matched on non-verbal cognitive abilities?

It was hypothesized that the developmental trajectories of vocabulary, NWR and phonological awareness across non-verbal mental age would not differ significantly between the TD group and the DS group in terms of the onset and rate of the development. Separate ANCOVA were carried out to explore these hypotheses using the language measures, APVT, AEVT, NWR and phonological awareness tasks (syllable, rhyme, and phoneme) as dependent variables, entering mental age as covariates and taking group as the fixed factor separately in each model. The results of the developmental trajectory approach for vocabulary across cognitive level (Ravens raw score) are shown in 5.5.1 (APVT) and 5.5.2 (AEVT).

5.5.1 Between-group comparison of APVT developmental trajectories across RCPM raw scores

To investigate whether performance in the DS group was at a level one would expect given their non-verbal cognitive abilities as measured by the RCPM, the developmental trajectory approach was calculated according to the raw RCPM scores.

The results of ANCOVA using RCPM raw scores as the independent variable with the group as a fixed factor and APVT as the dependent variable showed no overall effect of group (F(1, 88) = .107 p = .744, η^2 = .001), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. The covariate, RCPM, significantly predicted the levels of performance on APVT (F(1, 88) = 44.14, p = .00, partial η^2 = .33). There was no significant interaction between group and RCPM raw scores in predicting receptive vocabulary (F(1, 88) = 44.14, p = .606, partial η^2 = .003). Overall, the findings suggest similar developmental trajectories for APVT across RCPM in terms of onset and rate of the development in the DS and TD groups, in line with what was expected and as illustrated visually by the parallelism of the regression lines in Figure 5.1.

Table 5.4. Univariate regression analysis of APVT scores for DS and TD participants across RCPM

Independent variable	Dependent variable	F	Sig.
Group	APVT	.107	.744
RCPM		44.14	.000
Groups * RCPM		.269	.606

R^2 = .410

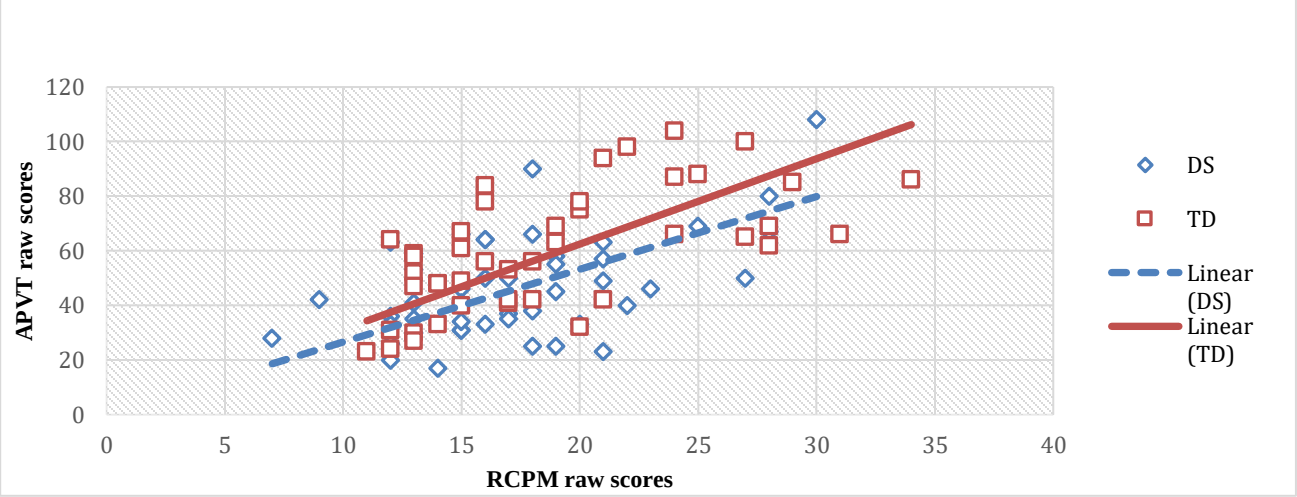

Figure 5.0.1. Development of receptive vocabulary (APVT) across RCPM

5.5.2 Between-group comparison of AEVT developmental trajectories across RCPM raw scores

The analysis was rerun using RCPM as a covariate, the group as a fixed factor and AEVT as the dependent variable. The ANCOVA results showed no overall effect of group (F(1, 88) = .602, p = .440, η^2 = .007), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. The covariate, RCPM, significantly predicted the levels of performance on AEVT (F(1, 88) = 66.89, p = .000, partial η^2 = .432). There was no significant interaction

between group and RCPM (F(1, 88) = 3.071, p = .083, partial η^2 = .034). Overall, the findings of the analysis suggest similar developmental trajectories for AEVT across RCPM in terms of the rate of development in the DS and TD groups, in line with what was expected and as illustrated visually by the parallelism of the regression lines in Figure 5.2.

Table 5.5. Univariate regression analysis of AEVT scores of DS and TD participants across mental age

Independent variable	Dependent variable	F	Sig.
Group	AEVT	.602	.440
RCPM		66.89	.000
Groups * mental age		3.07	.083

R^2 =.518

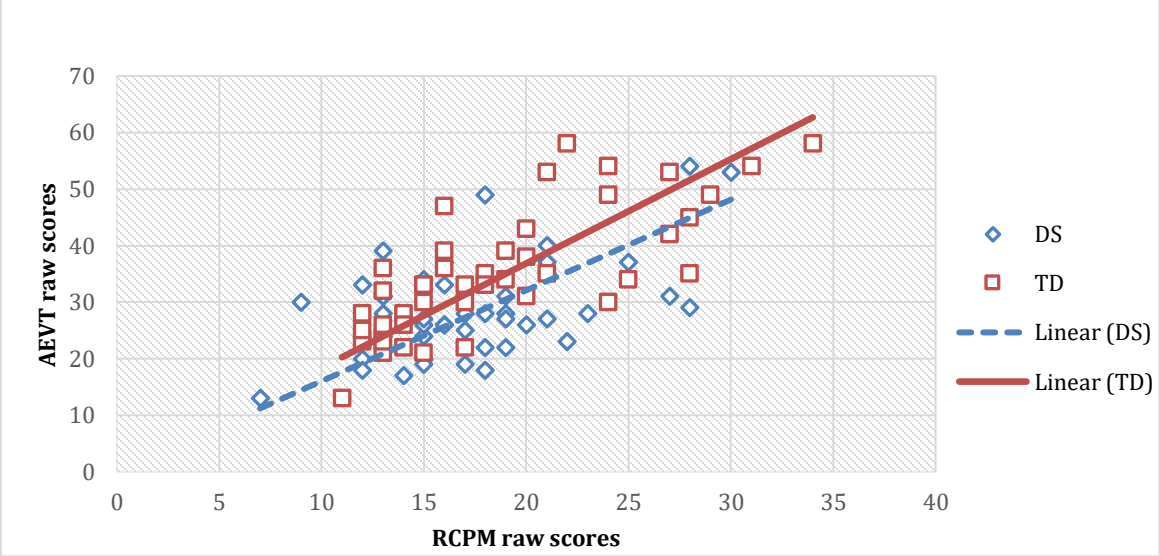

Figure 5.0.2. Development of expressive vocabulary across RCPM

5.5.3 Between-group comparison of NWR developmental trajectories across RCPM

The analysis was re-run using RCPM as a covariate with the group as a fixed factor and NWR as the dependent variable. It was hypothesized that the rate of development of NWR across cognitive level (Ravens raw score) would be similar for the DS and the TD groups. There would be no significant interaction between group and RCPM in predicting NWR. The results of the univariate regression found no overall effect of group (F(1, 88) = .497, p = .483, η^2 = .006), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. There was no main effect of RCPM on NWR for either group (F(1, 88) = 3.51, p = .064, partial η^2 = .038). Surprisingly, there was no significant interaction between group and RCPM in predicting NWR (F(1, 88) = 2.89, p = .092, partial η^2 = .032). Overall, the findings suggest a similar rate development of NWR in the DS and TD groups across RCPM (see Figure 5.3).

Table 5.6. ANCOVA of NWR scores of DS and TD participants across mental age

Independent variable	Dependent variable	F	Sig.
Group	NWR	.497	. 483
RCPM		3.53	.064
Groups * RCPM		2.89	.092

R^2 = .446

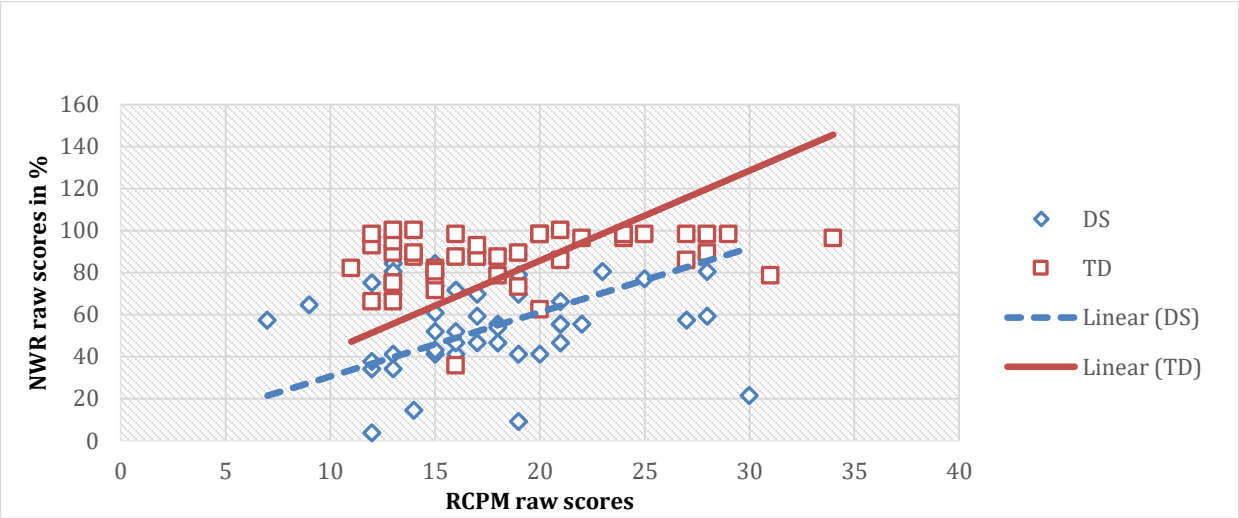

Figure 5.0.3. Development of NWR across RCPM

5.5.4 Between-group comparison of syllable awareness developmental trajectories across RCPM

As mentioned in 3.2.2, phonological awareness tasks consist of three levels: syllabic, intra-syllabic (onset and rime) and phonemic. This study investigated the developmental trajectory of phonological awareness at the syllable, rhyme and phoneme levels across cognitive level (Ravens raw score). Therefore, separate ANCOVA were performed for each of the phonological awareness tasks (syllable, rhyme, phoneme) as dependent variables, with RCPM entered as covariates and group as a fixed factor.

It was hypothesized that the rate of the development of phonological awareness (syllable, rhyme, phoneme) across cognitive level (Ravens raw score) would be similar for the DS and the TD groups as there would be no significant interaction between group and RCPM in predicting syllable awareness and no significant difference between the groups. The results of the ANCOVA found no overall effect of group ($F(1, 88) = .104$, $p = .747$, $\eta^2 = .001$), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. RCPM significantly predicted the levels of performance on syllable awareness ($F(1, 88) = .47.53$, $p = .00$, partial $\eta^2 = .351$). There was no significant interaction between group and RCPM in predicting syllable awareness ($F(1, 88)$

= .786, p = .378, partial η^2 = .009). Overall, the findings suggest a similar rate of development of syllable awareness in the DS and TD groups across RCPM raw scores (see Figure 5.4).

Table 5.7. ANCOVA of syllable awareness of DS and TD participants across RCPM

Independent variable	Dependent variable	F	Sig.
Group	Syllable awareness	.104	.747
RCPM		47.53	.00
Groups * RCPM		.786	.378

R^2 = .402

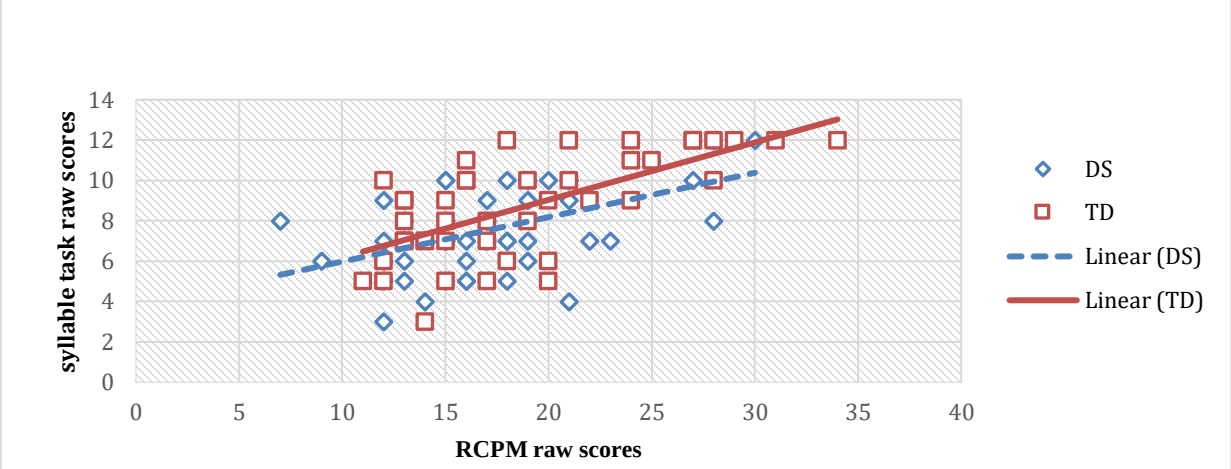

Figure 5.0.4. Development of syllable awareness across RCPM

5.5.5 Between-group comparison of rhyme awareness developmental trajectories across RCPM

The analysis was re-run using RCPM as an independent variable with group and rhyme awareness as the dependent variables. It was hypothesized that the rate of the developmental trajectory of rhyme awareness across cognitive level (Ravens raw score) would be similar for the DS and TD groups. The results of the ANCOVA found no overall effect of group (F(1, 88) = .035, p = .852, η^2 = .00), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. RCPM significantly predicted the levels of performance on rhyme awareness (F(1, 88) = 30.17, p = .00, partial η^2 = .255). There was no significant interaction between group and RCPM in predicting rhyme awareness (F(1, 88) = 1.03, p = .312, partial η^2 = .12). Overall, the findings suggest a similar rate of development of rhyme awareness for the DS and TD groups across RCPM raw scores (see Table 5.8 and Figure 5.5).

Table 5.8. ANCOVA of rhyme awareness scores for DS and TD participants across RCPM

Independent variable	Dependent variable	F	Sig.
Group	Rhyme awareness	.035	.852
RCPM		30.17	.00
Groups * RCPM		1.03	.312

R^2 = .344

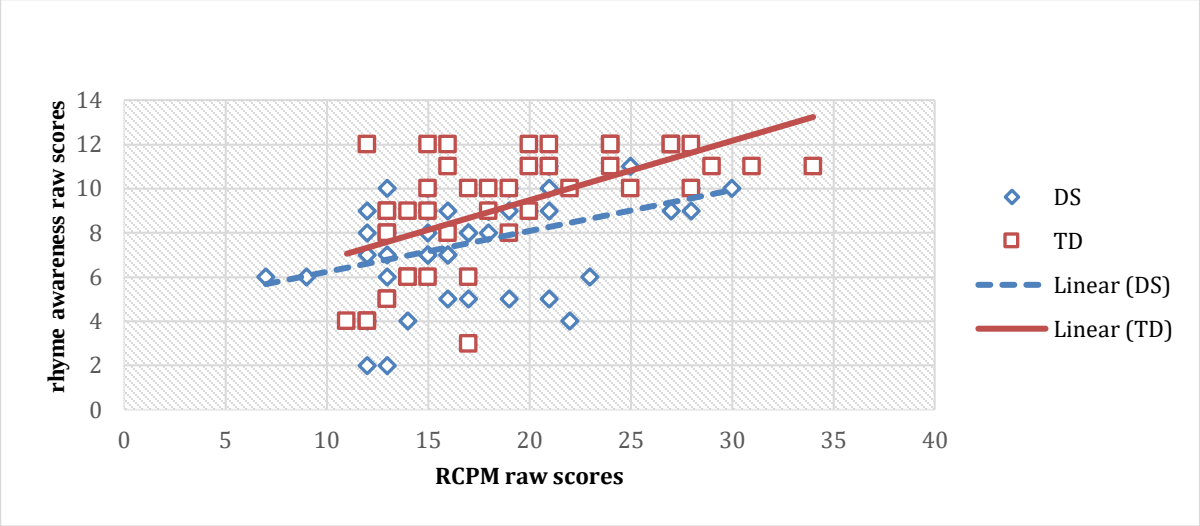

Figure 5.0.5. Development of rhyme awareness across RCPM

5.5.6 Between-group comparison of phoneme awareness developmental trajectories across RCPM

The analysis was re-run using RCPM as an independent variable with group and phoneme awareness as dependent variables. It was hypothesized that the rate of development of phoneme awareness across cognitive level (Ravens raw score) would be similar for the DS and the TD groups. The results of ANCOVA found no overall effect of group ($F(1, 88) = 2.34$, $p = .129$, $\eta^2 = .026$), suggesting that the DS and TD groups were similar in terms of onset and developmental trajectory. RCPM significantly predicted the levels of performance on phoneme awareness ($F(1, 88) = 33.97$, $p = .00$, partial $\eta^2 = .279$). There was no significant interaction between group and RCPM ($F(1, 88) = .034$, $p = .854$, partial $\eta^2 = .00$). Overall, the findings suggest a similar rate of development of phoneme awareness for the DS and TD groups across RCPM raw scores (see Table 5.9 and Figure 5.6).

Table 5.9. ANCOVA of phoneme awareness scores for DS and TD participants across RCPM

Independent variable	Dependent variable	F	Sig.
Group	Phoneme awareness	2.34	.129
RCPM		33.97	.00
Groups * RCPM		.034	.854

R^2 = .428

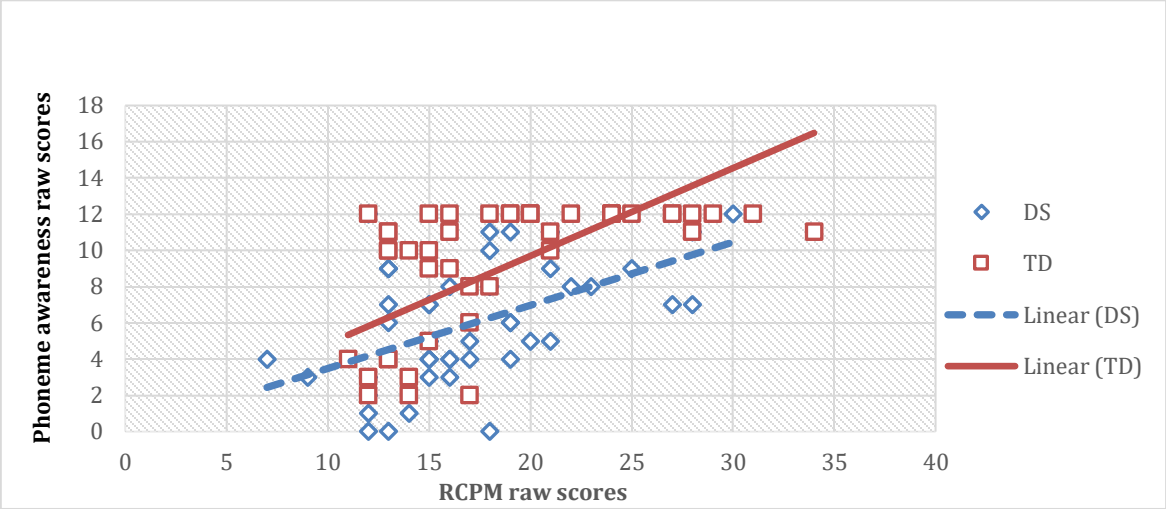

Figure 5.0.6 Development of phoneme awareness across RCMP

5.6 Results for RQ2

Does NWR performance predict vocabulary (APVT, AEVT) to a similar extent across DS and TD groups?

Following on from RQ1, it was hypothesized that NWR would predict vocabulary knowledge in the DS and TD groups, with a stronger correlation in the TD group, so there would be significant interaction between group and NWR in predicting vocabulary knowledge. Separate univariate regression analyses were performed on APVT and AEVT as dependent variables. To investigate the effect of group and NWR, and group by NWR interaction on APVT/AEVT, NWR was entered as an independent variable and group as a fixed factor, and APVT/AEVT were entered as the dependent variables.

5.6.1 Between-group comparison for NWR predicting APVT

The results of ANCOVA (Table 5.10) indicate a significant effect of group on APVT ($F(1, 88) = 9.738$, $p = .04$, partial $\eta^2 = .10$). NWR significantly predicted APVT ($F(1, 88) = 15.063$, $p = .00$, partial $\eta^2 = .14$). There was a significant interaction between group and NWR in predicting receptive vocabulary ($F(1, 88) = 11.973$, $p = .01$, partial $\eta^2 = .12$), which suggests that NWR

predicted APVT more strongly in the TD group than the DS group. The results were in line with expectations. As can be seen in Figure 5.7, the dots are widely spread and the relationship between NWR and APVT is weak for the DS group. In contrast, the dots are more concentrated around the line for the TD group and the relationship between NWR and APVT is strong.

Table 5.10. ANCOVA for NWR predicting APVT

Independent variable	Dependent variable	F	Sig.
Group		9.738	.00*
NWR	APVT	15.063	.00*
Groups * NWR		11.973	.00*

Figure 5.7 NWR predicting receptive vocabulary

5.6.2 Between-group comparison for NWR predicting AEVT

The results of ANCOVA presented in Table 5.11 indicate a significant effect of group on AEVT ($F(1, 88) = 11.920$, $p = .04$, partial $\eta^2 = .11$). NWR significantly predicted AEVT ($F(1, 88) = 20.09$, $p = .00$, partial $\eta^2 = .18$). There was a significant interaction between group and NWR in predicting expressive vocabulary ($F(1, 88) = 14.06$, $p = .00$, partial $\eta^2 = .13$), which suggests that NWR predicted APVT more strongly in the TD group than in the DS group. As illustrated in Figure 5.8, the scatterplot for the TD group shows a strong, positive, linear association between NWR and AEVT. However, the scatterplot for the DS group shows a weak and nonlinear association between NWR and AEVT. The results are in line with expectations.

Table 5.11. ANCOVA for NWR predicting AEVT

Independent variable	Dependent variable	F	Sig.
Group	AEVT	11.92	.00*
NWR		20.09	.00*
Groups * NWR		14.06	.00*

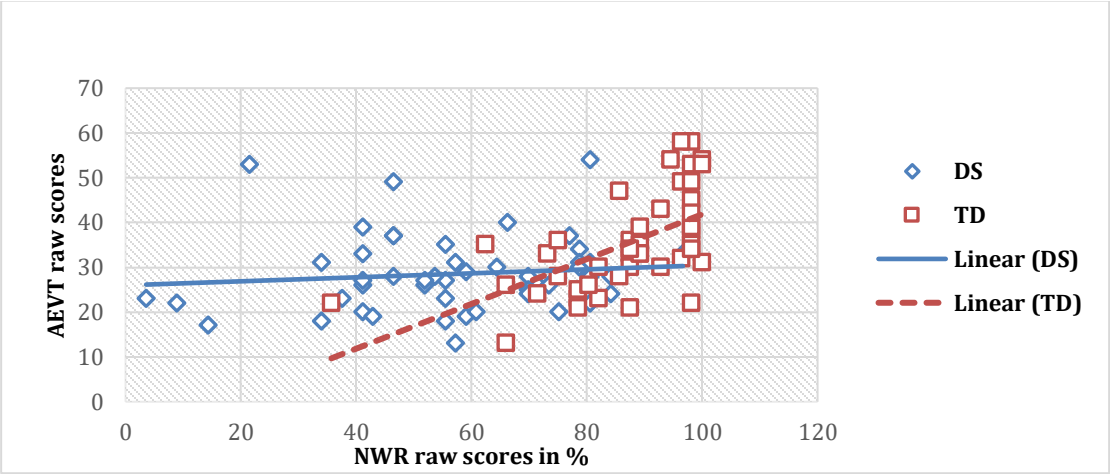

Figure 5.8 NWR predicting expressive vocabulary in DS and TD groups

5.7 Results for RQ3

Does vocabulary (APVT, AEVT) predict phonological awareness to a similar extent across DS and TD groups?

Following from RQ2, it was hypothesized that that there would be a significant interaction between group and vocabulary knowledge in predicting phonological awareness. Separate ANCOVA were performed on the total scores of all phonological awareness tasks (syllable, rhyme and phoneme) as the dependent variables. To investigate the effect of group and APVT and AEVT, and group × APVT and AEVT interaction on all phonological awareness tasks, APVT and AEVT were entered as independent variables, with group as a fixed factor and phonological awareness entered as the dependent variable.

5.7.1 Between-group comparison for APVT predicting phonological awareness

It is apparent from Table 5.18 that there was a significant effect of group on phonological awareness ($F(1, 88) = 7.86$, $p = .00$, partial $\eta^2 = .08$). APVT significantly predicted phonological awareness on all tasks ($F(1, 88) = 18.18$, $p = .00$, partial $\eta^2 = .17$). Surprisingly, there was no significant interaction between group and APVT in predicting phonological awareness ($F(1, 88) = 3.38$, $p = .06$, partial $\eta^2 = .03$), with the p-value showing a clear tendency towards significance. The results of the interaction suggest that APVT predicted phonological awareness similarly in the DS and TD

groups. The results were partially contrary to what was expected. The similarity in slopes can be seen in Figure 5.9 and it is clear from the scatterplots that both the DS and TD groups show a strong, positive, linear association between APVT and phonological awareness; therefore, receptive vocabulary predicted phonological awareness similarly in the DS and TD groups.

Table 5.12. ANCOVA for APVT predicting total phonological awareness

Independent variable	Dependent Variable	F	Sig.
Group		7.86	.00*
APVT	phonological	18.18	.00*
Groups * APVT	awareness	3.38	.06

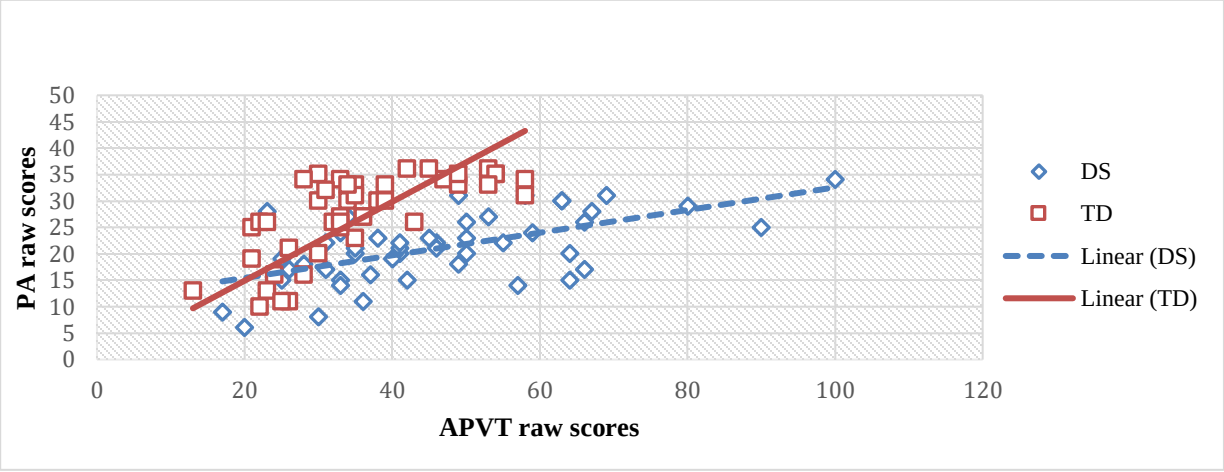

Figure 5.9. APVT predicting phonological awareness in the DS and TD groups

5.7.2 Between-group comparison for AEVT predicting phonological awareness

Table 5.19 indicates a significant effect of group on total phonological awareness ($F(1, 88) = 6.95$, $p = .00$, partial $\eta^2 = .00$). Although AEVT significantly predicted phonological awareness on all tasks ($F(1, 88) = 26.93$, $p = .00$, partial $\eta^2 = .00$), there was no significant interaction between group and AEVT in predicting phonological awareness ($F(1, 88) = 3.46$, $p = .06$, partial $\eta^2 = .03$), with the p-value demonstrating a clear tendency towards significance. The results of the interaction suggest that expressive vocabulary predicted phonological awareness similarly in the DS and TD groups. The results were partially contrary to what was expected. As illustrated in Figure 5.10, both DS and TD groups show a moderate positive linear association between AEVT and phonological awareness.

Table 5.13. ANCOVA for AEVT predicting total phonological awareness

Independent variable	Dependent variable	F	Sig.
Group	Phonological awareness	6.95	.00*
AEVT		26.93	.00*
Groups * AEVT		3.46	.06

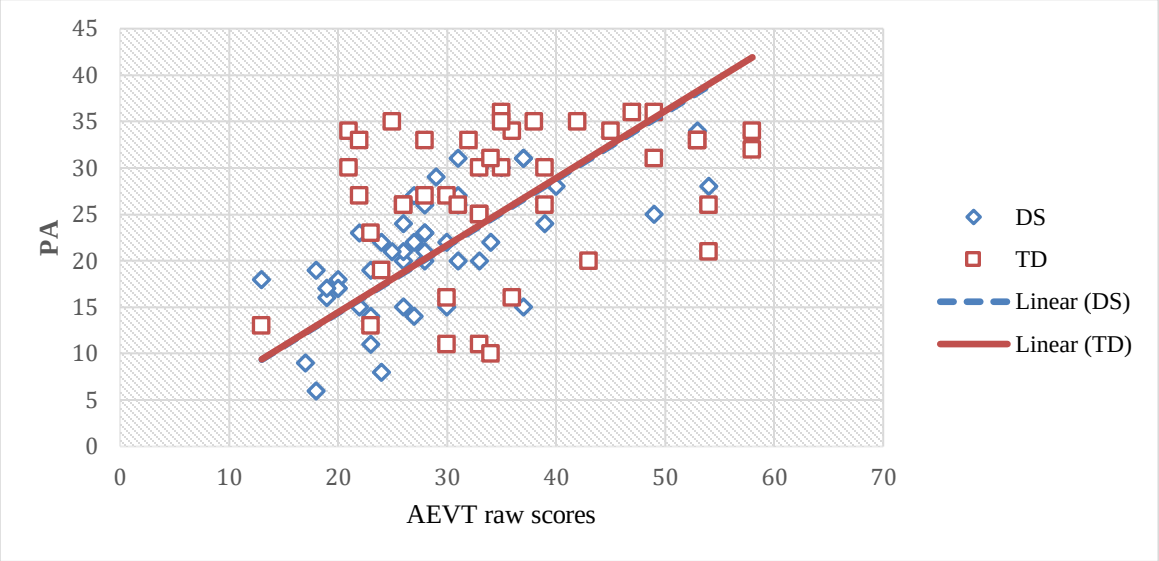

Figure 5.0.7. AEVT predicting phonological awareness in DS and TD groups

5.8 Results for RQ4

Does NWR predict phonological awareness to a similar extent across DS and TD groups?

Following on from RQ3, it was hypothesized that there would be significant interaction between group and NWR in predicting phonological awareness (syllable, rhyme, phoneme), as a result of a stronger correlation between NWR and phonological awareness in the TD group than in the DS group. ANCOVA was performed on syllable, rhyme and phoneme tasks as the dependent variables. To investigate the effect of group and NWR, and group × NWR interaction in predicting phonological awareness tasks, NWR was entered as an independent variable and group as a fixed factor, with all phonological awareness measures entered as dependent variables. Table 5.15 shows that there was a significant difference between the DS and TD groups in predicting phonological awareness on all tasks. NWR significantly predicted phonological awareness on all tasks – syllable, rhyme and phoneme – further to the significant interaction of group and NWR in predicting phonological awareness. This was in line with expectations, suggesting that NWR predicted phonological awareness more strongly in the TD group than in the DS group.

Table 5.14. ANCOVA for NWR predicting phonological awareness

Independent variable	Dependent variable	F	Sig.
Group	Syllable	11.01	.00*
	Rhyme	16.34	.00*
	Phoneme	15.26	.00*
NWR	Syllable	26.24	.00*
	Rhyme	41.07	.00*
	phoneme	45.86	.00*
Group * NWR	Syllable	10.53	.00*
	Rhyme	16.25	.00*
	Phoneme	18.19	.00*

Univariate regression analysis was also performed on the means of the phonological awareness tasks. Table 5.15 indicates similar results. Figure 5.11 shows that the scatterplot of the TD group presents a strong positive linear association between NWR and phonological awareness, which does not appear in the DS group.

Table 5.15. ANCOVA for NWR predicting the means of phonological awareness

Independent variable	Dependent variable	F	Sig.
Group	Phonological awareness	21.59	.00*
NWR		57.72	.00*
Groups * NWR		22.95	.00*

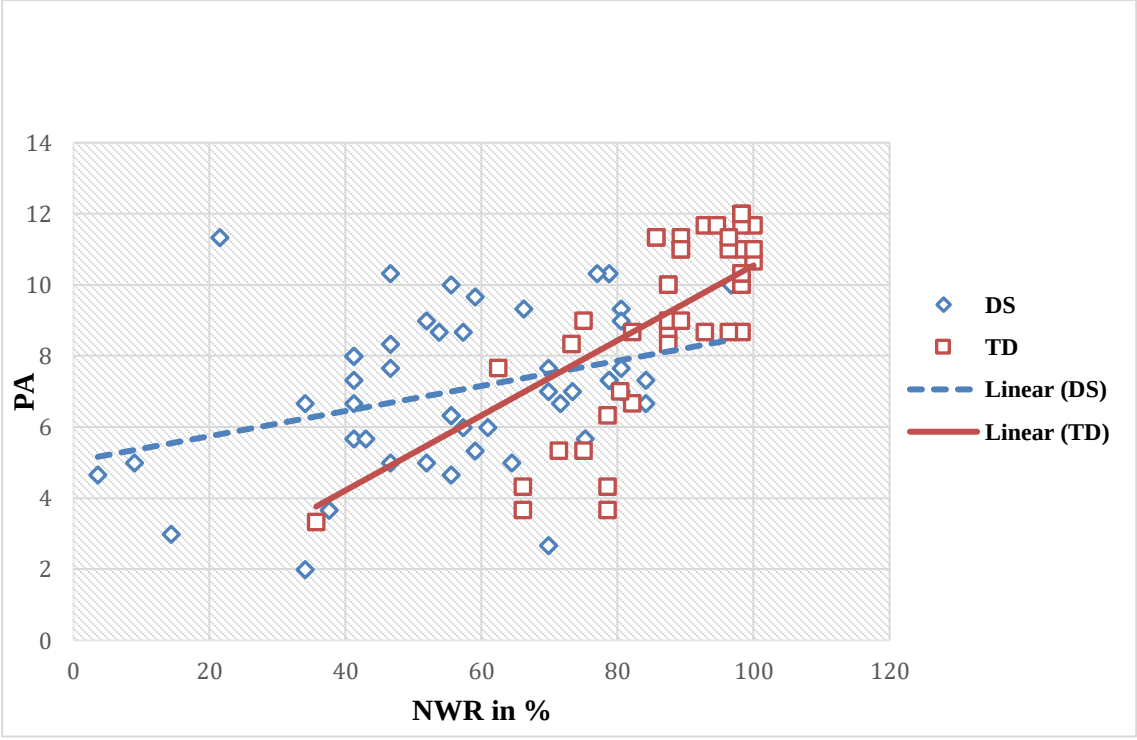

Figure 5.11. NWR predicting phonological awareness in the DS and TD groups

5.9 Supplementary findings for cognitive and linguistic plateau

Further analysis was undertaken because I was curious about the relationship between chronological age and cognitive level. This was done to investigate whether there is evidence for a cognitive plateau among individuals with DS. The results of univariate regression analysis indicated no significant effect of group on RCPM raw scores ($F(1, 88) = 5.66$, $p = .019$, partial $\eta^2 = .06$). Chronological age significantly predicted RCPM raw scores ($F(1, 88) = 26.31$, $p = .000$, partial $\eta^2 = .230$). A significant interaction between group and chronological age was found ($F(1, 88) = 26.31$, $p = .00$, partial $\eta^2 = .230$), which suggests a possible cognitive plateau among individuals in the DS group. Figure 5.12 shows a nonlinear trend among the DS group, indicating a clear trend of cognitive plateau. However, the previous analysis of the development of vocabulary and phonological abilities across chronological age provided no evidence of a linguistic plateau.

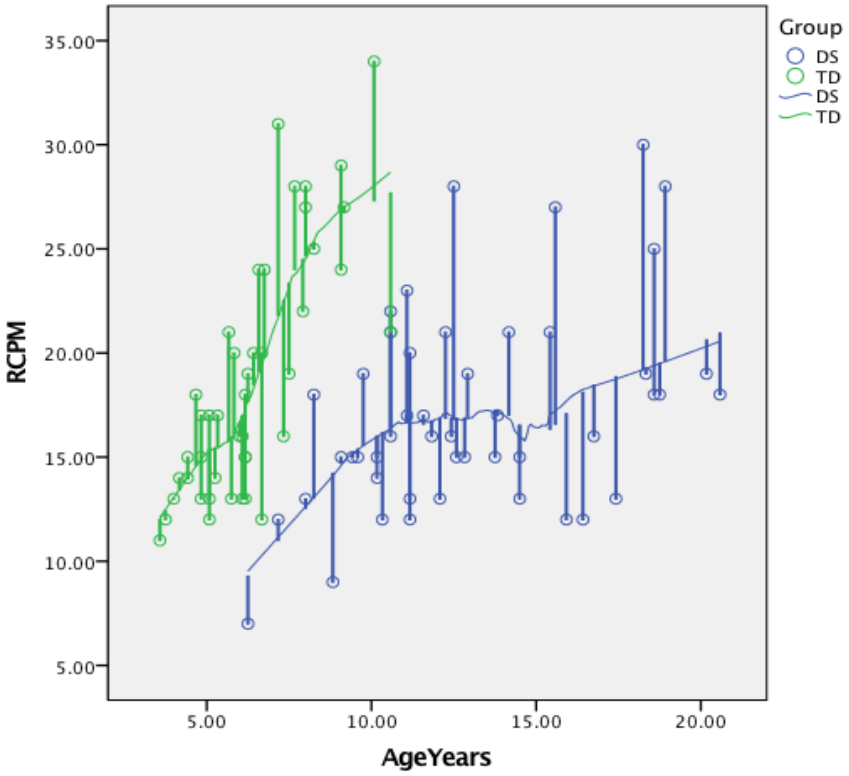

Figure 5.12. Development according to chronological age across RCPM raw scores

5.10 Summary

This chapter has examined the findings of the assessment, presenting the results of data analysis to answer the research questions regarding the comparison between the DS group and the TD group.

The developmental trajectories of vocabulary, NWR and phonological awareness across NVMA in the DS group were compared to those of the TD group. In addition, this chapter has compared the DS and TD groups in terms of the relationship between NWR and vocabulary, vocabulary and phonological awareness, and NWR and phonological awareness.

Several major findings arise from this study. First, the developmental trajectories of vocabulary, NWR and phonological awareness across NVMA had a similar rates of development for the DS and TD groups. Second, NWR predicts vocabulary (receptive and expressive) more strongly in the TD group than in the DS group. Third, vocabulary knowledge predicts phonological awareness to a similar extent across the DS and TD groups. Finally, NWR predicts phonological awareness more strongly in the TD group than in the DS group.

Chapter 6. Discussion and Conclusion

6.1 Introduction

This study has investigated language measures, including vocabulary knowledge (APVT, AEVT), phonological short-term memory (NWR) and phonological awareness, among Kuwaiti Arabic-speaking individuals with DS and TD matched on RCPM raw scores. The main aim of the study was to investigate whether individuals with DS showed a delayed onset/and or rate of development in vocabulary, phonological short-term memory and phonological awareness relative to their non-verbal mental abilities (RCPM). Thus, the primary research question focused on investigating the developmental trajectories of vocabulary (APVT, AEVT), phonological short-term memory (NWR) and phonological awareness (syllable, rhyme, phoneme) across RCPM raw scores among individuals with DS and TD children. A cross-sectional developmental trajectory approach was used, enabling discrimination across different language skills. These results might have implications for the continuation of speech and language therapy sessions for individuals with DS in adolescence and early adulthood. Further aims were to investigate the relationship between the results for different language measures in the DS group and compare them to those of the TD group. Previous chapters have discussed the methods used in this study, as well as the results for group performance on the tasks administered.

Several major findings emerge from this study as no previous study has been undertaken in the Gulf Arabic context. Using the developmental trajectory approach across non-verbal mental age, individuals with DS showed a similar onset and rate of development for vocabulary, non-word repetition and all phonological awareness levels. Second, NWR predicts vocabulary strongly in the TD group but not in the DS group. Third, vocabulary knowledge predicts phonological awareness similarly for the DS and TD groups. Fourth, NWR predicts phonological awareness more strongly in the TD group than in the DS group. A further finding that emerges is that NWR seems to play no part in predicting vocabulary knowledge skills in the DS group based on the correlations. Furthermore, it does not correlate significantly with RCPM scores in the DS group. This finding suggests that NWR does not play a key role in the development of vocabulary in individuals with DS. In contrast, a strong correlation between all these variables was found in the TD group.

This study addressed four research questions. The goal of this chapter is to compare the study findings to the existing literature and discuss the implications. The discussion focuses on each research question in turn, drawing on the findings for both DS and TD groups, followed by a

comparison between them. Clinical and educational implications and study limitations and future research will be discussed. This chapter ends with a conclusion for the study as a whole.

6.2 RQ1

Are the developmental trajectories of vocabulary, NWR and phonological awareness across non-verbal mental ability in individuals with DS similar to those of TD children in terms of onset and the rate of development?

It was hypothesized that the developmental trajectories of vocabulary, NWR and phonological awareness across non-verbal mental age would be similar in the DS and TD groups in terms of the onset and rate of development. The results from the cross-sectional developmental trajectory analysis showed that individuals with DS follow the same developmental trajectory in terms of onset and rate of development for vocabulary, NWR and phonological awareness when matched for non-verbal mental abilities. This supports the view that individuals with DS follow the same pattern in these language skills as TD children. These findings support the neuro-constructivist approach (Karmiloff-Smith, 2009), which suggests an intertwining of the development of language and cognition. Theoretically, this is important because it suggests that the language impairment in individuals with DS is a result of cognitive delay. Indeed, the findings go against a modular view of language, such as the neuropsychological view, which suggests that language is independent of cognitive development (D'Souza and Karmiloff-Smith, 2009, 2017).

An advantage of applying the cross-sectional developmental trajectory approach is the ability to recruit more data in each group. This might be challenging in a longitudinal approach as it places a burden on participants, resulting in drop out. Also, there is a long interval between the start of the study and the final report of the findings. In addition, the cross-sectional design is more efficient in terms of time and cost than the longitudinal design. However, a limitation of the cross-sectional developmental trajectory design is that there is no statistical control over individual variation in trajectories because each point is a different individual. This effect limits generalization to the population as a whole.

A further principal advantage of this approach over a traditional matched-group design is to allow us to compare developmental change over time for the groups. is the ability to test between-group differences in the relationship between the dependent measures and non-verbal cognitive ability over time. Group differences are tested using two coefficients for developmental trajectories:

intercepts (onsets) and gradient (rate of development). This can provide guidance for future longitudinal study to understand the emergence of linguistic phenotypes (Thomas *et al.*, 2009).

The discussion concerning this research question is divided into three parts: the first part will discuss the developmental trajectory of vocabulary knowledge across RCPM; the second part will discuss the developmental trajectory of phonological short-term memory across RCPM; the third part will discuss the developmental trajectory of phonological awareness across RCPM.

6.2.1 Developmental trajectory of vocabulary development in individuals with DS

The development trajectory of vocabulary knowledge across non-verbal mental abilities in individuals with DS and the TD group was consistent with expectations and supported earlier research (Glenn and Cunningham, 2005; Phillips *et al.*, 2014; Cuskelly *et al.*, 2016; Facon *et al.*, 2016), indicating a similar increase in vocabulary knowledge as a function of non-verbal ability across groups. This suggests that non-verbal ability and vocabulary are not highly discrepant in individuals with DS and TD, who are performing in the same range for non-verbal mental abilities. Thus, it might suggest some changes to the learning environments of individuals with DS, enabling them to learn vocabulary with individuals of similar non-verbal mental age levels (e.g. vocational work, classroom) (Chapman *et al.*, 1991). Involving children with DS in environments with peers of similar cognitive abilities would provide more experience of the language context and give them the opportunity to learn a greater range of different words. The ability to use these words for communication would develop the ability of individuals with DS to manage social situations, for example to ask for what they need and to express their feelings.

My study has confirmed in the Kuwaiti Arabic context the findings of other studies. The results are in line with those of Philips *et al.* (2014), who used a cross-sectional approach and compared the developmental trajectories of receptive vocabulary (PPVT) and non-verbal ability (Leiter R) for individuals in DS and TD groups. A similar rate of development was found in the DS group (aged 10–21 years) and the TD group (aged 4–13 years). However, when they used receptive vocabulary as a control variable to investigate receptive grammar, the DS group performed lower than the TD group. These differences between DS and TD groups were not found when matched on mental age. However, the results of this study are not in line with those of Carr and Carr (1995), who found that mental age (Leiter-R) predicted receptive vocabulary more strongly in the TD group than in the DS group. Similarly, Roberts *et al.* (2007) found a significant difference between children with DS and TD children matched on mental age in terms of trajectories. One might argue that their

sample comprised only boys and this might have influenced the comparison in terms of trajectories. Some studies have reported that females with DS have an advantage over males with respect to language development (Finestack and Abbeduto, 2010; Carr and Collins, 2014). Therefore, there might be an influence of gender on the development of vocabulary.

Another explanation for the different findings of various studies might be the matching variable. Groups in some of the studies were matched on RCPM and Leiter R, while others were matched on the Stanford-Binet test to assess vocabulary development. The different tests used to assess non-verbal cognitive ability might have an impact on vocabulary performance. Participants might find the RCPM and Leiter R easier than the Stanford-Binet test and this could affect their performance and consequently the selection of control groups. In addition, using receptive vocabulary to match individuals to a comparison group (Phillips *et al.*, 2014) might underestimate the cognitive abilities in participants with DS; however, when using non-verbal ability measures (e.g. RCPM, Leiter R) as a matching variable, the tasks require no verbal responses from the participants. It has been suggested that non-verbal ability measures are a more accurate measure of cognitive ability in individuals with ID, such as DS (Phillips *et al.*, 2014).

In summary, the developmental trajectories of vocabulary knowledge in the DS and TD groups were similar in terms of the onset and rate of development in the Gulf Arabic context. These findings are consistent with earlier research undertaken with English-speaking participants. A similar developmental trajectory was observed for vocabulary between the groups. The theoretical and clinical implications of these findings are discussed in 6.6.

6.2.2 Developmental trajectories of phonological short-term memory across NVMA??

It is worth mentioning that the RCPM and NWR were not significantly correlated in the DS group but correlated in the TD group (see 5.4). However, employing the cross-sectional developmental trajectory analysis of NWR for the DS and TD groups, the same onset and rate of development were observed across RCPM. This was in line with expectations based on prior research (Laws and Gunn, 2004; Conners *et al.*, 2018; Penke and Wimmer, 2020).

Similar to the findings of this study, but based on a longitudinal design, Hick *et al.* (2005) investigated a group of DS children compared to TD children matched on mental age and examined the development of verbal short-term memory (digit span and word span) and visuo-spatial short-term memory (pattern recall) at three time points over one year. The results showed a significant

interaction between time and group in predicting the development of verbal short-term memory. This means that the DS group performed significantly lower than the TD group over time. However, the DS and TD groups showed similar levels of visuospatial short-term memory over time. This lends support for the advantage of visual-spatial short-term memory over verbal short-term memory in individuals with DS (Laws, 2002). The findings of this study show no significant correlation between RCPM and NWR among individuals with DS, similar to those of Laws and Gunn (2004) and Hick *et al.* (2005), who suggest that NWR does not correlate with mental age and seems to stay at the same (low) level in individuals with DS.

There are clinical and education implications regarding this outcome (see 6.6). It is worth noting that the results of the simple correlation found no significant correlation between RCPM and NWR in the DS group, but a significant correlation was found between the RCPM and NWR in the TD group. In contrast, in 5.5.3, it was reported that the RCPM did not predict NWR in either the DS or TD groups. This does not necessarily mean the rate of development was the same for both groups. In addition, I found that NWR development in the DS group differed in two ways: it did not develop with increased cognitive development (as measured with RCPM), nor did it develop in line with vocabulary. This is therefore dissimilar from what was generally found for the TD group.

6.2.3 Developmental trajectory of phonological awareness across RCPM

Assessing the developmental trajectory of phonological awareness for the DS and TD groups, it is apparent that there was a linear relationship between non-verbal mental age and phonological awareness (syllable, rhyme, phoneme) in both the DS and TD groups. The results of the cross-sectional analysis suggested that the developmental trajectory of phonological awareness in terms of onset and rate of development was similar between the groups across non-verbal mental age. Although numerous studies have tested the development of phonological awareness in individuals with DS and TD, to the best of my knowledge, no prior study has investigated the development of phonological awareness in individuals with DS across non-verbal cognitive abilities. Therefore, this study fills a gap in the literature in terms of the development of phonological awareness in DS children matched with TD children on mental age (RCPM).

Theoretical implications regarding the development of language across cognition

The results show that non-verbal cognitive abilities (RCPM) are significantly related to language skills (vocabulary and phonological awareness), suggesting that for individuals with DS (children,

adolescents and young adults), vocabulary development is strongly related to cognition (Stojanovik, 2014). The similar rate of development to TD children indicates that individuals with DS may be following a similar trajectory of language development rather than a slowed or different trajectory (Levy and Eilam, 2013). The study findings are in line with the 'neuro-constructivist' theory (see 1.4), which claims that language development and processing are supported by general cognitive mechanisms.. It is worth noting that this study did not cover all language aspects (e.g. syntax) and therefore it might rather be proposed that the development of vocabulary (receptive and expressive) is intertwined with that of phonological awareness.

Furthermore, the analysis of language predictors in this study found that non-verbal cognitive ability was a significant predictor of language development for individuals with DS aged 6–20 years. This goes against the neuropsychological view, a recent model, which suggests that the development of language does not depend on cognitive development (D'Souza and Karmiloff-Smith, 2017).

Studying those with genetic disorders, such as DS, potentially makes it possible to tease out the different influences of different precursor skills which cannot be done with studies of TD populations as development occurs in synchrony. Therefore, it is difficult to establish which precursor might be more facilitating than another (Thomas *et al.*, 2009). Longitudinal study is proposed as a means of determining this trajectory for individuals with DS.

Cognitive and linguistic plateau

The results of development based on chronological age across RCPM raw scores among the DS and TD groups might suggest a cognitive plateau among the former. However, there is no evidence for a linguistic plateau given the development of vocabulary and phonological abilities into early adolescence. The discrepancy in these findings is difficult to explain. Studies arguing the existence of a cognitive plateau among individuals with DS are still very much in the air, especially those adopting a cross-sectional design, because of the different language measures used to evaluate receptive and expressive language (Abbeduto *et al.*, 2007; Facon and Magis, 2019).

6.3 RQ2

The second aim of this study was to investigate whether NWR performance would predict receptive/expressive vocabulary (APVT/AEVT) skills to a similar extent across DS and TD groups.

This study also explored the nature of the relationship between NWR and receptive and expressive vocabulary in Arabic-speaking individuals with DS and a TD group. It was hypothesized that NWR would correlate with receptive and expressive vocabulary skills in both the DS and TD groups, with a stronger correlation in the TD group than in the DS group. Correlation analysis was administered and a Fisher-z transformation was undertaken to investigate whether there was a significant difference between the correlations for the DS and TD groups. Univariate regression analysis was performed to investigate whether there was a significant interaction between group and NWR in predicting vocabulary skills.

Pearson correlation results were in accordance with what was expected for the TD group, but surprisingly the correlation was not significant for the DS group. The findings of the Fisher-z transformation were consistent with expectations, with a significantly stronger correlation between NWR and both receptive and expressive vocabulary skills for the TD group. Two separate univariate regression analyses indicated a significant interaction between group and NWR in predicting receptive and expressive vocabulary skills. This was in line with what was expected.

6.3.1 NWR and vocabulary skills for the TD group

The significant correlation between NWR and receptive vocabulary (APVT) reported for the TD group is consistent with many studies in the literature (Baddeley *et al*., 1998; Briscoe *et al*., 2001; Coady and Evans, 2008; Khater, 2016), although contrary findings were obtained in other studies (Bowey, 2001; De Jong and Olson, 2004). Bowey (2001), using a longitudinal study design, found no evidence that NWR was a predictor of vocabulary knowledge, while Shaalan (2010) found a weak correlation between the same NWR and APVT as used in this study. There could be several reasons for this non-significant correlation. Shaalan (2010) investigated the correlation for 11 TD children with an average age of 7:8 years. The small number of participants might explain the weak correlation. Moreover, Gathercole (2006) noted that the older the participants, the weaker the correlations between NWR and vocabulary.

This study showed a significant correlation between NWR and vocabulary in the TD group, in line with phonological short-term memory theory (Gathercole and Baddeley, 1990; Baddeley *et al*., 1998; Gathercole, 2006). There is more to add in that NWR is only thought to be important in the early stages of vocabulary acquisition. Gathercole (2006) found a very strong relationship between NWR and vocabulary learning in early stages of language development at around the ages of 4, 5 and 6 years ($r = .52$), but this declined at 8 years ($r = .27$), although remaining significant.

The significant correlation between NWR and expressive vocabulary (AEVT) in this study supports the findings of Khater (2016). The justification for the significant correlation between NWR and expressive vocabulary can be explained by both NWR and expressive vocabulary requiring the articulation and pronunciation of a series of sounds, speech perception and oral motor planning. This is not surprising as Krishnan *et al*. (2013) also found a strong correlation between NWR and articulation. However, these findings contrast with those of Briscoe *et al*. (2001), who found a weak correlation between NWR and expressive vocabulary in TD children. The age of the participants was higher than those in Khater's (2016) study. Among young children, NWR is thought to be a reflection of the initial stage of vocabulary learning in which the production of NWR relies on their long-term storage. However, this is not the case for older children at the ages of 6 and 8 years old. By this age, children might use their vocabulary knowledge to facilitate NWR. Moreover, the small number of participants in these studies could explain the weak correlation.

6.3.2 NWR and vocabulary skills for the DS group

The DS group presented a non-significant correlation between NWR and receptive vocabulary and expressive vocabulary. These findings are contrary to what was expected and contrary to those of many studies in the literature (Laws, 1998; Comblain, 1999; Laws and Bishop, 2003; Cairns and Jarrold, 2005; Loveall *et al*., 2016). However, this is not the only study that did not find a significant correlation between NWR and vocabulary. Similarly, Laws and Gunn (2004) showed a weak correlation between NWR and receptive vocabulary in adolescents with DS. A justification for the poor correlation is that hearing deteriorates with an increase in age and hearing level is correlated with NWR. Although the individuals with DS in this study had normal hearing based on the school report, we cannot assure the accuracy of the tests. This study extends that of Laws and Gunn (2004) by adding a control group of TD children and examining expressive vocabulary.

Similar findings were obtained in a study by Shaalan (2010), but with DLD children. The researcher found a poor correlation between NWR and vocabulary in children with DLD with a mean age of 11 years, which is quite close to the mean age of the DS participants in this study at 13 years. Gathercole (2006) found that the correlation between NWR and vocabulary knowledge declined with an increase in age. Therefore, the bigger gap between the ages in this study and other studies could explain the difference in findings. The weak correlation between NWR and expressive vocabulary in the DS group is perhaps due to phonological discrimination difficulties and speech discrimination difficulties (Dodd and Thompson, 2001), as both the NWR and

expressive vocabulary tasks required verbal responses. Moreover, some studies have suggested that poor performance in NWR is due to a lack of articulatory rehearsal and have contended that performance is affected by both hearing ability and speech production abilities (Edwards and Lahey, 1998). Furthermore, a weak correlation between NWR and vocabulary knowledge has been observed in Gulf Arabic studies with children with DLD (Shaalan, 2010; Khater, 2016). These similar findings suggest that methods of vocabulary learning rely on different mechanism in DS and DLD groups. Visual materials might be suitable for assisting DS children in the classroom. A further suggestion would be early intervention to improve vocabulary and language, as this is important from an early age. Indeed, a study found that early and high frequency language intervention for individuals with DS can result in significant gains in vocabulary (Yoder *et al*., 2014).

6.3.3 Group and NWR interaction in vocabulary skills/between-group developmental trajectory analysis

Although there was a poor correlation between NWR and vocabulary skills (APVT, AEVT) in the DS group, there was a strong correlation in the TD group. These outcomes are contrary to what was expected. The different patterns of predictive relationships between the DS and TD groups most likely reflect the different methods of vocabulary learning, which rely on different mechanisms in DS and TD groups.

These findings corroborate those of Næss *et al.* (2015), but based on a different research design as theirs was longitudinal. They compared the performance of Norwegian children with DS (n = 43) within a mean age of 6 years with a control group of TD children matched on non-verbal mental age (n = 57) with a mean of age of 3 years. They compared the performance of the two groups on NWR and vocabulary measures over a 2-year period at 3 test points. No correlation was found between NWR and vocabulary in the DS group across time points; in contrast, the TD group presented a significant correlation. Moreover, the role of the development of NWR in predicting vocabulary knowledge was significant for the DS and TD groups. The results indicated that children with DS showed slower development on NWR in terms of predicting vocabulary knowledge than TD children matched on mental age. According to these results, Naess and colleagues suggested early language intervention for children with DS could result in significant gains in vocabulary knowledge. One might argue that the narrow age range for children with DS in their study (12 months) may have had an impact on this development. This study included a

wide range of ages, including children, adolescents and young adults with DS; it would be useful to replicate this study using a longitudinal study design. However, it would be challenging to retain a large number of participants with DS over different time points.

Hick *et al.*'s (2005) longitudinal study investigated the development of verbal short-term memory (digit span, word span) and vocabulary (BPVS, EVT) at 3 time points over 1 year. They investigated children with DS (n = 12) within a mean age of 9 years, matched to TD children (n = 12) with a mean age of 4 years; both groups were matched on mental age. A significant time x group interaction (intervening variable) was shown for all memory and vocabulary tasks (dependent variables). The DS group performed significantly lower than the TD group on all tasks. They showed a plateau at times 2 and 3. This suggests that the rate development of vocabulary and verbal short-term memory is different from that of TD participants matched on mental age. One limitation of their study was the low number of participants (n = 12). This study had a larger number of participants in comparison and the results of their study might also have been different with a larger sample.

6.3.4 Theoretical implications regarding NWR and vocabulary

This section discusses the study findings in light of NWR theories, taking into consideration the implications of NWR performance in relation to receptive and expressive vocabulary skills. The NWR assessment developed by Shaalan (2010) was used in this study, with the theoretical assumption that this examines the work of the phonological loop, as shown in the working memory model of Baddeley and Hitch (1974) and the phonological short-term memory of Gathercole and Baddeley (1989); this is responsible for providing temporary storage of non-familiar phonological forms in addition to the sorting and processing of phoneme combinations. Consequently, any deficit or impairment in this part of working memory would result in a deficit in the phonological representation, thereby affecting the process of learning new words. The findings of this study are partially in line with these theories. Concerning the TD group, there was a high correlation between NWR and both receptive and expressive vocabulary knowledge, supporting both theories of NWR and vocabulary. However, the weak correlation between NWR and vocabulary in the DS group did not provide support for the two theories. It might be that individuals with DS use different mechanisms for vocabulary learning. The use of visual support has been encouraged in their education (see 6.6). Buckley (1995) suggested that seeing orthography (e.g. the written forms of the words) can help in the development of vocabulary and oral language. In addition, orthography

may provide children with DS another representation of the new word form, assisting the representation in the lexicon and then helping with later retrieval.

6.4 RQ3

Does vocabulary (APVT, AEVT) predict phonological awareness, to a similar extent across DS and TD groups?

The third aim of this study was to explore the nature of the relationship between vocabulary knowledge and phonological awareness tasks in Arabic-speaking DS and TD groups. It was hypothesized that vocabulary knowledge would correlate with phonological awareness tasks in both the DS and TD groups (see 3.4 and 3.5), with a stronger correlation in the TD group matched on RCPM raw scores than in the DS group. Pearson correlation showed a significant relationship between the vocabulary measures and phonological awareness measures. This was in line with expectations for the DS and TD groups. The results of the univariate regression analysis were also as expected as there was no significant interaction between group and vocabulary in predicting phonological awareness. This means that for individuals with DS and TD, phonological awareness is predicted based on vocabulary knowledge to a similar extent. These findings support those of Abbeduto *et al.* (2003).

In terms of *lexical knowledge and phonological awareness skills for the TD group,* the significant correlation between vocabulary knowledge and phonological awareness is consistent with many studies in the literature (Metsala, 1999; Carroll *et al.*, 2003; De Cara and Goswami, 2003; Lund *et al.*, 2015). Moreover, longitudinal studies have indicated that both receptive and expressive vocabulary tasks predict phonological awareness (Silvén *et al.*, 2002; Sénéchal *et al.*, 2006), which suggests that the perception of phonological awareness and the acquisition of vocabulary influence each other to some degree. Contrary findings were obtained in other studies (Gathercole and Baddeley, 1990; Garlock *et al.*, 2001). Garlock and colleagues (2001) assessed TD participants and divided them into 3 groups: i) 46 preschool children; ii) 46 elementary school participants; iii) 46 adults. All participants were tested on receptive vocabulary and phonological awareness (phoneme isolation tasks) to investigate whether vocabulary knowledge predicts performance on phonological awareness tasks. The results showed that vocabulary was not a significant predictor of phonological awareness in any of the groups. One might argue that this study assessed phonological awareness only at the phoneme level.

Concerning *lexical knowledge and phonological awareness skills for the DS/learning difficulties group,* the significant correlation between vocabulary knowledge and phonological awareness is consistent with many studies in the literature (Morais *et al.*, 1979; Bird *et al.*, 2000; Cupples and Iacono, 2000; Laws and Gunn, 2002). In a recent study, Deckers *et al.* (2019) also found a significant correlation between vocabulary skills (receptive and expressive) and phonological awareness among DS children with a mean age of 4:5 years. This may point towards a possible indirect impact from receptive to spoken expressive vocabulary, mediated by phonological awareness. The significant correlation was explained by proposing that as an individual's receptive vocabulary increases, phonological awareness develops via a process of lexical restructuring (Walley, 1993; Metsala and Walley, 1998). When the vocabulary of a child develops, he/she will become more aware of rhymes and sounds within the words as children learn many words that start with the same phoneme or rhyme, also making it easier to differentiate between phonemes and words in expressive vocabulary. Therefore, vocabulary development may predict phonological awareness skills. The correlation between vocabulary and phonological awareness might also indicate that children with high vocabulary scores have more words in their lexicon and do well in distinguishing similar–dissimilar sounding words (Munson *et al.*, 2005b).

Laws and Gunn (2002) investigated the correlation between vocabulary (receptive vocabulary), and expressive language (MLU) and phonological awareness skills in 16 children and adolescent readers with DS after controlling for non-verbal ability. A strong significant correlation was found between APVT and phonological awareness ($r = .60$), as well as a strong correlation between MLU and phonological awareness ($r = .63$). However, the addition of the control group in this study adds more valuable results in terms of investigating the strength of the correlation through comparison with the TD group matched on non-verbal mental age.

The findings of this study contrast with those of Zhang and Lee (2017), who investigated the correlation between vocabulary size and phonological awareness at all levels (syllable, rhyme, phoneme) among Chinese high school students with learning difficulties ($n = 36$). A weak negative, but significant, correlation was found between vocabulary and phonological awareness ($r = -.34$). Moreover, they investigated the predictive value of vocabulary (independent variable) to predict phonological awareness. A further linear regression was applied and found no linear relationship between vocabulary and phonological awareness. A possible justification is that Chinese has a logographic writing system and the tests were administered in English. One might argue that all

the tasks used to assess vocabulary size and phonological awareness required verbal responses and the participants may have faced difficulties digesting the tasks. The findings of the study were contrary to those of this study and those of Metsala and Walley (1998), who emphasized the role of vocabulary knowledge in enhancing phonological awareness development.

6.4.1 Group and vocabulary interaction in relation to phonological awareness

The results of the univariate regression analysis suggested that vocabulary predicts phonological awareness to a similar extent across the DS and TD groups and this is consistent with what was expected. It was anticipated that there would be no significant differences between the groups in terms of predicting phonological awareness based on vocabulary knowledge, similar to the study of Abbeduto *et al.* (2003). Similar performance in the DS and TD groups concerning vocabulary predicting phonological awareness can be explained in relation to several aspects. First, vocabulary knowledge is known to be a strength in individuals with DS in comparison to other language components, as reflected in the participants' performance on phonological awareness tasks related to real words, and individuals with DS are known to perform better in the case of real words rather than non-words. In addition, Cardoso-Martins *et al.* (2002) suggested that the words used to assess phonological awareness should not affect the results as long as they are high-frequency words. Second, the receptive vocabulary test and syllable and rhyme awareness tasks used in this study did not require a verbal response, overcoming articulation and speech intelligibility difficulties with DS.

6.4.2 Theoretical implications regarding vocabulary knowledge and phonological awareness

The findings of a positive relationship between vocabulary knowledge and phonological awareness skills in the DS and TD groups support the LR model, which contends that vocabulary development promotes phonological awareness development through the reorganization of the lexicon (Walley, 1993; Metsala and Walley, 1998). In other words, as a child's vocabulary grows, the size of the vocabulary affects his/her understanding that words are built of smaller segments including syllables and phonemes. The similarities between the DS and TD groups suggest the importance of growth in vocabulary knowledge for prompting phonological awareness development. This is in line with studies of TD children and adults (Garlock *et al.*, 2001) and adults with mild ID (Saunders and DeFulio, 2007). This study is one of the first to demonstrate the relationship between vocabulary knowledge and phonological awareness skills in children, adolescents and young adults with DS.

To my knowledge, no prior study has been undertaken investigating the differences between DS and TD groups to predict phonological awareness based on vocabulary knowledge. The correlation results for the DS group support the findings of other works (Morais *et al.*, 1979; Bird *et al.*, 2000; Cupples and Iacono, 2000; Laws and Gunn, 2002; Deckers *et al.*, 2019), which have indicated a significant correlation between vocabulary knowledge and phonological awareness on tasks among children and adolescents with DS. As this is the first Gulf Arabic study to investigate DS, more research is needed to replicate it to generalize the results in this respect.

6.5 RQ4

Does NWR predict phonological awareness to a similar extent across DS and TD groups?

The fourth aim of this study was to explore the relationship between NWR and phonological awareness in both the DS and TD groups. It was hypothesized that NWR would correlate with phonological awareness tasks in both groups, with a stronger correlation in the TD group than the DS group. The Pearson correlation results were in line with expectations for the DS and TD groups. Univariate regression analysis indicated a significant interaction between group and NWR in predicting phonological awareness on tasks. This was also in line with what was expected.

6.5.1 Phonological short-term memory tasks and phonological awareness in the TD group

It has been suggested that phonological short-term memory plays an important role in tasks that require phonological awareness (Alloway *et al.*, 2004). Therefore, this study investigated the relationship between them. The significant correlation between phonological short-term memory/working memory and phonological awareness in the TD group is consistent with many studies in the literature (Oakhill and Kyle, 2000; Alloway *et al.*, 2005; Milwidsky, 2008; Zayed *et al.*, 2013). In particular, it reflects the Arabic study undertaken by Zayed and colleagues (2013), who investigated the correlation between phonological short-term memory (digit recall test, listening recall task) and phonological awareness (syllable blending task, rhyme detection task, phoneme isolation task and phoneme blending task) in two groups of children, one at risk of dyslexia and the other without risk of dyslexia, aged 5–6 years old. The children at high risk of dyslexia performed significantly lower than those without a risk of dyslexia. Further significant correlations were found between phonological short-term memory and phonological awareness for all participants. Separate correlation analysis to compare between groups is warranted, investigating whether significant differences might arise. Milwidsky (2008) undertook a study investigating the correlation between phonological short-term memory and phonological

awareness (sound categorization, syllable splitting and phoneme deletion) in monolingual and bilingual South African children with a mean age of 86 months. Separate correlation analysis was run for each group to draw a comparison between them. The results indicated a stronger correlation for the bilingual group than the monolingual group. This suggests that the bilingual group may be functioning at a different developmental level than the monolingual group in terms of working memory.

Partially similar findings were obtained in a study conducted by Cárnio *et al.* (2015), who adopted a cross-sectional research design. The study compared the performance of 80 Brazilian TD children at the beginning (1st year) and end (5th year) of elementary school on phonological short-term memory (pseudowords repeat test) and phonological awareness (syllable and phoneme level) abilities. In terms of the correlation between phonological short-term memory and phonological awareness tasks, a positive correlation was observed only for the 5th year group. No correlation was observed for the 1st year group. The results of the correlation involving the 5th year group indicated the influence of literacy skills, years of education on the correlation between phonological short-term memory and phonological awareness. One might argue that the correlation between working memory and phonological awareness appears to be dependent on the depth of analysis of working memory, which determines the level of demand on phonological awareness.

6.5.2 Phonological short-term memory tasks and phonological awareness in the DS group

The significant correlation between NWR and phonological awareness (rhyme, phoneme) skills in the DS group was in line with the work of Laws and Gunn (2002), who found a significant correlation between NWR and phonological awareness (rhyme awareness) in DS reader participants. However, no such correlation was identified for non-reader participants with DS due to the small number in the group. This study identified a relationship among non-reader participants with DS in addition to making a comparison with TD participants. No prior study has investigated the relationship between NWR and phonological awareness among Gulf Arabic individuals with DS and TD. Therefore, more studies are needed to replicate this study to generalize the outcomes in this respect.

The results of univariate regression analysis suggest that NWR predicts phonological awareness to a greater (steeper) degree in the TD group than in the DS group, in line with expectations. The possible explanation for this finding is that performance related to phonological short-term memory and phonological awareness is associated with chronological age, maturity and school education

(Adams and Gathercole, 1995; Gindri *et al.*, 2007). All DS participants in this study were attending special education schools for special needs and these schools had lower communication outcomes in comparison to mainstream schools (e.g. speech, language, literacy, and daily living skills) (Buckley *et al.*, 2006). Although the TD group was younger than the DS group, the children had higher academic skills than those in the DS group. They had learned literacy skills (e.g. phonics reading and spelling) in Kuwait at kindergarten, i.e. approximately 4 years old. However, this was not the case for individuals with DS. In addition, the DS individuals presented variations in literacy skills.

The results of the study concerning the relationships between NWR, phonological awareness, and vocabulary are puzzling. A significant correlation was found between NWR and vocabulary among the TD group, but not with the DS group. The discrepant findings around vocabulary and NWR suggested how PSTM interacts with vocabulary learning is different for children with DS. This suggests that individuals with DS could be learning vocabulary via a different route, which minimizes the role of phonological short-term memory. The explanation of the different routes could be learning words as wholes rather than sequences of sound, and reliance on visual memory to link words with the items they describe. More research is needed to replicate this study and validate the findings in this respect.

6.6 Educational and clinical implications of the study

The results of this study have both educational and clinical implications. Understanding the cognitive-behavioural phenotype of DS, such as the developmental trajectory across non-verbal mental abilities, may guide intervention practices (Fidler, 2007). It is likely to be more effective to provide training as early as possible in language development to re-route the developmental trajectory of a particular skill towards the typical trajectory. For example, given the data suggest that onset and rate of development of vocabulary, phonological short-term memory, and phonological awareness occur at a similar rate to TD individuals of the same mental age, continuous and early intervention for individuals with DS would seem advisable. In addition, intervention and language therapy should not be restricted to the early years for those with DS. Moreover, as the results of the present study showed that language aligns with NVMA, it is suggested that interventions are important for individuals with DS as long as mental age continues to grow. In addition, therapy/intervention strategies that capitalize on strengths in visual memory, such as story books, may improve learning in individuals with DS (Chapman, 2003; Hick *et al.*,

2005). Group treatment approaches are also proposed within the classroom setting as these might help improve language skills and pragmatics since individuals with DS have good social skills (Kumin, 1996).

Understanding the predictors of individual differences in this study could aid the selection of individualized intervention targets in several domains of language, including vocabulary, phonological short-term memory and phonological awareness. Moreover, the results of the study should encourage future innovations in language therapies that would aim to jointly facilitate the development of vocabulary, NWR and phonological awareness for individuals with DS. In addition, it would be beneficial to develop a comprehensive language assessment to evaluate cognition, vocabulary skills, phonological short-term memory and phonological awareness abilities, and intervention should involve families to help the development of language in individuals with DS (Kumin, 1996).

The strong correlation between PA and vocabulary knowledge in the DS group argues for an emphasis on vocabulary skills (receptive and expressive) and phonological awareness skills in therapy sessions, which might help the development of reading comprehension and academic skills. Therefore, it would be worth developing Arabic vocabulary and phonological awareness tasks suitable for individuals with DS that can be used for assessments and intervention.

The low correlation between NWR and vocabulary in the DS group suggests that methods for vocabulary learning might depend on mechanisms that differ from those in TD children. The use of visual materials (e.g. pictures, photos, interactive white boards) might be helpful in assisting in the education of DS individuals and might enhance their learning and vocabulary development. In addition, seeing the orthography, or written form of words, could help the development of language in those with DS (Mengoni, 2012).

6.7 Implications for policy and practice

Communication skills are important for life opportunities. The stronger the skills of participants with special needs, the greater their chance to make and keep friends in the TD population (Wadman *et al.*, 2011). Moreover, there is a greater chance of being employed (Foley *et al.*, 2013) and acquiring literacy skills (Nash and Heath, 2011), both of which are correlated with life outcomes. The significant correlation between chronological age and language measures, including vocabulary knowledge and phonological awareness, suggest the need to extend educational and

learning opportunities for this population, either in school or clubs. The children demonstrate the capacity to learn throughout childhood and therefore should be given more opportunities to learn. However, Moni and Jobling (2014) suggest that vocabulary deterioration in adulthood among DS individuals provides an early indication that cognition is deteriorating and therefore health checks in this population are highly recommended. This would help explore and identify preventive actions, involving the provision of an intellectually stimulating environment. This is also suggested for the aging TD population, at high risk of Alzheimer's disease.

6.8 Limitations and directions for future studies

This study has several limitations. The first is the cross-sectional design, which means there is no statistical control over individual variation in developmental trajectory. This affects the ability to generalize to the population as a whole. In addition, the cross-sectional design provides a snapshot of the development of DS and TD individuals in terms of language measures, i.e. at a single time point, and this might not be representative of participants' overall NWR, vocabulary knowledge or phonological awareness. For practical reasons, it was not possible to conduct longitudinal research spanning a long time period and therefore a cross-sectional design was the only option. Therefore, for future research, longitudinal and interventional designs based on making comparisons over time and using other language measures and cognitive abilities as predictors might be beneficial.

It could also be very useful to follow a larger sample of participants developing these skills, as it would strengthen the study's statistical power. For example, future studies could follow a larger sample of individuals with DS (dividing them into 3 groups – children, adolescents and young adults – compared with TD groups at 3 time points and measure their ability with regard to syntactical comprehension and literacy. This would provide greater understanding of development in DS participants. However, Hertzog (1996, cited in Facon and Magis, 2019) suggested that one of the best ways of studying language development would be to start with comparisons of different age groups, followed by a cross-sectional approach, then extending the analysis with a longitudinal design.

The positive correlation between chronological age and language measures, except NWR, in this study indicates that future studies should examine whether language therapy sessions are still effective in adolescents and young adults with DS and whether a decline in vocabulary knowledge and phonological awareness can thereby be delayed or prevented.

The second limitation is related to hearing and vision impairments. As individuals with DS have a high prevalence of vison and hearing impairments, it would be useful to screen participants' hearing and vision rather than depending on school reports and parent questionnaires, which might have a significant impact on task results. However, testing vision in DS participants is challenging and applying the test requires a lot of time (Stephen *et al.*, 2007).

The third limitation is related to the schools the TD children were attending. Some of the TD children attended government schools in which they were considered to be monolingual, while others attended private schools in which they were considered bilingual, although their first and dominant language was Arabic. The style of teaching and language background may have contributed to the difference in performance on all tasks administered in this study. It would be useful to replicate this study with only monolinguals to ensure that all participants had a similar language background.

A fourth limitation relates to the questionnaire given to parents before recruiting participants. Although the design of the questionnaire was based on existing questionnaires used in quite similar research, an effort was made to keep it simple and brief to facilitate completion. For future studies, it would be beneficial to add questions related to the parents' educational backgrounds and SES as it has been found that these factors are related to language development among TD children (Hoff, 2013) and those with ID (Dzurova and Pikhart, 2005; Price *et al.*, 2007). It would be worth investigating whether the effects of parents' level of education and SES status were similar for TD and DS groups of children.

Another limitation concerns the Arabic assessments administered in this study. The tests applied in the study were either developed specifically for the research or for other studies. It is recommended that Arabic researchers consider developing standardized tests in Arabic for NWR, vocabulary knowledge and phonological awareness. The availability of standardized testing materials would be beneficial for future investigations.

In terms of the non-significant correlations between NWR and vocabulary in the DS group, similar findings have been found among Gulf Arabic children with DLD (Shaalan, 2010; Khater, 2016). These findings suggest the need for further research to explain the similarities between language impairment in Gulf Arabic individuals with DS and DLD groups.

According to many study findings concerning the development of receptive language in the DS population, females tend to perform significantly better than males on receptive language skills (Crombie and Gunn, 1998; Carr and Collins, 2014). It would therefore be worth investigating in future studies if sex predicts language measures differently in DS groups.

6.9 Conclusion

In conclusion, to the best of my knowledge this is the first Gulf Arabic study to investigate language skills in individuals with DS. The study investigated vocabulary knowledge (APVT, AEVT), phonological short-term memory (NWR) and phonological awareness (syllable, rhyme, phoneme) in individuals with DS within an age range of 6–20 years, matched to TD children aged 3–10 years on cognitive development (as measured by RCPM). The DS group performed significantly lower than the TD group on all language measures. Correlation analysis was also used to investigate the relationships between RCPM and all language measures. A significant correlation was found between RCPM and all language measures in the DS and TD groups, except for NWR, which was not significantly correlated with RCPM or vocabulary knowledge in the DS group. This might suggest that there is wide variation among participants with DS in their performance on this task and that variation is not explained by age or non-verbal ability.

This thesis makes an original contribution to knowledge of language development in Gulf Arabic individuals with DS and TD by applying cross-sectional developmental trajectory analysis of vocabulary, phonological short-term memory and phonological awareness in individuals with DS and TD children across RCPM. Between-group comparison indicated that individuals with DS displayed a similar onset and rate of development for these language measures across the DS and the TD groups. This is broadly in line with neuro-constructivist theory, which states that cognition and the development of language are intertwined. However, it is worth noting that this study did not look at all aspects of language (e.g. syntax). The developmental trajectory approach afforded better understanding of the type of the delay regarding vocabulary, phonological memory and phonological awareness abilities in DS children, thus enriching current knowledge of the contributions of genetic abnormalities to behavioural phenotypes. Methodologically, this study is significant as it tests vocabulary, NWR and phonological awareness in Arabic, something that has not been done previously in Kuwait among individuals with DS.

In addition to employing the developmental trajectory approach, correlations between NWR and vocabulary were examined in the DS and TD groups. No significant correlation was found between

NWR and vocabulary in the DS group. This is not in line with theories of NWR and vocabulary, such as the working memory model (Baddeley and Hitch, 1974) and the phonological processing account (Gathercole and Baddeley, 1989; Gathercole and Baddeley, 1990). Moreover, NWR predicted vocabulary knowledge only in the TD group and not in the DS group. The relationship between vocabulary and phonological awareness was examined and showed a similar relationship in the DS and TD groups. Therefore, the findings for the DS and TD groups were in line with the LR model (Walley, 1993; Metsala and Walley, 1998). Moreover, the study investigated the relationship between NWR and phonological awareness in the DS and TD groups, finding a significant correlation. NWR predicted phonological awareness more steeply in the TD group than the DS group.

Finally, longitudinal research should be undertaken to explore the findings from this cross-sectional study in greater depth. Moreover, further cross-syndrome comparisons are warranted to explore the syndrome-specific aspects of developmental trajectories.

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Appendix A1. Information Sheet for DS Parents in Arabic

عنوان الدراسة: تطور الذاكرة قصيرة المدى والمفردات، و الوعي الصوتي لدى أفراد متلازمة الداون و الأطفال الطبيعيين الناطقين باللغة العربية في الكويت.

جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

ورقة معلومات للآباء/المسؤولين عن أفراد متلازمة داون

عزيزي ولي الأمر،
أنا طالبة دكتوراه في جامعة نيوكاسل، وبحثي يقوم على أفراد متلازمة الداون والأفراد الطبيعيين. الهدف الأساسي من بحثي هو دراسة تطور الذاكرة، والمفردات، والوعي الصوتي لدى أفراد متلازمة داون ومقارنتهم بالأفراد الطبيعيين. لقد طلب منك أن تشارك في هذه الدراسة لأن ابنك/ابنتك لديه متلازمة داون.

لا بد لي من المشاركة؟
المشاركة في الدراسة تطوعية تماما. أنت حر في سحب ابنك/ابنتك من الدراسة في أي وقت دون أن يؤثر هذا على أي رعاية أو خدمة يتلقاها الآن أو في المستقبل.
ماذا سيحدث ل ابني/ابنتي إذ شارك في الدراسة؟

إذا اخترت المشاركة في الدراسة، نود أن نرى ابنك/ابنتك في جلستين لمدة حوالي 40 دقيقة في كل جلسة، مع وجود راحة 5 دقائق بين الاختبارات. وسوف تشمل تقييم ما يلي:

1. اختبار الذكاء غير اللفظي: يقوم المشارك باختيار الصورة التي تكمل أفضل نمط. وهذا سوف يستغرق 15-20 دقيقة.
2. اختبار مخارج الأصوات وسوف يستغرق حوالي 10 دقائق.
3. اختبار لقياس الحصيلة اللغوية للغة الإستقبالية وسوف يستغرق حوالي 15 دقيقة.
4. اختبار لقياس الحصيلة اللغوية للغة التعبيرية وسوف يستغرق حوالي 15 دقيقة..
5. اختبار تكرار الكلمات: ويشمل تكرار الطفل للكلمة بعد سماعها وسوف يستغرق حوالي 15 دقيقة.
6. اختبار الوعي الصوتي: ويشمل قدرة الطفل على اختيار الكلمات التي لها نفس البداية أو النهاية بعد سماعها من الباحث. وسوف يستغرق حوالي 10 – 15 دقيقة.
7. اختبار القدرة على القراءة لمن يستطيع القراءة: ويشمل قدرة المشارك على قراءة حروف اللغة العربية والمفردات. وسوف يستغرق حوالي 30 دقيقة.

من الذي سوف يطبق الإختبارات ؟
سيتم إجراء الدراسة بواسطة الأستاذة/سارة السعيد ولديها خبرة بالعمل مع الأطفال و المراهقين و الكبار الطبيعيين ومن ذوي الإحتياجات الخاصة, كما أنها كانت تعمل بمستشفى الطب الطبيعي وتعمل على تأهيل المرضى الذين يعانون من مشاكل بالنطق و الكلام و البلع.
أين ومتى سوف تتم الدراسة؟
الدراسة تتم في غرفة هادئة في المدرسة أو في البيت أو في المجتمع الكويتي لمتلازمة الداون خلال ساعات العمل.
ما هي الفوائد الممكنة من المشاركة؟

المعلومات التي نحصل عليها من خلال الاختبارات تساعدنا في تحسين تصميم أهداف على المدى القصير والمدى الطويل للغة لعلاج النطق من أجل فهم أفضل لنقاط القوة والضعف لدى متلازمة الداون.

هل توجد أي مخاطر لهذه الدراسة؟

لا توجد أي مخاطر بدنية تنتج عن إجراء الدراسة, ولكن قد يمل المشارك من طول فترة الجلسة ولكن هناك فترة راحة بين الاختبارات.

هل سوف تتم حماية أسرار وخصوصية ابني؟

نعم, فمن المهم لدينا أن تتم المحافظة على أسرار وخصوصية المشارك بالبحث عن طريق وضع بيانات ونتائج اختبارات المشارك في مكان آمن.

كيف يمكنني العلم بنتائج الدراسة؟

إذا أردت معرفة نتائج الدراسة, فيمكنك على الرحب والسعة الاتصال بنا هاتفيا أو عبر البريد الإلكتروني الواردين في أعلى الصفحة.

من الذي ينظم هذه الدراسة ومن يقوم على تمويلها؟

ينظم هذه الدراسة الباحثة سارة السعيد والمشرف كارولين ليتس ويتم تمويلها من قبل ديوان الخدمة المدنية.

إذا كنت ترغب في مشاركة ابنك في هذه الدراسة. يرجى التكرم بتعبة استمارة الموافقة. ولكم جزيل الشكر على اهتمامكم بدراستنا.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

Appendix A2. Information Sheet for DS Parents in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: The development of short-term memory, vocabulary and phonological awareness in individuals with Downs Syndrome Arabic-speaking in Kuwait.

INFORMATION SHEET FOR PARENTS/GUARDIANS of individuals with Down syndrome

Dear Parent/Guardian,

I am a PhD student at the Newcastle University, doing my research on individuals with Down syndrome and typically developing. The primary aim of my research is to investigate the developmental of working memory, vocabulary, and phonological awareness in individuals with Down syndrome and to compare this to that of typically developing children. You have been asked to participate in the study as your son/daughter has Down syndrome.

Do I have to participate?

Participation in the study is completely voluntary. You are free to withdraw your son/daughter from the project at any time without this affecting any care or services you/your child may be receiving now or may receive in the future.

What will happen to my son/daughter if s/he takes part in the study?

If you choose to participate in the study, we would like to see your son/daughter in two sessions for around 40 minutes in each session, within 5 minutes break between the tasks. The assessment will include the following:

1. Measure of nonverbal IQ. This will involve the participant selecting a picture that best completes a pattern. This will take 15 – 20 minutes.
2. Receptive and expressive one-word vocabulary. This will involve the participant to point to the picture that is the same word that have been said, and naming pictures after presenting it. This will take approximately 15 minutes.
3. Non-word repetition. This will involve the participant repeating the word after hearing it. This will take approximately 15 minutes.

4. Phonological awareness tasks. 3 tasks involved to assess phonological awareness. First task will involve the participant to repeat verbally presented word(s) while omitting some sounds. Second task, participant will be asked to say which of the words begins with the same sound as the initially spoken word by the examiner. Third task, participant will be asked to say which of the words ends with the same sound as the initially spoken word by the examiner. Each of these tasks takes about 10-15 minutes.

Who will be present?

The tasks will be conducted by Sarah Al Saeed who has experience in working with Children, adolescents and adults with communication disorders. She is a certified Speech-Language Pathologist, and has been through the formal Disclosure procedure and has been approved to work with special needs.

Where and when will the study take place?

The study will take place in a quiet room of the school or Down syndrome society during working hours.

What are the possible benefits of taking part?

The information we get will help us as a speech and language therapist of how to improve our design for short term and long-term goals for language and speech therapy in order to understand better the strengths and weaknesses of children with Down syndrome language.

Are there any possible disadvantages and risks?

There are no physical risks and children usually enjoy the tasks. Possible risks are for children to get tired, distressed or bored. To avoid them getting tired, there will be breaks during each session and the length of each session will be based on the age and attention span of each child. To avoid distress, before starting the tasks we explain to the children what they have to do and they can practice. This makes sure that children are confident and happy to perform the tasks. To avoid children getting bored, we use lively pictures. This keeps them concentrated, and makes the tasks fun.

What we do with the data

Any personal information given will remain confidential; all personal data will be stored securely in a locked cupboard. Personal information will be kept for 5 years and then disposed. Anonymised data may be kept at the University for future research. This application has been reviewed by the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. All investigators on this project have had criminal records checks and have been approved by the School to work with children. If you would like to know the outcome of the study, you are welcome to contact us to request this. It will not be possible, however, to disclose individual scores but group scores will be available.

What will happen to the results of this study?

The results of this study will be presented in conferences and written up as part of a doctoral dissertation. Participants will not be identified in any presentation or publication.

How can I get informed about the results of this study?

If you would like to know the results of the study, you are welcome to contact us on the phone number or e-mail at the top of Page 1. It will not be possible to disclose individual scores, but we can send you group scores.

Who is organizing and who is funding this study?
This study is being organized by Newcastle University and has been funded by the civil service commission in Kuwait.

Who has reviewed this study?
This application has been reviewed by the School Research Ethics Committee and has been given a favourable ethical opinion for conduct. If you would like your child to take part in this study, please fill in one of the consent forms and give it directly to the investigator.
Please keep the second copy of the Information Sheet/Consent Form for your own future Reference. If you have any questions you can contact us at any time on the phone number or email at the below.

Thank you for considering this study and for taking time to read this information sheet.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

Appendix B1. Information Sheet for TD Parents in Arabic

جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

عنوان الدراسة: تطور الذاكرة قصيرة المدى و المفردات والوعي الصوتي, لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.

ورقة معلومات لأولياء أمور الأطفال الطبيعيين

عزيزي ولي الأمر،
أنا طالبة دكتوراه في جامعة نيوكاسل، وبحثي يقوم على أفراد متلازمة الداون والأفراد الطبيعيين. الهدف الأساسي من بحثي هو دراسة تطور الذاكرة، والمفردات ، و الوعي الصوتي لدى أفراد متلازمة داون ومقارنتهم بالأفراد الطبيعيين. لقد طلب منك أن تشارك في الدراسة لأن ابنك/ابنتك مستوى ذكاؤه طبيعي.

لا بد لي من المشاركة؟

المشاركة في الدراسة تطوعية تماما. أنت حر في سحب ابنك/ابنتك من الدراسة في أي وقت دون أن يؤثر هذا على أي رعاية أو خدمة يتلقاها الآن أو في المستقبل.

ماذا سيحدث ل ابني/ابنتي إذ شارك في الدراسة؟

إذا اخترت المشاركة في الدراسة، نود أن نرى ابنك/ابنتك في جلستين لمدة حوالي 40 دقيقة في كل جلسة، مع وجود راحة 5 دقائق بين الاختبارات. وسوف تشمل تقييم ما يلي:

1. اختبار الذكاء غير اللفظي: يقوم المشارك باختيار الصورة التي تكمل أفضل نمط. وهذا سوف يستغرق 15-20 دقيقة.
2. اختبار مخارج الأصوات وسوف يستغرق حوالي 10 دقائق.
3. اختبار لقياس الحصيلة اللغوية للغة الإستقبالية وسوف يستغرق حوالي 15 دقيقة.
4. اختبار لقياس الحصيلة اللغوية للغة التعبيرية وسوف يستغرق حوالي 15 دقيقة..
5. اختبار تكرار الكلمات ويشمل تكرار الطفل للكلمة بعد سماعها. وسوف يستغرق حوالي 15 دقيقة.
6. اختبار الوعي الصوتي: ويشمل قدرة الطفل على اختيار الكلمات التي لها نفس البداية أو النهاية بعد سماعها من الباحث. وسوف يستغرق حوالي 10 – 15 دقيقة.
7. اختبار القدرة على القراءة لمن يستطيع القراءة: ويشمل قدرة المشارك على قراءة حروف اللغة العربية و المفردات, و سوف يستغرق حوالي 30 دقيقة.

من الذي سوف يطبق الإختبارات ؟

سيتم إجراء الدراسة بواسطة الأستاذة/سارة السعيد ولديها خبرة بالعمل مع الأطفال و المراهقين و الكبار الطبيعيين ومن ذوي الإحتياجات الخاصة, كما أنها كانت تعمل بمستشفى الطب الطبيعي وتعمل على تأهيل المرضى الذين يعانون من مشاكل بالنطق و الكلام و البلع.

أين ومتى سوف تتم الدراسة؟

الدراسة تتم في غرفة هادئة في المدرسة خلال ساعات العمل أو في البيت.

ما هي الفوائد الممكنة من المشاركة؟

المعلومات التي نحصل عليها من خلال الاختبارات تساعدنا في تحسين تصميم أهداف على المدى القصير والمدى الطويل للغة لعلاج النطق من أجل فهم أفضل لنقاط القوة والضعف لدى متلازمة الداون.

هل توجد أي مخاطر لهذه الدراسة؟

لا توجد أي مخاطر بدنية تنتج عن إجراء الدراسة, ولكن قد يمل المشارك من طول فترة الجلسة ولكن هناك فترة راحة بين الاختبارات.

هل سوف تتم حماية أسرار وخصوصية ابني؟

نعم, فمن المهم لدينا أن تتم المحافظة على أسرار وخصوصية المشارك بالبحث عن طريق وضع بيانات ونتائج اختبارات المشارك في مكان آمن.

كيف يمكنني العلم بنتائج الدراسة؟

اذا أردت معرفة نتائج الدراسة, فيمكنك على الرحب و السعة الاتصال بنا هاتفيا أو عبر البريد الإلكتروني الواردين في أعلى الصفحة.

من الذي ينظم هذه الدراسة ومن يقوم على تمويلها؟

ينظم هذه الدراسة الباحثة سارة السعيد والمشرف كارولين ليتس ويتم تمويلها من قبل ديوان الخدمة المدنية.

إذا كنت ترغب في مشاركة ابنك في هذه الدراسة. يرجى التكرم بتعبة استمارة الموافقة. ولكم جزيل الشكر على اهتمامكم بدراستنا.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

Appendix B2. Information Sheet for TD Parents in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: The development of short-term memory, vocabulary and phonological awareness in individuals with Downs Syndrome Arabic-speaking in Kuwait.

INFORMATION SHEET FOR PARENTS/GUARDIANS of individuals with typically developing children

Dear Parent/Guardian,

I am a PhD student at the Newcastle University, doing my research on individuals with Down syndrome and typically developing. The primary aim of my research is to investigate the developmental of working memory, vocabulary, and phonological awareness in individuals with Down syndrome and to compare this to that of typically developing children. You have been asked to participate in the study as your child is typically developing.

Do I have to participate?

Participation in the study is completely voluntary. You are free to withdraw your son/daughter from the project at any time without this affecting any care or services you/your child may be receiving now or may receive in the future.

What will happen to my son/daughter if s/he takes part in the study?

If you choose to participate in the study, we would like to see your son/daughter in two sessions for around 40 minutes in each session, within 5 minutes break between the tasks. The assessment will include the following:

1. Measure of nonverbal IQ. This will involve the participant selecting a picture that best completes a pattern. This will take 15 – 20 minutes.
2. Receptive and expressive one-word vocabulary. This will involve the participant to point to the picture that is the same word that have been said, and naming pictures after presenting it. This will take approximately 15 minutes.
3. Non-word repetition. This will involve the participant repeating the word after hearing it. This will take approximately 15 minutes.

4. Phonological awareness tasks. 3 tasks involved to assess phonological awareness. First task will involve the participant to repeat verbally presented word(s) while omitting some sounds. Second task, participant will be asked to say which of the words begins with the same sound as the initially spoken word by the examiner. Third task, participant will be asked to say which of the words ends with the same sound as the initially spoken word by the examiner. Each of these tasks takes about 10-15 minutes.

Who will be present?
The tasks will be conducted by Sarah Al Saeed who has experience in working with Children, adolescents and adults with communication disorders. She is a certified Speech-Language Pathologist and has been through the formal Disclosure procedure and has been approved to work with special needs.

Where and when will the study take place?
The study will take place in a quiet room of the school, or during family gathering at home.

What are the possible benefits of taking part?
The information we get will help us as a speech and language therapist of how to improve our design for short term and long-term goals for language and speech therapy in order to understand better the strengths and weaknesses of children with Down syndrome language.

Are there any possible disadvantages and risks?
There are no physical risks and children usually enjoy the tasks. Possible risks are for children to get tired, distressed or bored. To avoid them getting tired, there will be breaks during each session and the length of each session will be based on the age and attention span of each child. To avoid distress, before starting the tasks we explain to the children what they have to do and they can practice. This makes sure that children are confident and happy to perform the tasks. To avoid children getting bored, we use lively pictures. This keeps them concentrated, and makes the tasks fun.

What we do with the data

Any personal information given will remain confidential; all personal data will be stored securely in a locked cupboard. Personal information will be kept for 5 years and then disposed. Anonymized data may be kept at the University for future research. This application has been reviewed by the University Research Ethics Committee and has been given a favourable ethical opinion for conduct. All investigators on this project have had criminal records checks and have been approved by the School to work with children. If you would like to know the outcome of the study, you are welcome to contact us to request this. It will not be possible, however, to disclose individual scores but group scores will be available.

What will happen to the results of this study?
The results of this study will be presented in conferences and written up as part of a doctoral dissertation. Participants will not be identified in any presentation or publication.

How can I get informed about the results of this study?

If you would like to know the results of the study, you are welcome to contact us on the phone number or e-mail at the top of Page 1. It will not be possible to disclose individual scores, but we can send you group scores.

Who is organizing and who is funding this study?
This study is being organized by NEWCASTLE University and has been funded by the civil service commission in Kuwait.

Who has reviewed this study?
This application has been reviewed by the School Research Ethics Committee and has been given a favourable ethical opinion for conduct. If you would like your child to take part in this study, please fill in one of the consent forms and give it directly to the investigator.
Please keep the second copy of the Information Sheet/Consent Form for your own future Reference. If you have any questions you can contact us at any time on the phone number or email at the top of Page 1.

Thank you for considering this study and for taking time to read this information sheet.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

Appendix C1. Consent Form for Parents in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: the development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals.

I, …… agree my child to participate in the study: the development of vocabulary, phonological awareness and working memory in Down syndrome and typically developing Kuwaiti individuals, being conducted by Sarah Al Saeed and Carolyn Letts at Newcastle university.

- I have given information about the study; I have had time to think about what is involved and ask any questions.
- I have been given the opportunity to ask questions about the study and these have been answered to my satisfaction.
- I understand that all personal information will remain confidential to the Investigator and arrangements for the storage and eventual disposal of any identifiable material have been made clear to me.
- I understand that participation in this study is voluntary and that my child can withdraw at any time without having to give an explanation.
- I agree my child to participate in the tests.

I am happy to proceed with my child participation.
Signature

Name (in capitals)

Date

Appendix C2. Consent Form for Parents in Arabic

جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

استمارةموافقةلأولياء أمور الأطفال المشاركين بالدراسة

عنوان الدراسة:تطور الذاكرة قصيرة المدى و المفردات والوعي الصوتي, لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.

1. أؤكد بأنني قد قرأت ورقة المعلومات التي تدور حول الدراسة، وأنني أفهم سبب إجراء هذه الدراسة كما أنني قد تمت إتاحة الفرصة لي لطرح أسئلة حول الدراسة، وأعبر عن مدى ما أشعر به من سعادة حيال ما تم تقديمه من اجابات على ما طرحته من أسئلة.
2. أنا أفهم بأن مشاركة ابني/ابنتي في هذه الدراسة تطوعية وأن لي الحق في الإنسحاب من الدراسة في أي وقت بدون حتى الإضطرار إلى تقديم أي تفسير أو سبب، وأن ذلك لن يتسبب في أي أثر سلبي على تقديم المحتوى التلربوي الذي يتلقاه الطفل الآن أو بالمستقبل.
3. أنني أتفهم أن كافة المعلومات الشخصية سوف تظل سرية لدى الباحث، وقد استوضحت الترتيبات من أجل تخزين أية مادة محددة أو التخلص منها في البداية.
4. سوف أستلم نسخة إضافية من استمارة الموافقة ومن ورقة المعلومات.
5. أوافق على اختبار ابني/ابنتي على جلستان لإستكمال جميع الإختبارات.

اسم الطفل:	تاريخ الميلاد:	التوقيع:
اسم الشخص المسؤل عن الطفل:	التاريخ:	التوقيع:
اسم الباحث:	التاريخ:	التوقيع:

Appendix D1. Reader Participants' Information Sheet in English

Faculty of humanities and language sciences

School of Education, Communication, and Language Sciences: ɛnces

KGVI King George VI Building, University of Newcastle, Queen Victoria Rd, Newcastle upon Tyne, NE1 7RU

INFORMATION SHEET FOR READER PARTICIPANTS

Title of the study: The development of short-term memory, vocabulary and phonological awareness in individuals with Downs Syndrome Arabic-speaking in Kuwait

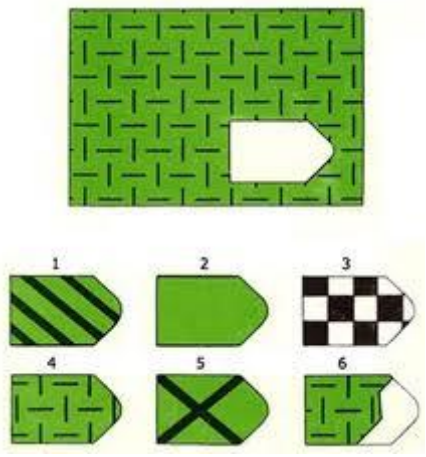
Dear participant,

How are you, I am doing a study about language and memory for children. I need some participants to participate in my study. We will do it in two sessions, and each session will no long be more than 40 minutes, and don`t worry, we will have break between the tasks.

I have puzzle game, picture cards to point on, and repeating words.

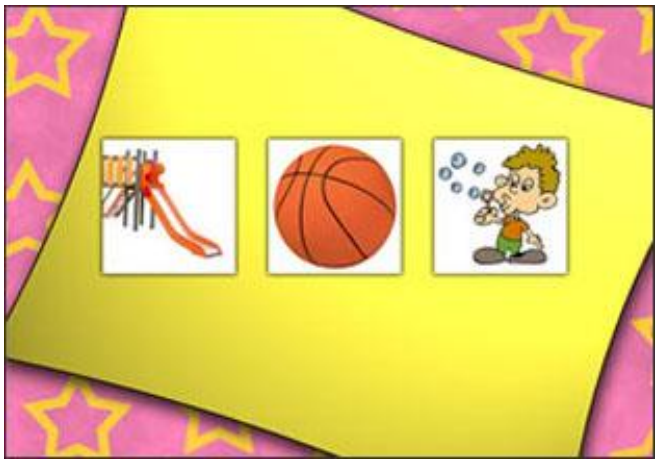
Let's have a look to the tasks that we are going to do, and then you can see if you want to participate in the tasks or not.

1. The first game, as you can see, looks like a puzzle. You must select the best picture, from the small pictures numbered 1 to 6, to fill in the missing part of the large picture.



2. For the second game, as you can see below, I am going to show you several pictures. You must name the pictures, you will see familiar pictures of food, animals, objects, vehicles, body parts etc.

3. Lets now move to the third game. This will involve pointing to pictures that match the words you hear me say. For example, as you can see in this picture, if you hear the word ‘ball’, you should point to the ball in the middle, and ignore the other pictures.



4. We are now in the last task for the first session; I hope you aren’t getting bored. This task won’t take a long time, so let’s try our best. For this task you just need to repeat what I am saying. Be careful of how I am producing the sounds, as the words might not be familiar to you. Just imitate me.

Now, what do you think? Do you want to participate? it is up to you, and you are free to decide whether you want to take part, and you can stop taking part at any time.

If you decide to participate, then let’s move to the other tasks for the next coming session.

This session will not be longer than the previous session, it is required from you to listen carefully for the words you will hear them from me.

1. now we have a picture of dog, what is the first sound of dog?/d/is the first sound.
2. The second task, but you need to focus which word has the same words ends with the same sound as the initially spoken word. For Example, I say "which has the same last sound as gum: goat, nut, or farm? “You have to select the word/farm/.

3. We are now in the last task, in this task I would give you a word, and asked to clap your hands or tap on the table based on the number of syllables the word have. I think this is funny game, what do you think? For example, the word “table” has 2 syllables, lets clap our hands.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

Appendix D2. Reader Participants' Information Sheet in Arabic

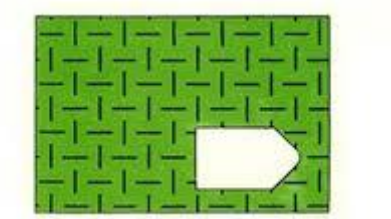
جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

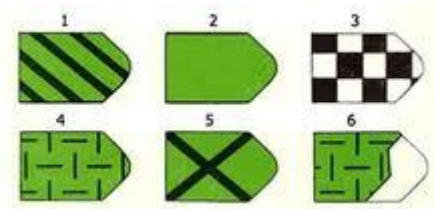
ورقة معلومات للأفراد القارئين المشاركين بالدراسة

عنوان الدراسة: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.

عزيزي المشارك بالاختبارات،
كيف حالك؟ أنا أقوم بعمل بحث عن اللغة و الذاكرة لدى الأطفال و البالغين. وأنا بحاجة لبعض المشاركين للمشاركة في دراستي. سنقوم بعمل الدراسة في جلستين, وكل جلسة لا تزيد مدتها عن 40 دقيقة, وستكون هناك فترة راحة بين الاختبارات. لدي لعبة اللغز، والصور الملونة، وتكرار الكلمات وقراءة الكلمات.

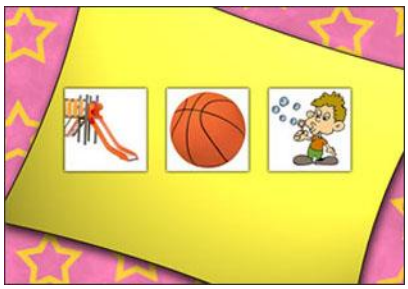
1. **اللعبة الأولى: كما هي في الصورة أمامك عبارة عن لغز وينبغي عليك اختيار النقش المناسب لإكمال الصورة.**





2. **اللعبة الثانية: سترى مجموعة من الصور، وينبغي عليك الإشارة الى الصورة المناسبة التي ستسمعها من الباحث, كما هي موضحة بالصورة بالأسفل.**

3. دعونا ننتقل الآن الى اللعبة الثالثة، على سبيل المثال. كما ترون في الصورة، اذا سمعت كلمة "كرة"، يجب أن تشير الى الكرة في وسط الصور، وتجاهل الصور الأخرى.

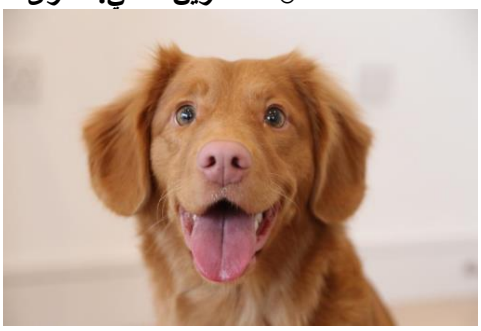


4. وصلنا الآن الى آخر لعبة. وهذه اللعبة لن تستغرق وقتا طويلا, لذلك نريد أن نبذل قصارى جهدنا. لهذه اللعبة تحتاج فقط الى تكرار ما أقوله. كن حذرا واسمع جيدا لأن الكلمات لن تكون مألوفة عندك, مجرد تقليد ما تسمعه.

الآن، ما رأيك؟ هل ترغب في المشاركة؟ الأمر متروك لك، وأنت حر في أن تقرر ما إذا كنت تريد المشاركة، ويمكنك التوقف عن الاختبار في أي وقت.
إذا قررت المشاركة، دعنا ننتقل الى الاختبارات الأخرى للجلسة الثانية ان شاء الله.

5. هذه الجلسة لن تكون أطول من الجلسة السابقة، مطلوب منك أن تسمع بعناية الكلمات حتى تختار الكلمة المناسبة:

- التمرين الأول: كلمة (ماي) نهايتها/اي/، ستسمع مني كلمتين وترى صورهم (شاي- جبن) ويجب أن تختار من بين الكلمتين والصورتين, الصورة التي تكون نهايتها/اي/. يجب أن تختار كلمة شاي.
- التمرين الثاني: سترى صورة (كلب) وسيطلب منك نطق أول صوت من كلب ألا وهو/ك/.



- التمرين الثالث: يجب أن تعد المقطع في الكلمة عن طريق التصفيق بيدك. مثال: بلسم تتكون من مقطعين ويجب عليك التصفيق مرتين.

Sarah Al Saeed
Contact #: [redacted]
Email: S.M-F-KH-Alsaeed2@newcastle.ac.uk
Dr Carolyn Letts
Contact #: 00441912086518
Email: Carolyn.letts@ncl.ac.uk

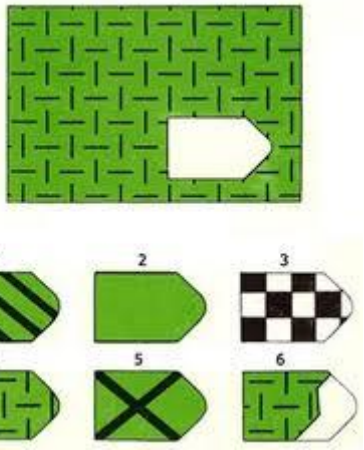
Appendix E. Information Sheet for Non-Reader Participants in English

<u>Title of the study:</u> The development of short-term memory, vocabulary and phonological awareness in individuals with Downs Syndrome Arabic-speaking in Kuwait

Dear participant,

How are you, are you ready to play with me? Ok let's begin, As you can see this picture is a conversation between a child and a teacher, this is how the conversation is going to be between us if you would like to participate in the study

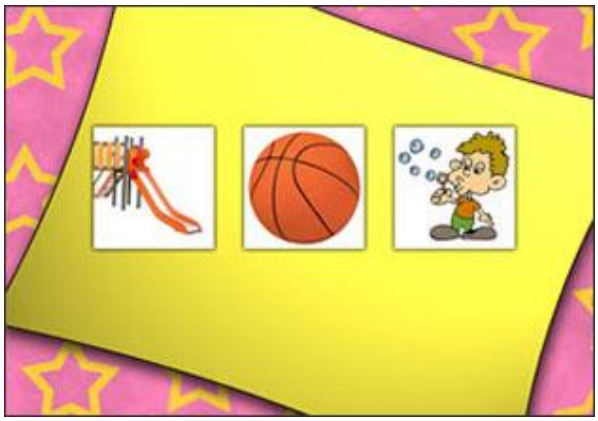
What do you think the suitable picture from the 6 bottom pictures that suit the missing?



1. As you can see, the man is showing the boy some picture cards.

As you can see on the above picture, we will play the same game, and you have to name the picture I will show it to you. Is that clear?

1. On this picture, for example, if I say ball you have to point on it rather than pointing on anything else, just point on what I am saying. Easy? Difficult?



2. The next game without pictures, just imitating some words you hear them from me.
Now, what do you think? Do you want to participate? it is up to you.and you are free to say yes if you want. or no if you don't want to, and you can stop taking part at any time.

We have other games for the next session, I will tell you next time when I see you.

How are you today? Are you excited today? Shall we start now?

It all about listening to words and sounds, I will show you some picture and I will give you an example of the way we can answer the questions.

4. Now we have a picture of dog, what is the first sound of dog?/d/is the first sound. So lets practise now. Ready, steady, lets go.
5. The second task, but you need to focus which word has the same words ends with the same sound as the initially spoken word. For Example, I say "which has the same last sound as gum: goat, nut, or farm? "You have to select the word/farm/.

We are now in the last task, in this task I would give you a word, and asked to clap your hands or tap on the table based on the number of syllables the word have. I think this is funny game, what do you think? For example, the word "table" has 2 syllables, lets clap our hands.

Bear in mind there is no pass/fail for these assessments but try your best, and don’t worry I will take off your name, I want to discover how children and participants can understands pictures. Sounds, and words.

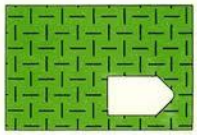
Appendix E2. Information Sheet for Non-Reader Participants in Arabic

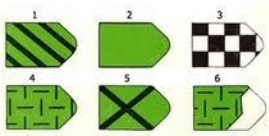
ورقة معلومات للأطفال الغير قارئين المشاركين بالدراسة

عنوان الدراسة: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.

عزيزي كيف حالك؟ ترى في هذه الصورة كلام بين الطفل و المعلمة، هكذا سنقوم أنا و أنت اذا كنت تود المشاركة بالاختبارات معي. مستعد, متحمس ؟ اذا هيا نبدأ

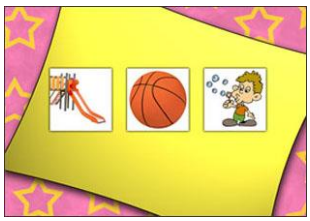
1. **ماذا تعتقد الصورة المناسبة التي يجب أن تختارها لاستكمال الجزء المتبقي؟**





2. **ستسمع مني بعض الكلمات المألوفة لديك تسمعها بشكل يومي وأريد منك ترديد الكلمات من بعدي, حتى أعرف اذا كانت لديك بعض المشاكل في نطق ووضوح الأصوات.**
3. **التمرين الذي يليه.كما ترى في هذه الصورة الرجل لديه مجموعة من الصور يعرضها على الطفل. أنا سأقوم بنفس العمل معك ويجب عليك تسمية الصور. هل هذا سهل؟ واضح؟**

4. **في هذه الصورة على سبيل المثال. عندما تسمع مني كرة يجب أن تؤشر على صورة كرة وتتجاهل باقي الصور. واضح؟ سهل**



5. **الآن توصلنا الى آخر لعبة، سهلة وبسيطة. فقط عليك بتقليد الكلمات التي تسمعها مني، وقد تكون الكلمات ليست مألوفة عندك. هل تريد المشاركة بالاختبارات؟ لك مطلق الحرية. لا يوجد شيء إجباري.**

لم ننتهي بعد، لدينا مجموعة من الألعاب نلعبها بالأحرف والكلمات من غير صور في الجلسة القادمة.

كيف حالك اليوم؟ متشوق للعب معي؟ مستعد

6. **هذا التمرين يحتاج منك التركيز على الأصوات والمقاطع في الكلمات.**

- **التمرين الأول: كلمة (ماي) نهايتها/اي/، ستسمع مني كلمتين وترى صورهم (شاي- جبن) ويجب أن تختار من بين الكلمتين والصورتين, الصورة التي تكون نهايتها/اي/كلمات: شاي – جبن. يجب أن تختار كلمة شاي.**

- **التمرين الثاني: سترى صورة (كلب) وسيطلب منك نطق أول صوت من قاري ألا وهو/ك/.**
- **التمرين الثالث: ينبغي أن تعد المقطع في الكلمة عن طريق التصفيق بيدك. مثال: بلسم تتكون من مقطعين ويجب عليك التصفيق مرتين.**

سارة السعيد/كارولين ليتس

Appendix F1. Consent Form for Reader Participants in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: the development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals.

I, …… agree to participate in the study: the development of vocabulary, phonological awareness and working memory in Down syndrome and typically developing Kuwaiti individuals, being conducted by Sarah Al Saeed and Carolyn Letts at Newcastle university.

- I have given information about the study; I have had time to think about what is involved and ask any questions.
- I have been given the opportunity to ask questions about the study and these have been answered to my satisfaction.
- I understand that all personal information will remain confidential to the Investigator and arrangements for the storage and eventual disposal of any identifiable material have been made clear to me.
- I understand that participation in this study is voluntary and that I can withdraw at any time without having to give an explanation.
- I agree to participate in the tests.

I am happy to proceed with my participation.
Signature

Name (in capitals)

Date

Appendix F2. Consent Form for Reader Participants in Arabic

جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

استمارة موافقةلأولياء للأفراد المشاركين بالدراسة

عنوان الدراسة: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.

- ✓ **أنا..... أوافق على المشاركة في هذه الدراسة بعنوان: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت.**
- ✓ **منحت فرصة كافية من قبل الباحث للأسئلة، وتم الرد على أسئلتي بكل أريحية.**
- ✓ **أنا أفهم بأن مشاركتي في هذه الدراسة تطوعية وأن لي الحق في الانسحاب من الدراسة في أي وقت بدون حتى الاضطرار إلى تقديم أي تفسير أو سبب.**
- ✓ **أنني أتفهم أن كافة المعلومات الشخصية سوف تظل سرية لدى الباحث.**
- ✓ **أوافق على المشاركة في الاختبارات مع الباحث.**

التوقيع

الاسم

تاريخ

Appendix G1. Screening Questionnaire for TD parents in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: The Development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals.

Screening questionnaire for typically developing parents

1 General Information about the Child

1.1 Birth Date: …….

1.2 What is your child's first language? Arabic – English

2 Child's early history:

2.1 How old was your child when he/she first walked?

2.2 How old was your child when he/she spoke his/her first word?

2.3 Were you concerned about your child's language development at an early age?

-If yes, please explain: _____.

2.4 How old was your child when he/she first put words together to make short sentences?

_____ _ Example: more water; more milk; etc.

2.5 Has your child ever had any hearing problems?

-Hearing loss: YES or NO

-Frequent ear infections: YES or NO

-Other (specify): ……

2.6 do your child had any health problems at birth or subsequently?

if yes. what are they? Heart disease, chest infections.

Appendix G2. Screening Questionnaire for TD parents in Arabic

جامعة نيوكاسل
كلية العلوم الإنسانية والعلوم الإجتماعية
مدرسة التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

عنوان الدراسة: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت

استبيان لأولياء أمور الأطفال الطبيعيين

بيانات عامة عن الطفل:

- تاريخ الميلاد:
- ما هي لغة الطفل الأولى؟ اللغة العربية – اللغة الإنجليزية

التاريخ المبكر للطفل:

كم كان عمر طفلك عندما مشى لأول مرة؟.....

كم كان عمر طفلك عندما تكلم وقال أول كلمة له؟.....

كم كان عمر طفلك عندما قام بتجميع كلماته لعمل جمل قصيرة؟.....

مثال: أريد أن أذهب الجمعية, أريد أن أشرب بعضا من الماء

التاريخ المرضي للطفل:

هل عانى طفلك من أية مشاكل بالسمع؟.....

- فقدان السمع: نعم – لا
- حالات عدوى متكررة في الأذن: نعم – لا
- اخرى (حدد ذلك):.....

Appendix H1. Screening Questionnaire for DS Parents in English

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Title of the study: the development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals.

Screening questionnaire for Down syndrome parents

General information about the participant

Birth date:

What is type of the Down syndrome?

What is the first language of the participant? Arabic - English

Perinatal Factors

Was your child born full term? Yes – No

How much did your child weigh when they were born?

Health Conditions:

- Did your child have any health problems at birth or in childhood? Yes - No
- Does your child have any current health problems? Yes – No
- If yes, specify? Which health condition from the below list

Cardiovascular – Respiratory- Gastrointestinal- Hematological problems-Neurological problems-Skeletal problems

Vision/Hearing

- Does your child have hearing difficulties? Yes – No
- If yes, when did you first become aware of this?
- Does s/he have frequent ear infections?

- Does your child wear a hearing aid? Yes - No
- Has your child ever had grommets? Yes - No
- Does your child have any problems with their eyesight? Yes - No
- Does your child wear glasses? Yes – No

Appendix H2. Screening Questionnaire for DS Parents in Arabic

جامعة نيوكاسل
كلية التربية والتواصل وعلوم اللغة
مبنى كينج جورج
شارع فيكتوريا -نيوكاسل NE17RU

عنوان الدراسة: تطور الذاكرة قصيرة المدى، والمفردات، والوعي الصوتي لدى أفراد متلازمة الداون والأطفال الطبيعيين الناطقين باللغة العربية في دولة الكويت

استبيان لأولياء أمور أفراد متلازمة الداون

بيانات عامة عن الطفل:

- تاريخ الميلاد:
- ما هي لغة الطفل الأولى؟ عربية – انجليزية
- ما نوع متلازمة الداون؟ تريسومي ٢١-- موزاييك

تاريخ الحمل والولادة:

- كم كان وزن ابنك/ابنتك عند ولادته؟
- هل ابنك/ابنتك كانت لديه أي مشاكل صحية بعد ولادته أو خلال فترة طفولته؟ نعم – لا
  اذا كانت الاجابة بنعم. فما هي المشاكل؟
- هل لدى ابنك/ابنتك أي مشاكل صحية حاليه؟

التاريخ المرضي للطفل:

هل عانى طفلك من أية مشاكل بالسمع؟.....

- فقدان السمع: نعم – لا
- حالات عدوى متكررة في الأذن: نعم – لا

هل عانى طفلك من أي مشاكل بالنظر؟.....

- هل يرتدي نظارة؟ نعم لا
- اخرى (حدد ذلك):.....

Appendix I. Parents' Debriefing Sheet

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Dear parents of (name of child),

I am writing to thank you for consenting for your child's participation in the study of "**the development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals"** and would like to inform you that your son/daughter participation was successfully completed in (minutes) on: (date). at (time).

Your son/daughter participation and information about him/her will be securely stored, with only a number attached to each participant. Therefore, it will not be possible to link any set of data with any individual. Personal data will be stored for 5 years. Anonymous data will be retained for future research and destroyed when no longer needed. It is my duty to inform you that data collection period for this study is 6 months long and to be completed in May 2017. For this reason, outcome results will not be available before end of year 2017. Finally, a newsletter with outcome results will be disseminated to schools and participating families on January 2018.

If you have any questions or enquiries about this research project, please do not to hesitate to contact the researcher: Sarah Al Saeed, at

S.M-F-KH-Alsaeed2@newcastle.ac.uk or via phone at [redacted]

Sarah Al Saeed

Appendix J. Participants' Debriefing Sheet

Faculty of Humanities and Language Sciences
School of Education, Communication and Language Sciences
KGVI King George VI Building
Newcastle University
Queen Victoria Rd
Newcastle upon Tyne
NE1 7RU

Dear participant,

I would love to thank you for your participation in my study "**The development of vocabulary, phonological awareness, and working memory in Down syndrome and typically developing Kuwaiti individuals**".

Again, we thank you for your participation, and patience in this study. We greatly appreciate your cooperation. If you have any questions regarding this study, please feel free to ask the researcher at this time, or call [redacted] the researcher will respond to your call.

If you feel psychologically distressed that you participated in this study, don't hesitate to call Dr Carolyn Letts, senior lecturer at school of education, communication, and language sciences Newcastle University (+44 (0) 191 208 7390)

Thanks again for your participation.

Best regards

Appendix K. Rhyme Judgment Task

Practice items:

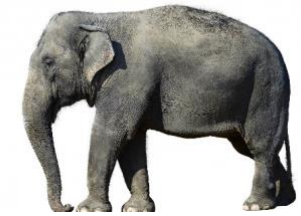
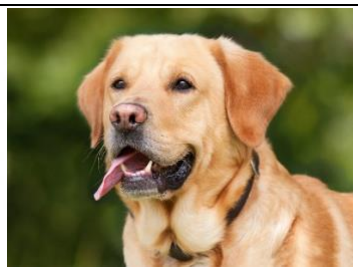
Target	options
عَسَلُ ʕasalu	كَلَبُ – فِيلُ fi:lu - kalbu
مَاءُ ma:ʔu:	هَاتِفُ - رِداءُ Ridaʔu: - hati:fu

Test items:

Target	Options
سَرِيرْ Sari:r	فَقِيرْ- نَظِيف naðˤi:f – faqi:r
غَنَمْ ɣanam	فَهَد – لَحَمْ Laħam- fahad
كَبِيرْ Kabi:r	يَطِيرْ - كِتَابْ Kita:b- jatˤi:r
نَامَ Na:ma	قَازَ – صَامَ sˤa:ma – fa:za
نَظِيفُ naði:fu	رَصِيفُ – شَمْسُ ʃamsu - rasˤi:fu
نُقودْ Nuqu:d	لصوص – قرود Quru:d – lusˤu:sˤ
يَطْبُخْ jatˤbox	يَنْفُخُ – يَلْعَبْ jalʕab - janfox
سُورْ Su:r	بَصَلْ – نُورْ Nu:r - basˤal
حُوتُ ħu:tu	تُوتُ – وَلَدُ Waladu – tu:tu
صَعَدَ sˤaʕada	أكل – سَجَدَ saʒada- ʔakala
جَمَلُ ʒamalu	جَبَلُ – أرْنَبُ ʔarnabu - ʒabalu
شَجَرْ ʃaʒar	قَلَمْ – حَجَرْ qalam -ħaʒar

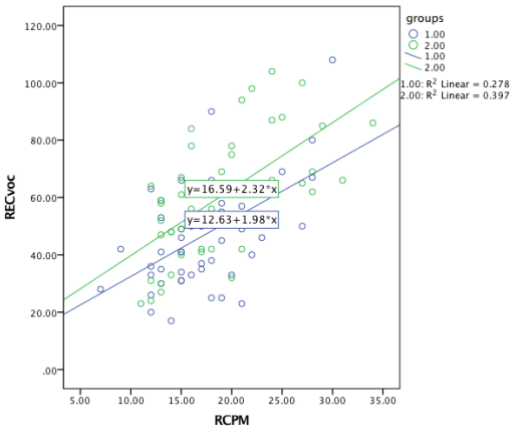
Examples of picture stimuli:

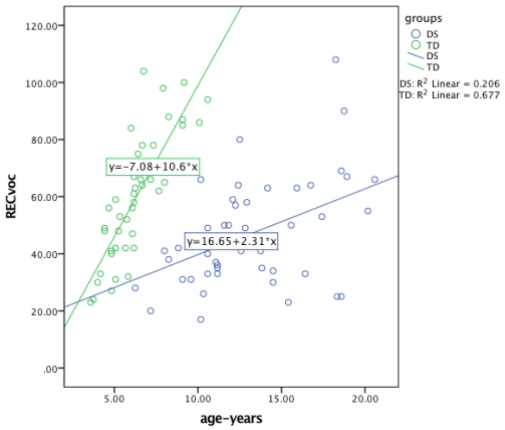
Target	Options
عَسَلُ ʕasalu مَاءُ ma:ʔu:	كَلَبُ – فِيلُ fi:lu - kalbu هَاتِفُ – رِداءُ Ridaʔu: - hati:fu

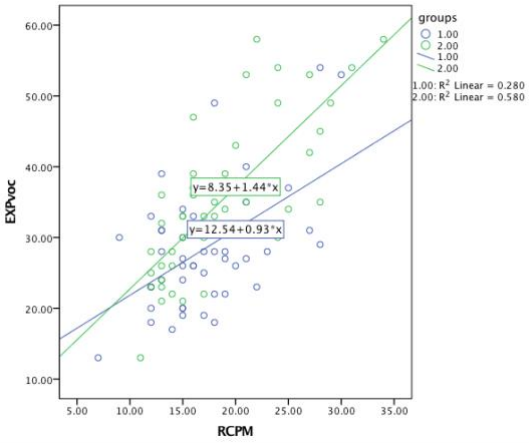




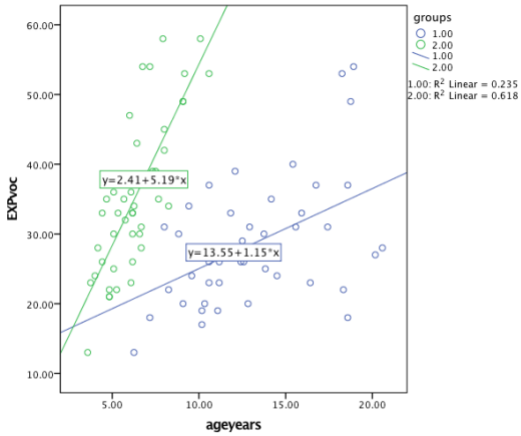

Appendix L. Scatterplot for the Correlation between CA/RCPM and Language Measures

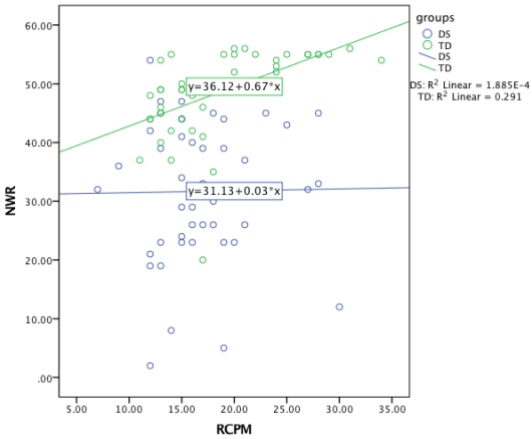
Group 1 = Down syndrome group, Group 2 = typically developing group
DS = Down syndrome, TD = typically developing
NWR = non-word repetition, RCPM = Raven's coloured progressive matrices
Age years = chronological age

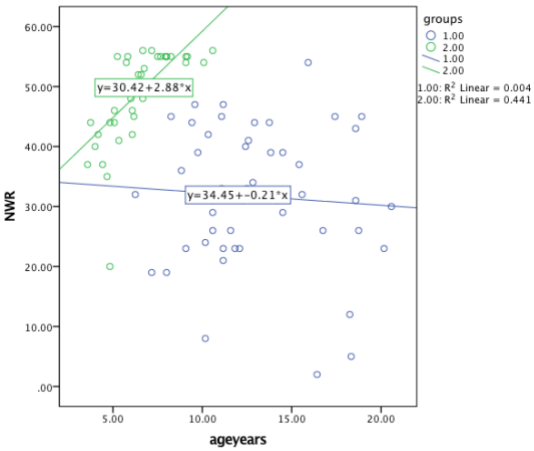

groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.278
2.00: R² Linear = 0.397
y=16.59+2.32*x
y=12.63+1.98*x
RECvoc
RCPM

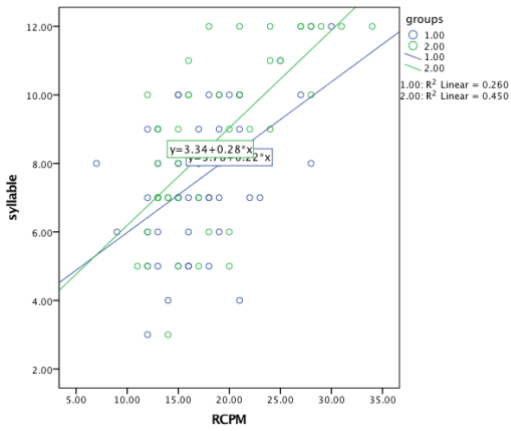

groups
DS
TD
DS
TD
DS: R² Linear = 0.206
TD: R² Linear = 0.677
y=-7.08+10.6*x
y=16.65+2.31*x
RECvoc
age-years

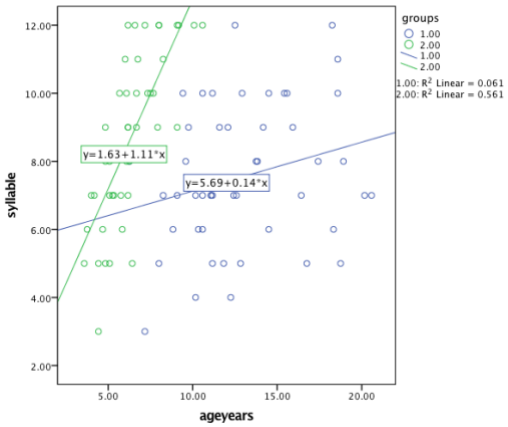

groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.280
2.00: R² Linear = 0.580
y=8.35+1.44*x
y=12.54+0.93*x
EXPvoc
RCPM

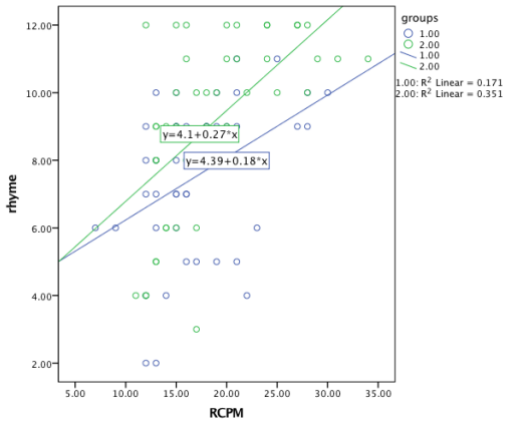

groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.235
2.00: R² Linear = 0.618
y=2.41+5.19*x
y=13.55+1.15*x
EXPvoc
ageyears

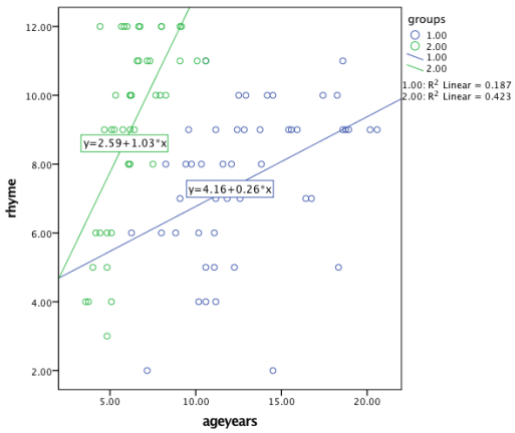

groups
DS
TD
DS
TD
DS: R² Linear = 1.885E-4
TD: R² Linear = 0.291
y=36.12+0.67*x
y=31.13+0.03*x
NWR
RCPM

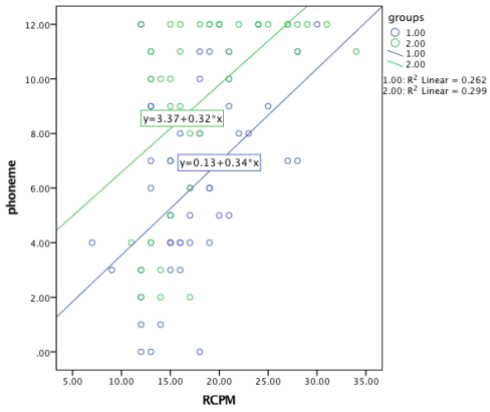

groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.004
2.00: R² Linear = 0.441
y=30.42+2.88*x
y=34.45+-0.21*x
NWR
ageyears

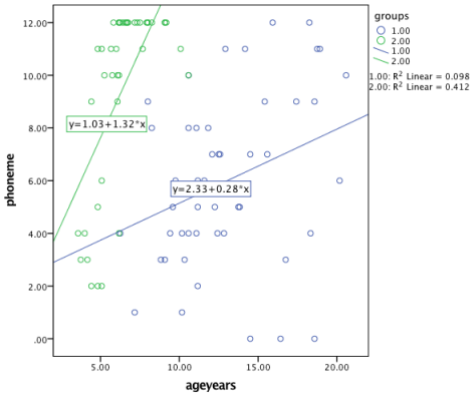

groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.260
2.00: R² Linear = 0.450
y=3.34+0.28*x
syllable
RCPM


groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.061
2.00: R² Linear = 0.561
y=1.63+1.11*x
y=5.69+0.14*x
syllable
ageyears


groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.171
2.00: R² Linear = 0.351
y=4.1+0.27*x
y=4.39+0.18*x
rhyme
RCPM


groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.187
2.00: R² Linear = 0.423
y=2.59+1.03*x
y=4.16+0.26*x
rhyme
ageyears


groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.262
2.00: R² Linear = 0.299
y=3.37+0.32*x
y=0.13+0.34*x
phoneme
RCPM


groups
1.00
2.00
1.00
2.00
1.00: R² Linear = 0.098
2.00: R² Linear = 0.412
y=1.03+1.32*x
y=2.33+0.28*x
phoneme
ageyears

Appendix M. Pearson Correlations (r) between NWR and Articulation Screening among DS Group

Pearson correlations	NWR
Articulation	-.51
sig.	.158

n = 9