# Early Literacy Development in Mandarin-Speaking Children: The Role of Phonological Awareness, Rapid Naming and Spoken Language Skills

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# Abstract

In Taiwan, many children grow up in a bilingual environment, namely Mandarin and Taiwanese. They learn Zhuyin Fuhao – a semi-syllabic transparent orthography – at the beginning of the first grade before learning traditional Chinese characters. However little is known about the acquisition of literacy in this complex context, especially about the role of phonological awareness (PA), rapid automatized naming (RAN) and other spoken language skills. This longitudinal study is the first systematic attempt to investigate the trajectory of literacy acquisition in Mandarin-speaking children and the impact of instruction in both Zhuyin Fuhao and character.

The study was carried out in Taipei. A sample of 92 children were tested in their first grade (mean age of 6;7), and then followed up a year later in their second grade. A comprehensive PA battery was designed to measure implicit and explicit PA of syllables, onset-rime, phonemes and tones. RAN, spoken language skills and literacy skills, including reading accuracy and comprehension in Zhuyin Fuhao and character were also measured, alongside non-verbal intelligence and children's home languages.

It was found that the role of PA in early literacy development of Mandarin-speaking children in Taiwan varies as a function of the orthography system. PA was closely linked to ZF-related tasks and reading comprehension, but not character reading where it had no predictive role. On the other hand, graphological RAN was found to be a good predictor of reading performance in both scripts, both concurrently and longitudinally. Additionally, non-graphological RAN had a role in predicting lexical-related literacy skills. Lastly, all spoken language skills, except semantic fluency, were significantly associated with reading comprehension indicating that oral language competence contributes major variances in reading comprehension. Moreover, vocabulary and auditory memory were associated longitudinally with many CH-related tasks. However, the variance of ZF word reading or spelling could not be

explained by any spoken language skills. Investigation of children with atypical development revealed that children with reading difficulties performed less well on RAN and PA tasks while children with speech difficulty performed less well on sub-syllabic PA, Zhuyin Fuhao literacy tasks and character recognition, but no differently to their peers on RAN and character reading accuracy and character knowledge in radical form or position. The theoretical, methodological and practical implications of these findings are discussed.

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Lastly, I would like to dedicate the thesis to my eighty-two-year-old mother, who first taught me rhymes and poems in Taiwanese and/or Japanese: I still remember and treasure them as you do.

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# List of Abbreviations

| Symbols | Full Name |
|---|---|
| **C** | consonant |
| **CH** | Chinese character |
| **CH_R** | Character Recognition |
| **ExPA** | explicit phonological awareness |
| **ExPA_O**nset | explicit phonological awareness on the onset level |
| **ExPA_P**honeme | explicit phonological awareness on the phoneme level |
| **ExPA_R**ime | explicit phonological awareness on the rime level |
| **ExPA_S**yllable | explicit phonological awareness on the syllable level |
| **ExPA_T**one | explicit phonological awareness on the tone level |
| **FAC1** | Phonological awareness factor I |
| **FAC2** | Phonological awareness factor II |
| **FAC3** | Phonological awareness factor III |
| **Form** | Form subtask of the Character legality judgement |
| **ImPA** | implicit phonological awareness |
| **ImPA_O**nset | implicit phonological awareness on the onset level |
| **ImPA_P**honeme | implicit phonological awareness on the phoneme level |
| **ImPA_R**ime | implicit phonological awareness on the rime level |
| **ImPA_S**yllable | implicit phonological awareness on the syllable level |
| **ImPA_T**one | implicit phonological awareness on the tone level |
| **LK** | Letter knowledge |
| **M** | medial |
| **Mem_span** | Pseudo word memory span |
| **PA** | Phonological awareness |
| **PhAB** | Phonological Assessment Battery |
| **Place** | Placement subtask of the Character legality judgement |
| **PPVT** | Peabody Picture Vocabulary Test |
| **RA_CH** | CH Reading Accuracy |
| **RA_ZF** | ZF Reading Accuracy |
| **RAN** | Rapid automatized naming |
| **Read_compr** | Reading comprehension task (ZF plus CH) |
| **RT** | Reaction time |

| Symbols | Full Name |
|---|---|
| **SD** | Speech difficulty group |
| **TONI** | Test of Nonverbal Intelligence |
| **V** | vowel |
| **Y1** | Year 1 |
| **Y1-Po** | Year 1_after the intensive ZF course |
| **Y1-Pr** | Year 1_beginning of the intensive ZF course |
| **Y2** | Year 2 |
| **ZF** | Zhuyin Fuhao |
| **ZF_LK** | ZF letter knowledge |

# Introduction

Chinese orthography is used by 1.3 billion people and is therefore one of the most popular orthographies in the world. It provides a unified writing system across different regions where several distinct languages are spoken, for example Mandarin, Taiwanese, Cantonese, Shanghainese, and many other tonal-syllabic languages spoken across Asian countries (Li, 2006). Research undertaken by cognitive psychologists and educators in these regions has broadened the knowledge of literacy acquisition in Chinese (Chan, Hu & Wan, 2005; Hanley, 2005; Ho & Bryant, 1997).

Even though there has been more and more research into how children learn to read and write Chinese, most of it has been carried out in isolation from the spoken language background; for example, most children live in a multi-linguistic environment. The educational context has also not been taken into account; for example, in Taiwan, a supplemental phonetic and semi-alphabetic writing system (Zhuyin Fuhao, ZF) has been adopted in all textbooks of the first four grades in primary schools. As a result, little is known about the combined effects of these contextual factors on literacy acquisition in Chinese. In addition, even less is known about the literacy acquisition of those children who perform less well than typically developing groups on reading accuracy, reading comprehension or speech output skills.

One area that has been studied widely in young children is phonological awareness (PA). This has been found to be a strong predictor of reading acquisition across languages (Ziegler & Goswami, 2005). PA is the ability to be aware of or manipulate the sound structure of an utterance. For example, a child who can produce rhymes [bat – mat – pat; big – pig – fig], or who recognizes that the words [big] and [bat] share the [b] sound at the beginning, shows phonological awareness at the rhyme or onset level. It has been argued that there is a reciprocal relationship between PA and literacy: having good PA helps you acquire reading and writing skills, but the acquisition of reading and writing also develops PA skills further (Ziegler & Goswami, 2005). According to the psycholinguistic model proposed by Stackhouse and Wells (1997), PA assists the acquisition of reading and spelling because phonologically aware children can understand better how written language reflects speech sounds and are in a better position to 'crack the code' of an alphabetic language. Learning to read and spell offers clues to the sound structure of spoken language, thus boosting phonological awareness. While most studies in PA and literacy have focused on the alphabetic languages, competence in phonological awareness has also been shown to predict success in learning to read in Mandarin-speaking children (Ho, 2003; Huang & Hanley, 1997; Hu & Catts, 1998).

However, the relationship between PA and literacy is still uncertain in Mandarin. It is not known what specific aspects of PA awareness are most closely linked with literacy acquisition. For example, it is not clear if the awareness of syllables, rhymes, phonemes or tones is most important for literacy development. Further, is identification of those units sufficient, or it is the ability to *segment and produce* them that guarantees successful literacy development? We also do not know exactly what aspects of PA are a *prerequisite* of successful literacy acquisition, and what aspects are its *consequence*. A comprehensive battery of PA measurements is necessary to determine how various linguistic levels of Mandarin PA in both input and output modes would develop during the first year of formal education and how PA development relates to children’s learning of written language.

To date, knowledge about the relationships between many spoken languages (tonal-syllabic languages, such as Cantonese) and the Chinese written system is very tentative (McBride-Chang & Ho, 2000). Further examination of the connection between spoken language skills and PA will increase our understanding of the role of PA in Mandarin/Chinese language development and of how the written language develops from spoken skills.

Apart from PA, some other integrating skills have proven to be effective predictors of future reading performance, such as rapid automatized naming (RAN) (Fricke, Szczerbinski, Stackhouse & Fox-Boyer, 2008). RAN tasks measure speed of naming familiar visual stimuli (digits, letters, patches of colour, or pictures of common objects) displayed repeatedly on a single page. Several studies (e.g. Allor, 2002) have shown that RAN correlates with both word-reading accuracy and passage-reading fluency at the early stage of literacy acquisition. It seems that the processes involved in RAN (such as visual analysis of an object, efficient name retrieval from long-term memory, and articulation of those names) are important for efficient reading. Although previous studies showed that RAN of digits and objects was highly related to Chinese literacy competence (Tzeng, 2006), it remains unclear which particular aspects of RAN performance are most closely related to early literacy acquisition in young Mandarin-speaking children.

Therefore, the current study focuses on describing the interrelation between spoken language skills, PA, RAN and reading performance in Mandarin/Chinese language acquisition. The main aims of this study are to investigate the following:

1. Phonological awareness development and literacy acquisition progress in children speaking two different languages (Mandarin and Taiwanese) and learning two writing systems: ZF and traditional Chinese.
2. The development of different aspects of phonological awareness during the early years of schooling and how it relates to concurrent spoken language skills.
3. Whether phonological awareness and rapid automatized naming, if measured early in grade 1, can predict the child's progress in acquiring literacy one year later.
4. Whether there is a reciprocal relationship between phonological awareness and literacy acquisition in Mandarin-speaking children, and, if so, how the interaction works.
5. Whether there is any significant difference in literacy, PA, RAN and spoken language between children who perform less well in ZF/ Chinese reading or in speech output than typically developing children.

In this study, children aged 6-7 who were attending a mainstream school in Taiwan were invited to take part. Only children with significant and observed special needs were excluded (e.g. Down's syndrome, autism). This is the age at which children in Taiwan start their formal education by receiving a ten-week intense ZF course before learning Chinese. A one-year longitudinal design was adopted to capture the developmental changes at the critical stage and identify relationships that are likely to be causal. The development of Mandarin phonological awareness in the first two years of schooling in Taipei, Taiwan, was examined in relation to spoken language skills and literacy performance. Children's spoken language skills, including speech intelligibility, receptive vocabulary, semantic fluency and auditory comprehension and memory, were also assessed. The expected predictors of future performance on reading, such as RAN and letter knowledge, were measured at the beginning of schooling. Furthermore, background variables, including gender, social economic status, family languages (Mandarin dominant or not), and control variables, e.g. non-verbal IQ, were also examined. Knowing which of the above variables interact with each other and reflect the process of literacy acquisition in Mandarin-speaking children, and how they do so, would be helpful not only in understanding if knowing two languages helps or hinders their development of phonological awareness, but also in identifying those children who might be at high risk of having difficulty in learning to read at the beginning of their schooling.

**Thesis Outline**

The thesis comprises seven chapters in addition to the introduction. Chapter 1 reviews the relevant literature; firstly it focuses on introducing the spoken and written languages used in Taiwan and reviews the previous studies that have explored Chinese literacy acquisition. The review of literature then covers predictive variables of reading, including phonological awareness and rapid automatized naming. The role of oral spoken language skills and the components of structuring a local model of reading development were then reviewed. Lastly, research questions derived from the review are listed. While the chapter refers to studies of other languages, particular attention is paid to findings on the Mandarin language and Chinese orthography.

Chapter 2 presents the methodology of the study, and describes the design, the participants, the materials used, including those specifically designed for the study, and the data collection procedure. The results are presented in the next four chapters (Chapters 3 to 6). Chapter 3 focuses on the development of PA during the first year of schooling, and how PA performance correlates with spoken language skills. Chapter 4 deals with the development of literacy skills and RAN as well as the interrelations between different aspects of literacy and RAN. Chapter 5 describes how literacy and PA are predicted by other measures, both longitudinally and concurrently. The main analyses presented in this chapter are correlation and multiple regression analysis. Chapter 6 describes and compares the literacy, PA, RAN and spoken language profiles of those children singled out because of their poor reading accuracy, comprehension, or speech output skills with those of typically developing children.

The last chapter, Chapter 7, presents some general discussion of the study and concludes the study with the theoretical, methodological and practical applications of the findings.

# Chapter 1 Literature Review

This chapter provides background information on languages, orthography and literacy education and acquisition. In the first section, the major languages used in Taiwan will be introduced, followed by orthography systems used in Taiwan, such as traditional Chinese characters and Zhuyin Fuhao, together with how these are taught to school entrants. Next, literature about the role of phonological awareness in the context of reading acquisition, particularly in Mandarin-speaking children, will be reviewed; followed by the introduction and evidence of rapid automatized naming as another powerful predictor of learning to read. The research questions of the study will conclude this chapter.

## 1.1 Languages, Orthography and Literacy Acquisition in Taiwan

### 1.1.1 Spoken Languages

In Taiwan, Mandarin is the only official language. The vast majority of people are able to speak Mandarin. However, Mandarin is not the most popular first language. Many people speak Taiwanese or other dialects as a first language and do not learn Mandarin formally until preschool or primary school education (Chen, 1999; Roger, 2005). For example, up to seventy per cent of the population in Taiwan consists of southern Min people who speak Taiwanese as their first language and Mandarin as their second (Liao, 2008). In this section, Mandarin phonology will be introduced first, followed by the bilingual environment in Taiwan and the characteristics of Taiwan Mandarin.

#### 1.1.1.1 Mandarin Phonology

Mandarin is a tonal language largely based on the Beijing dialect which has a highly constrained sound structure (Zhu, 2006). That is, there are a very limited number of elements that are allowed to be present in certain parts of a syllable. Further analysis of its sound structure shows the only syllable template in Mandarin is: (C)(V)V(C) T, where tone, consonants and vowels are abbreviated as C, V and T. Segments in the parentheses indicate a non-compulsory part in a Mandarin syllable.

Two approaches to analysing this structure have been proposed. The sound structure of a syllable in Mandarin has been traditionally segmented into initial, final segment and tone since ancient times in China (Ching & Tien, 1995; Chen, 1999; Hu, 2008; Roger, 2005). *Initial* (or onset) in Mandarin is normally a consonant and not a compulsory part. That is, legal syllables in Mandarin might contain no consonant onset but one rhyme segment. *Final* in Mandarin is a combination of *medial* and *syllabic ending* (Chen, 1999; Hu, 2008; Roger, 2005). The *medial* would be one of only three vowels, /i/, /u/ and /y/. A *syllabic ending* can be a vowel or diphthong plus a final nasal consonant (either /n/ or /ŋ/). More specifically, the single vowel or diphthong in a syllabic ending is the only compulsory part for a Mandarin syllable (Ching & Tien, 1995). Figure 1.1 presents the suprasegmental and detailed segmental components in the syllable sound structure in Mandarin according to this perspective. This approach highlights the importance of the tonal element and the constrained possibility of the medial and coda. It also reflects the conventional segmentation of a legal syllable in Mandarin: that is, the only compulsory part of a syllable serves as a nucleus connecting other optional elements such as coda, medial and onset.

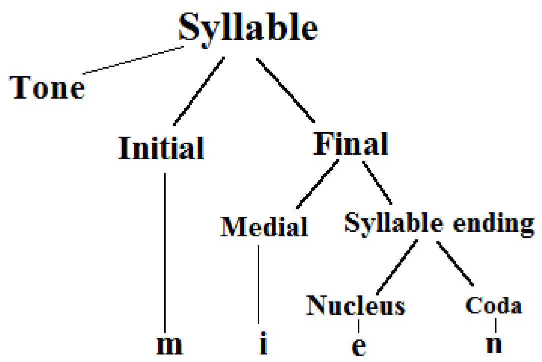


**Figure 1.1 The sound structure of a syllable in Mandarin (based on Hu, 2008, p.47)**

**Various Linguistic Levels within a Syllable in Mandarin**

According to this sound structure, there could be at least five linguistic levels included within a syllable: syllable, onset, rime, tone and phoneme.

The typical syllable itself may include at least onset, rime and tone. The onset level in Mandarin includes only one consonant and therefore it may be counted as an onset (phoneme) level as well. The rime level includes a single vowel, a diphthong, or the combination of these two elements, with or without a final nasal consonant. This flexibility allows this level to be a potentially larger segment than the onset and phoneme level where only a phoneme segment is allowed. Regarding the tone level, it cannot be separated with any legal syllable for it is a suprasegmental element. The phoneme level here may be one of three medial single vowels or two final nasal consonants. In contrast with onset phoneme, the phoneme level is not stressed in intensity or duration when compared to the compulsory nucleus part.

The other approach to analysing the sound structure of a syllable in Mandarin, proposed by Zhu (2006), follows the structure of alphabetic languages such as English, and is illustrated in Figure 1.2. Compared with the sound structure in Figure 1.1, this structure does not include the tonal part, and ignores the medial part by clustering vowels together as a nucleus. According to this perspective, up to eleven diphthongs and four triphthongs can be found within a syllable in Mandarin. However, it does not distinguish the non-compulsory medial vowels from the nucleus which should be an obligatory component.

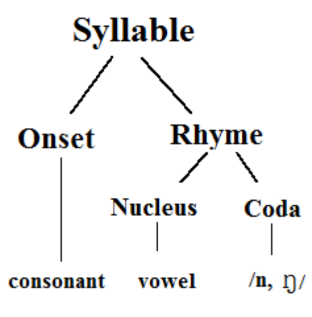


**Figure 1.2 The sound structure of a syllable (based on Zhu, 2006, p.82)**

Tone variation in Mandarin provides different semantic information. Four tone categories in spoken Chinese are widely recognized (Sanders, 2008). They are high level (tone 1), mid to high rising (tone 2), mid to low to mid dipping (tone 3) and high to low falling (tone 4) in fundamental frequency level (Lee & Zee, 2003). The pitch contours of these four tones are illustrated in Figure 1.3.

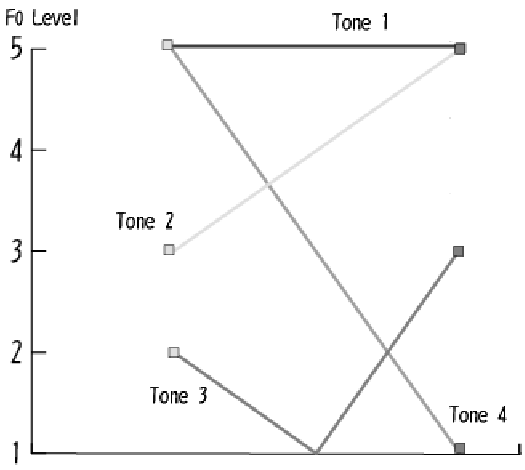


**Figure 1.3 $F_0$ levels of four tones in Mandarin (based on Ching & Tien, 1995, p.69)**

Regardless of the variations of the four tones, around four hundred syllables are used in Mandarin(Lee & Zee, 2003; Chen, 1999). When the four tones are taken into consideration, Mandarin includes 1330 syllables (Ching & Tien, 1995; Zhu, 2006).

**Consonants and Vowels in Mandarin**

There is no agreement on the exact number of consonants in Mandarin. The number ranges from twenty-two to twenty-four (Ching & Tien, 1995; Lee & Zee, 2003; Zhu, 2006). Nevertheless, twenty-two consonants are commonly recognized. The other two approximant consonants (/w/ and /j/) will be categorised as a shortened form of two vowels (/u/ and /i/) in this study(Ching & Tien, 1995).

In general, a single consonant is sufficient for an onset; that is, no cluster onset exists in Mandarin. Additionally, only two consonants (/n/ and /ŋ/) can be final consonants (coda). The first one (/n/) may serve as onset as well. Table 1.1 presents these twenty-two onset consonants categorised by their placement and manner.

**Table 1.1 Consonants in Mandarin (based on Ching & Tien, 1995; Zhu, 2006; Lee & Zee, 2003)**

| | Bilabial | Labiodental | Alveolar | Post-alveolar | Palatal | Velar |
|---|---|---|---|---|---|---|
| Plosive | p pʰ | | t tʰ | | | k kʰ |
| Affricate | | | ts tsʰ | tʃ̺ tʃ̺ʰ | tɕ tɕʰ | |
| Fricative | | f | s | ʃ̺ | ɕ | x |
| Approximant | | | | ɹ̺ | | |
| Lateral approximant | | | l | | | |
| Nasal | m | | n | | | ŋ |

A single vowel in Mandarin is the most basic element, since diphthongs and/or triphthongs are the combination of two or three of them. As with consonants, there is no agreement on the exact number of single vowels in Mandarin according to various regions. The number of single vowels ranges from eight to twelve (Wang & Jaeger, 2003; Zhu, 2006). Ching and Tien (1995) listed six basic single vowels, nine diphthongs and four triphthongs. Zhu (2006) categorized vowels into three groups, with nine single vowels, nine diphthongs and four triphthongs.

Since the study focuses on Mandarin-speaking children in Taiwan, the vowel system used in Taiwan is presented as the following (Wang and Jaeger, 2003):

/i/ → [i, ɨ, j]
/y/ → [y, ɥ]
/u/ → [u, w]
/ə/ → [e, ɛ, ə, ɔ, o, ɤ]
/a/ → [a, ɑ]

According to this vowel system, five major vowels would manifest differently in various phonetic contexts.

Diphthongs in Mandarin are uttered by gliding one single vowel towards the other (Ching & Tien, 1995; Zhu, 2006). Ching and Tien (1995) listed nine diphthongs including four offglides (/ai/, /ei/, /ao/, /ou/) and five onglides (/ia/, /ie/, /ua/, /uo/, /üɛ/). The difference between the two groups is the difference between two elements in their duration and the direction of intensity. One element is longer and has more intensity. For the offglides, the first vowel would be pronounced longer and louder, and vice versa for the onglides. Similarly, but using different symbols to those of the International Phonetic Alphabet, Zhu (2006) agreed that there are nine diphthongs in Mandarin (offglides: /ae/, /ei/, /au/, /ou/; onglides: /ia/, /iɛ/, /uᴀ/, /uo/, /yɛ/). On the other hand, Lee and Zee (2003) analysed the narrative data from a typical young adult in Beijing, and listed eleven diphthongs in total with two extra onglides: /uə/ and /iu/.

Nevertheless, according to the traditional sound structure of a syllable in Mandarin, the four onglides diphthongs, including both a medial and a syllable ending, can be further segmented into two single vowels, and therefore it is not very proper to apply the definition of diphthongs in a strict sense. Only those four offglide diphthongs where two vowels both belong to a syllable ending and cannot be separated should be counted as diphthongs, for they do not start with the medial vowel in Mandarin, namely /i/, /u/ or /y/. The same principle could be applied to the four so-called triphthongs in Mandarin (/iao/, /iou/, /uae/ and /uai/) based on the simplified sound structure in fig. 1.2 (Ching & Tien, 1995; Zhu, 2006; Lee & Zee, 2003). They may be further segmented into medial and diphthong syllable endings. Therefore, from this viewpoint, there are twenty-two consonants and nine vowels (five single vowels and four diphthongs) in Mandarin. In other words, there are thirty-one phonemes in Mandarin to be used and combined into four hundred and twenty syllables.

To conclude, there is a disagreement on the advantages of the two sound structures in Mandarin. In this study, the traditional sound structure (see fig. 1.1) was applied, because it matches more closely the way of spelling with Zhuyin Fuhao (ZF) (see section 1.1.2.2), which is a phonetic writing system used in Taiwan.

### 1.1.1.2 Bilingual Environment in Taiwan

The bilingual environment in Taiwan has been shaped by its historically peculiar situation in the last few centuries. Taiwan was part of the Fujianprovince of China from 1683, where the major part of the population spoke the Min dialect which was the predecessor of Taiwanese.

Taiwanese is a dialect of Hokkien Min which is a mother tongue of the south-eastern area of China. Taiwanese and Mandarin are not mutually intelligible despite a few phonological similarities between them (Luo, 2005). Figure 1.4 presents the percentages of similarity between Taiwanese and Mandarin in tones, consonants and vowels.

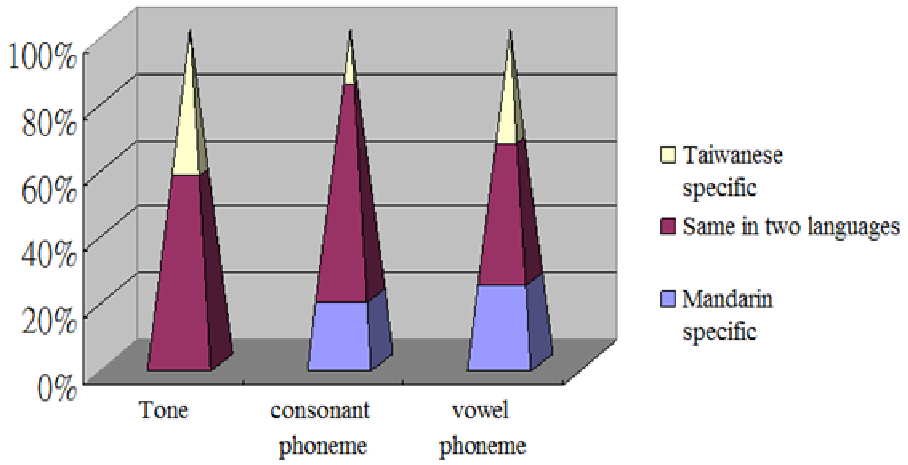


**Figure1.4 The percentages of similarity between Taiwanese and Mandarin (based on Luo, 2005)**

Taiwan was ceded to Japan in 1895 by the Qing government of China and was governed by Japan until 1945. Japanese was promoted as the only official language in Taiwan under Japan’s governance. Students in school were forbidden to use other languages. It was found that up to 71 per cent of the population in Taiwan were proficient in Japanese by 1944 (Chen, 1999). When Taiwan was returned to China in 1945, Mandarin as a new official language was promoted strongly by the new government at that time. Since then Mandarin has been the mainstream language used on official occasions and in schools. School-age children speaking dialects at school would be penalised. This rule was not formally abolished by the Ministry of Education until 1983 (Chen, 1999). A large number of people, regardless of their ages, were again encouraged and/or forced to acquire Mandarin as their second (or third) language at the same time. The great majority of the population who were Min native speakers had to acquire Mandarin in a very short period of time. This was thought to be one of the reasons for language assimilation between Mandarin and Taiwanese (Fon, Hung, Huang & Hsu, 2011). In addition, it is now established that assimilation between these two languages is on-going (Hsu &Tse, 2007; Her, 2009).

Currently Taiwanese is still the most popular language, spoken by up to 70 per cent of the population in Taiwan (Liao, 2008). Taiwanese is particularly used in informal situations. Z. Qiu and van den Berg (1994, cited in Chen, 1999) found that sixty per cent of people would use Taiwanese to communicate in markets whereas only twenty-two per cent of people use Mandarin. On the other hand, in workplaces, both languages are used to a similar extent, with 43 per cent speaking Taiwanese and 42 per cent Mandarin. For a Taiwanese native speaker, pronouncing some phonemes in Mandarin may be very challenging, particularly those that do not exist in Taiwanese, such as post-alveolar and labiodental consonants (Luo, 2006).

The phonological impact of Taiwanese on Mandarin can be observed in consonants, vowels and tones (Kubler & Ho, 1984; Sanders, 2008; Wan & Jaeger, 2003). The label ‘Taiwan Mandarin’ was used to distinguish it from those forms of Mandarin used or influenced by speakers of other dialects, such as Beijing Mandarin. Furthermore, Taiwan Mandarin particularly refers to the standard Mandarin spoken by bilingual people alongside their parents’ first language. Taiwan Mandarin is the preferred language for them (Hsu, 2007). In other words, Taiwan Mandarin has become a particular Mandarin dialect. Its deviation from the standard Mandarin depends on speakers’ social and linguistic factors (Kubler & Ho, 1984).

The following are the most important features of Taiwan Mandarin compared to Beijing Mandarin:

*Initial*

The post-alveolar consonants (/tʃ̺/, / tʃ̺ʰ/, /ʃ̺/ and /ɹ̺/) are merged with their corresponding alveolar consonants (/ts /, / tsʰ/, / s / and / l/). In addition, labiodental /f/ is mostly replaced by /x/(Kubler & Ho, 1984).

*Nucleus*

When preceded by a labial initial (/p/, /pʰ/, /m/, /f/) or medial /u/, a syllable ending with /ə/ would become [o], such as /əŋ/→ [oŋ](Kubler & Ho, 1984).

*Syllable final*

Syllable final nasal mergers were found in Taiwan Mandarin, /in/→[iŋ], /iŋ/→ [in] and /əŋ/→[ən], which may be attributed to innovations or negative Min transfer (Fon et al., 2011).

*Tone*

The difference of tone contour between tone 2 and tone 3 is decreased in Taiwan Mandarin. That is, the contour of tone 2 is changed from a rising contour to a dipping one, which used to be the main pitch contour of tone 3 (Sanders, 2008).

To conclude, because Taiwan Mandarin has assimilated some phonological features from Taiwanese, school entrants who grow up in such a bilingual environment would inevitably face a challenge in acquiring standard Mandarin from school age. In particular, Chinese characters are annotated by a phonetic system, ZF, that is based on Beijing Mandarin rather than Taiwan Mandarin. The next section will introduce these two orthography systems in order to elaborate the linguistic context and/or needs of school entrants.

## 1.1.2 Orthography Systems in Taiwan

Chinese characters are used in many countries, such as Taiwan, Mainland China and Singapore, as a written form of many languages or dialects which are not always mutually intelligible. Even in Japan and Korea, people are using Chinese characters as part of their writing systems (Rogers, 2005). In Taiwan, the traditional Chinese characters which have been used for thousands of years are the official orthography of Mandarin. Figure 1.5 shows a layout example of a literacy textbook for Grade 1 students where ZF letters are presented on the right. As it is shown here, in Chinese, the boundaries between words and phrases are unmarked phonologically as well as graphically. The translation of the text (Fig. 1.5) is: “Lesson One. I get up. The sky has become lighter. I get up. (And I see) the sun is getting up.”


**Figure 1.5 An example of a literacy textbook**

In order to annotate the pronunciation of characters, a phonetic orthography system based on the Beijing dialect, Zhuyin Fuhao (ZF, ‘sound annotating symbols’), was promulgated in 1918 by the Ministry of Education of the Republic of China, which is now the official name of the government in Taiwan. This idea of using ZF for exclusively representing the pronunciation of the official language, Mandarin, was realized and adopted to facilitate learning the pronunciation of characters in 1930 (Chen, 1999). Currently, these two orthography systems are used in parallel in the textbooks for the first four years of primary school in Taiwan. The following section will present what these systems are and how they relate to the sound structure of Mandarin and its role in learning to read Chinese.

### 1.1.2.1 Chinese Characters: A Morpho-syllabic System

There is not always a difference between the spoken and written forms in which sentences (or messages) are conveyed as long as people use written words to note down the spoken message or read out the written passages at any time. Thus, even though Chinese is commonly thought to be a logographic system without a consistent correspondence in graphic-phonemic mappings, DeFrancis (1989) claimed that it belongs among syllabic writing systems representing meanings and phonetic messages in their written form. Chinese orthography is not a written system designed to represent the written form of a particular language or dialect but rather represents a group of tonal-syllabic languages or dialects, the family of Chinese spoken languages, which are mutually unintelligible in general (Ho, 2003; Roger, 2005).

Chinese orthography uses symbols known as characters that generally correspond to a syllable segment of speech. However, a Chinese character encodes a meaning and/or phonetic message without a one-to-one mapping relationship between its morpheme and speech segment (syllable). That is why the Chinese writing system is described as a morphographic or morpho-syllabic system (Chen, 1999; Rogers, 2005). The relationship between script and language is not transparent at all but complicated (Chen, 1999; Lee, Hung & Tzeng, 2006). Many characters may share the same pronunciation as homophones. A good example of homophones is *ji* which has 137 distinct characters regardless of their tone variations (Chen, 1999).

Although Chinese orthography is commonly thought to be logographic without encoding pure phonetic values, there is only a small portion of characters (10 per cent) conveying meaning by pictographic representation (Ho, 2005). Up to 74 per cent of the 2000 most common characters are composed of a phonetic and a semantic form (Chen, 1999). It is open to debate if literacy acquisition in Chinese is closely related to accessing a phonetic message via its orthography (Li, Shu, McBride-Chang, Liu & Xue, 2008). This relationship would more or less reflect the importance of spoken language skills and phonological awareness in learning to read Chinese. In a later section (see 1.1.3.2), this issue will be developed further.

The graphic component of a character is the stroke. The average number of strokes per traditional character, based on the most common 2000 characters, is 11.2 (Chan, 1982, cited in Ho, 2003). Combined strokes are used to form any of the three units (or radicals) of characters, namely phonetic, semantic and/or symbolic marks. A character can be either a single unit or composed of two or three units (Chen, 1999). For example, 白 /pai ˧˥/ is itself a character and means ‘white colour’. It could also be a phonetic unit of another character 百 /pai ˨˩˦/ which means ‘hundred’. Moreover, it may be a symbolic unit in 的 /ti˥˩/ which means ‘target’ (see Figure 1.6). There is no convention determining the positions of units and their roles in a character (Florian, 1996). However, in some cases, such as phonetic-semantic compound characters, there is a habitual position for a phonetic or semantic radical. Semantic radicals normally are located at the left or top of a character (Tsai & Nunes, 2003).

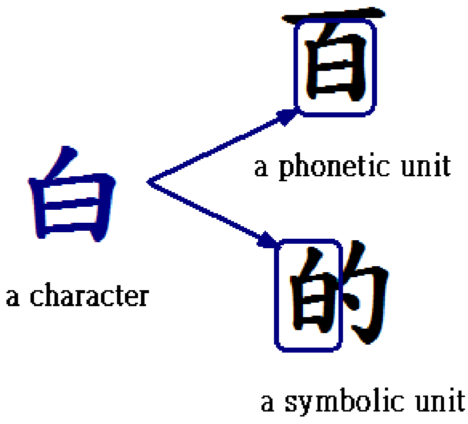


**Figure 1.6 An example of a character being a unit of other characters**

### 1.1.2.2 Zhuyin Fuhao: A Semi-syllabic System

ZF provides a simple phonetic spelling system for children to retrieve lexical information about Chinese characters. Symbols of ZF are derived from ancient or simplified Chinese characters with simple strokes (Chen, 1999). It can be written either top-down or left-to-right, like characters. Tonal marks are always placed at the right side of ZF letters.

ZF was published in 1918 and called ‘Zhuyin Zimu’ (sound-annotating letters). Its author originally designed it as an independent written system to replace Chinese characters. In 1930, it was renamed ‘Zhuyin Fuhao’ (sound-annotating symbols), for this writing system was not expected by the government at that time to serve its original intention, but was simply used as a complementary tool to annotate characters (Chen, 1999). When the same government regained control of Taiwan in 1949, this official policy was retained and promoted in Taiwan.

Being a semi-syllabic orthography system, ZF includes 37 letters[1] representing either the onset (21 letters) or rime (16 letters) of a syllable (Bertelson, Chen & Gelder, 1997; Ching & Tien, 1995). Its spelling corresponds to the sound structure of a syllable in Mandarin, including onset, medial and syllable ending. ZF was mistakenly thought to be an alphabetic orthography by researchers investigating the cognitive profile of developmental dyslexia or predicting the effect of phonological awareness (Hu, 2005; Huange & Hanley, 1997; Li & Ko, 2009). The defining feature of ZF as a semi-syllabic orthography is that its spelling of initial and medial is alphabetic (see Figure 1.1), but the syllable ending (nucleus and coda) is combined in syllabaries and symbolized by single ZF letters (Wikipedia, 2011). For example, ㄌㄧㄤˊ (measure) is pronounced as /liaŋ/ in tone 2. The first two ZF letters (ㄌ and ㄧ) corresponding to its initial /l/ and medial /i/ accordingly, but the last letter /ㄤ/ symbolizes the combination of nucleus /a/ and coda /ŋ/. Table 2.4 presents all the ZF symbols and the correspondingsymbols of the International Phonetic Alphabet (IPA).

As presented in Table 1.2, each letter represents a single consonant or vowel, except four ZF letters (Nos. 30-33) representing syllable endings which comprise two phonemes, and another four letters (No. 26-29) representing diphthongs. The average number of strokesin the 37 ZF letters is 2.24 which is far less than that of traditional characters (11.2) used in Taiwan.

[1]Even though ZF is a syllabary system where symbols correspond to either phonemes or syllable endings, for the sake of simplicity and its function in spelling, the ZF symbols are called ‘letters’ in the thesis.

**Table 1.2 IPA List for Zhuyin-Fuhao**

| No. | Letter Symbol | IPA | No. | Letter Symbol | IPA |
|---|---|---|---|---|---|
| 1. | ㄅ | p | 20. | ㄘ | $ts^{h}$ |
| 2. | ㄆ | $p^{h}$ | 21. | ㄙ | s |
| 3. | ㄇ | m | 22. | ㄚ | a |
| 4. | ㄈ | f | 23. | ㄛ | o |
| 5. | ㄉ | t | 24. | ㄜ | ə |
| 6. | ㄊ | $t^{h}$ | 25. | ㄝ | ɛ |
| 7. | ㄋ | n | 26. | ㄞ | ai |
| 8. | ㄌ | l | 27. | ㄟ | ei |
| 9. | ㄍ | k | 28. | ㄠ | au |
| 10. | ㄎ | $k^{h}$ | 29. | ㄡ | ou |
| 11. | ㄏ | x | 30. | ㄢ | an |
| 12. | ㄐ | tɕ | 31. | ㄣ | ən |
| 13. | ㄑ | $tɕ^{h}$ | 32. | ㄤ | aŋ |
| 14. | ㄒ | ɕ | 33. | ㄥ | oŋ |
| 15. | ㄓ | tʃ | 34. | ㄦ | ɤ |
| 16. | ㄔ | $tʃ^{h}$ | 35. | ㄧ | i |
| 17. | ㄕ | ʃ | 36. | ㄨ | u |
| 18. | ㄖ | ɻ | 37. | ㄩ | y |
| 19. | ㄗ | ts | | | |

**The Pros and Cons of Using ZF as a Phonetic System of Mandarin**

ZF is not the only phonetic system to annotate Mandarin. For example, in Mainland China, the pinyin system, being an alphabetic system, has adopted 25 alphabet letters to annotate Mandarin, its official language (Wong & Lau, 1983). As with ZF in Taiwan, pinyin is taught during the first weeks of schooling to facilitate children's literacy acquisition in Chinese (Chen, 1999) Therefore, it is worth reviewing the pros and cons of using ZF as the complementary orthography, particularly for beginners in literacy education.

One of the advantages of the ZF system compared to the pinyin system in annotating Chinese characters is its correspondence with the sound structure of Mandarin. That is, with at most three ZF letters, a ZF syllabic composite represents the initial, medial and syllable ending part of a syllable in Mandarin. In addition, for a zero initial syllable in Mandarin, such as /i/, a single vowel ZF letter is enough to annotate it straightforwardly, while an extra 'y' in front of 'i' is necessary to annotate the sound using the pinyin system (Wang, 1985).

However, the correspondence between the ZF syllable composite and Mandarin phonology is not always consistent, particularly for those letter composites that represent syllable endings with a final nasal consonant or a bilabial initial followed by /o/ or /ŋ/ (Wang, 2003) . For example, letter ㄢ represents /an/ in ㄊㄢ; but the same letter representing /en/ in ㄊㄧㄢ.This gap between phonetic symbols and pronunciation in daily usage may be attributed to the on-going assimilation between languages used by a community.

Regarding the graphic features of ZF, this semi-syllabic system uses graphics originating from simplified Chinese characters; the familiarity of these symbols might to some extent facilitate children's emergent knowledge of the characters' form (Ou, 2011). Thus, using ZF as a phonetic index allows children to pronounce new characters without assistance from their teachers or parents. It also extends children's vocabulary knowledge to written material, and helps children to teach themselves in learning new characters by reading characters assisted by pronunciation cues provided by ZF (Lee, Hung & Tzeng, 2006).

### 1.1.3 Literacy Acquisition in Chinese

Literacy provides children with a new way of learning to express themselves. As children acquire literacy skills, they develop the competence to decode written forms connecting to its phonological and/or lexical representation. In this section, literacy instruction in Taiwan, which begins with the intensive ZF course, will be introduced, followed by a review of how Chinese characters are acquired by school-age children, including the cognitive process involved.

#### 1.1.3.1 Literacy Instruction: Teaching ZF before Chinese Characters

The systematic instruction of ZF starts when children enter primary school after the age of six. It is officially forbidden to teach ZF letters de-contextually in preschool in Taiwan (Ministry of Education in Taiwan, 1987). Therefore, most of the preschool teachers would embed ZF letter recognition and practise letter-sound mapping in literacy-related activities; some of them might teach ZF de-contextually under pressure from parents (Chen & Kao, 2009). According to a previous study by Hung (2008), over 90 % of Grade 1 pupils had learnt all ZF letters before school entrance.

Formal teaching of ZF starts right after children enter primary school. During the first ten weeks of schooling, children are taught the thirty-seven letters of ZF, and learn to speak and spell out ZF ‘words’ combining letters and tonal marks. After a ten-week intense ZF course, students are expected to acquire the skills to read and spell ZF without difficulty. The first school examination, normally in the eleventh week, would then test their level of proficiency in ZF literacy. Accuracy and fluency in reading ZF words are crucial if school entrants are to progress well with their literacy, since all writing is presented only in ZF in the first months of their schooling.

Chen and Yuen (1991) argued that learning such a phonetic system before learning characters might encourage children to take more notice of the phonological information of written words in Chinese and therefore strengthen children’s skill in phonological processing. However, they also suggest that this ability might be detrimental when the target orthography being acquired is lexical-based and has no consistent correspondence between graphemes and phonemes, as is the case with Chinese orthography. They investigated the effect of different instruction systems of Chinese literacy in Hong Kong, Mainland China and Taiwan. Although Chinese orthography is used in all the above areas, the script used in Mainland China is simplified in comparison to the traditional characters used in Hong Kong and Taiwan. In addition, school entrants in Hong Kong do not receive phonetic instruction prior to learning characters. In contrast, however, two different phonetic systems, ZF and pinyin, were taught in Taiwan and Mainland China, respectively.

Their participants were school-age children (average age 7.5 to 8.1) in Hong Kong (72 children), Shanghai (67 children) and Taipei (73 children). The results showed that children who received phonetic instruction before learning characters increased their accuracy rate in naming pseudo-characters without suffering any negative effect on their acquisition of real characters. Besides, learning traditional characters enhances children's epilinguistic knowledge of character radicals when they apply their orthographic knowledge to complete a lexical decision task. Here, epilinguistic knowledge is defined as the implicit knowledge of how language is organized in various aspects, such as phonology, and how it is acquired by accumulated experience. This study also found that children in Taiwan and Hong Kong were more inclined to adopt phonological information on decoding characters than children in Mainland China, who mainly relied on the visual information. It thus showed that whether or not they learnt phonetic systems did not change children's preference for relying on phonological knowledge to judge the legality of characters.

However, the ZF orthography system is not always recommended in annotating Chinese characters. Wong and Lau (1983) compared two groups of adolescents (age between 12;8 and 16;7 ) on mono- or multi-syllabic spelling immediately after they learnt either pinyin or ZF for eight weeks. Each group had 40 participants from a secondary school in Hong Kong where children do not learn any phonetic system, neither ZF nor pinyin, at their primary school stage. They found that eight weeks were not enough for the ZF group to master the ZF letter-sound mapping. The pinyin group performed better than the ZF group in the spelling test. The result was attributed to the fact that students in Hong Kong normally acquire alphabetic letters which are used in the pinyin system before entering secondary schools. The higher level of difficulty in learning ZF letters might be attributed to the larger number of letters in the ZF system

(31 letters) than in the pinyin system (25 letters) and some visual similarity among letters, such as ㄋ/ㄎ, ㄉ/ㄌ and ㄇ/ㄈ. A further error analysis revealed an advantage of the ZF system in which single letters are used to annotate each of the four diphthongs (/ai/, /ei/, /ao/ and /ou/) which are single phonemes, rather than two separate vowels. In addition, the ZF system creates no confusion in annotating a sentence where a ZF letter compound represents the sound of a character (i.e., a syllable). In contrast, writing sentences in the pinyin system would rely on the knowledge of syllable boundary markings heavily. Table 1.3 presents the phrase‘the phonetic system of Han language’ in ZF and pinyin scripts. The ‘ ' ’ in ‘fāng'àn’ is a syllable boundary marking to avoid confusion.

**Table 1.3 The scripts of ZF and pinyin for ‘the phonetic system of Han language’**

| | |
|---|---|
| **ZF** | ㄏㄢˋ ㄩˇ ㄆㄧㄣ ㄧㄣ ㄈㄤ ㄢˋ |
| **pinyin** | Hànyǔ pīnyīn fāng'àn |

Wong and Lau’s results for adolescents should not be taken as evidence for the behaviour of preschool children, that is, whether it may take longer or shorter for a younger child to become fully familiar with this system is unknown. However, theirstudy showed the importance of acquiring ZF letter knowledge early enough to master spelling skills. It is also important to examine whether or not ten weeks of intense ZF teaching at school entrance is enough for typical children to master sound-letter mapping in order to use the ZF phonetic system for reading and spelling. It is noteworthy that systematic phonological awareness training is not included in the curriculum of either preschools or primary schools in Taiwan.

### 1.1.3.2 The Acquisition of Chinese Characters

In Taiwan, characters are not introduced to primary school entrants until the 11th week of schooling, after which they are always used alongside ZF for the first four years in primary school. However, children might acquire a few characters in their daily life or preschool education where story books are easily available. Investigating the number of characters recognised by preschool children with a standardized character recognition test originally designed for school-age children, Wu (2010) found that it ranged from below twenty to more than eighty.

By random sampling characters shown in books and/or newspapers of university readers, it was found that the 4500 most common characters are enough for daily usage in Taiwan (Liu, Chuang and Wang, 1975, cited in Ho, 2003). The first 1000 high frequency characters cover 90 per cent of those used in a newspaper (Lee, Hung & Tzeng, 2006). Literacy skills therefore should take the number of recognized characters into account, rather than the number or range of words only. Chen (1999) proposed that the number of characters acquired by children is the only measure to reflect their literacy level, rather than learnt words, as in the case of alphabetic languages. According to the national curriculum target for literacy, children are expected to learn 700-800 characters by the end of their second school year (Ministry of Education in Taiwan, 2011).

Wang, Hung, Chang and Chen (2008) investigated the average number of characters recognized by 2,842 school-age children from Grades 1 to 6 (age range 6 to 11) of mainstream primary schools in Taiwan. The results showed that the number of recognized characters increases according to the number of years of formal literacy education (Figure 1.7). This implies that the acquisition of Chinese characters requires specific practice or experience in order to progress through the years of primary school.

In addition, they found the individual difference increased substantially from Grade 2 (standard deviation = 363.54) to Grade 3 (standard deviation = 816.30) and then continued in the same way for the remaining years of primary school. They proposed that this result reflects the critical effect of learning to read for those children who acquire a certain number of recognized characters; the accumulated epilinguistic knowledge of decoding new characters would accelerate their competence in reading and therefore reciprocally extend the range of recognized characters. In contrast, children who can only recognize a limited number of characters before Grade 3 may remain at the lowest end of a class or group unless they are identified and intervention is delivered.

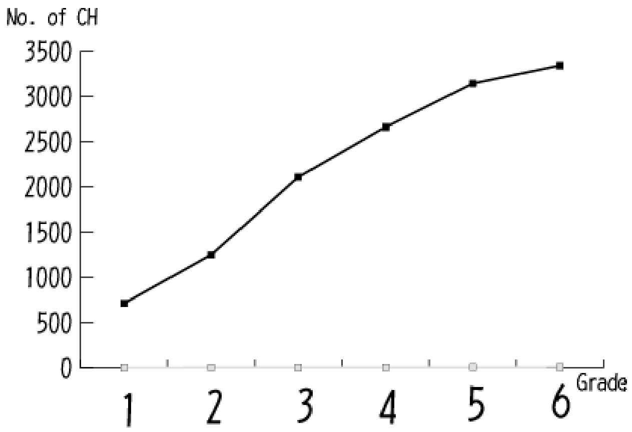


**Figure 1.7 The average number of characters recognized by school-age children (based on Wang et al., 2008, p. 562)**

Wanga, Perfetti and Liub (2005) found that processing of form and position of radicals forming characters is a powerful predictor of future performance in character recognition. That is, the process of decoding characters is not simply logographic but involves epilinguistic knowledge of how characters are structured into units.

**The Cognitive Processes Involved in the Acquisition of Chinese Orthography**

Ho and Bryant (1997) investigated whether the orthography-phonology correspondence (OPC) rules, unlike analytic decoding of grapheme-phoneme correspondence (GPC) in alphabetic languages, can describe how school entrants decode phonetic-semantic compounds, which account for the great majority of characters (see section 1.1.2.1.). Their results showed that reading Chinese does not involve a logographic recognition process since lexical access is not possible without intermediate phonological coding. Children relied on the phonetic radical of a new character to provide its phonological clue and were inclined to assume a pseudo-phonetic-semantic compound to be an ideophonetic compound. That is, they would pronounce a pseudo-phonetic-semantic compound according to the name of its phonetic radical. They concluded that younger readers seem to develop their skills in reading Chinese naturally, discovering script-sound regularity (OPC rules) first, and explore exceptions to this regularity at a later stage. It is noted that the participants in this study lived in Hong Kong and had not received any phonetic instruction before learning these characters.

Hu (2010) investigated the epilinguistic knowledge of how a character should look when it comes to a semantic-phonetic compound in Grade 4 (age range 9 to 10) children in Taiwan. A pseudo-character choice task with fourteen items was designed and conducted with 104 typically developing children. Participants were asked to choose from three options the most suitable script to fit a description of the lexical and phonetic characteristics. Each item included three pseudo-characters: (a) a character with a matched semantic radical and a foil phonetic radical; b) a character with a foil semantic radical and a phonetic radical either totally or partially matched; c) a character with a foil semantic radical and a foil phonetic radical.

The result showed that, when the pronunciation of a phonetic radical perfectly matched the pronunciation of that character, this option was the one most likely to be chosen by the children as its written form. Otherwise, there was no significant preference between semantic match and partial phonetic match of a pseudo-character which was a semantic-phonetic compound. In addition, this preference was not correlated to children’s competence at character recognition. Hu therefore concluded that school-age children explore and process the phonetic information of a new character at the sub-character level in reading.

However, this study did not take into account the conventional pronunciation of semantic-phonetic compounds with those chosen radicals. It is possible that children made each judgement on the basis of their implicit knowledge of those radicals, such as whether certain radicals are legal characters on their own. This kind of epilinguistic knowledge might also influence children’s decisions, in addition to the fully phonetic match of a target character.

Another study focusing on the difficulty level of correctly pronouncing phonetic-semantic compounds showed that it depends on how the pronunciation of a compound relates to its phonetic radical. Wu and Huang (2004) investigated the difficulty level of speaking aloud phonetic-semantic compound characters in primary and secondary schools participants (age range 6 to 14). They categorized five groups of phonetic-semantic compound characters according to the degree of similarity between the pronunciation of the phonetic radical and the pronunciation of the entire compound: a) sharing the same pronunciation completely; b) sharing the same tone only; c) sharing the same onset only; d) sharing the same rime only; and e) having nothing in common. The results on the accuracy in naming characters across the above five groups in primary school participants are shown in Figure 1.8. It was found that the degree of accuracy across all types of semantic-phonetic compounds increased through the grades, with the grade accounting for 62% of variance in naming accuracy. Type (e) (with nothing in common between the phonetic clue and its pronunciation) had the highest accuracy while type (a) (with a perfect match between the phonetic clue and its pronunciation) had the lowest accuracy. In addition, the contribution to accuracy variance from all five kinds of mapping of phonetic-semantic characters was only 3 per cent.

Although having a low contribution to accuracy variance, this result showed that school-age children do not simply depend on the phonological clues of the phonetic radical to name a character. The finding that various levels of similarity in tone, onset, and the rime part of a phonetic radical led to different accuracy rates in this study implies that school-age children are able to decode these linguistic levels of phonetic radicals and apply them to the pronunciation of a particular character. Thus, these linguistic levels of awareness play an important role in naming a new character for school-age children. Further, the high contribution to accuracy variance from the grades implies that character acquisition largely relies on practice and experience. In other words, the results confirmed that the link between phonetic information and character pronunciation lacks consistency and may be confusing for beginners. Therefore, learning the name of a character by rote seems to be unavoidable (Lee et. al., 2008).

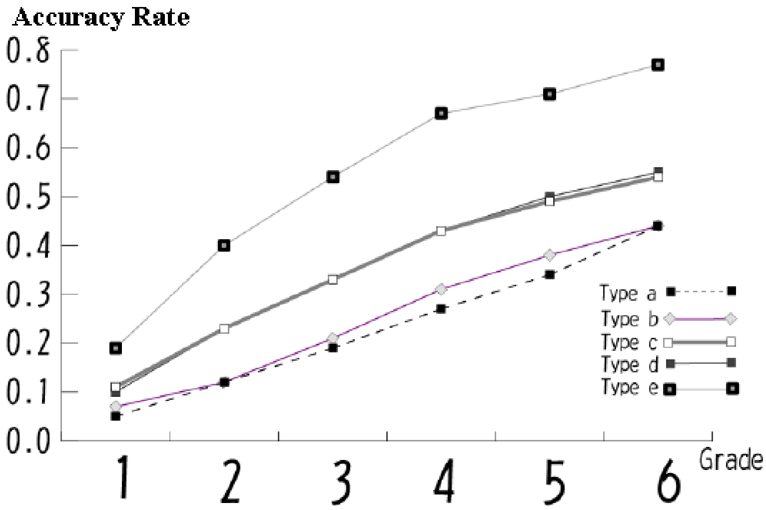


**Figure 1.8 Difficulty level of naming phonetic-semantic compound characters (from Wu & Huang, 2004, p.8)**

In conclusion, for the majority of Chinese characters, the phonetic radical more or less provides clues to their pronunciation, at the level of syllable, tone, onset and rime. Therefore, character acquisition might involve or relate to a certain degree of phonological processing in the above linguistic levels. Moreover, how children acquire the complicated mapping between sound and script of characters warrants further investigation (Lee, 2009). An review of PA and how it relates to literacy acquisition in Chinese will be presented next.

## 1.2 Phonological Awareness and its Relationship to Language

Phonological awareness (PA) in particular at the phoneme level has been found to be an effective predictor of reading acquisition in alphabetic languages in many studies over the past four decades. However, it is not yet clear if this would apply to tonal languages using a morphosyllabic orthography system, such as Chinese, where our knowledge of the relationship between different aspects of PA and literacy in such a non-alphabetic script is rather sketchy.

**Definition of Phonological Awareness**

PA comprises a collection of speech processing skills since any PA task can involve speech input skills, e.g. auditory discrimination and/or speech output skills, e.g. rhyme production, spoonerisms. Performance on PA tasks is also supported by an individual's stored lexical representations, e.g. phonological, orthographic (Stackhouse and Wells, 1997). The development of phonological representations is 'carved' from larger segments (e.g. syllables) into finer grain-sized segments (e.g. phonemes) through linguistic and/or orthographic exposure (Goswami, 2000). As children's range of vocabulary grows, it becomes more necessary to detect distinctive features in utterances, such as small unit sounds, by elaborating their phonolgical representation toward finer grain-size levels. Therefore, the range of young children's lexical representation has been hypothesized as one of the precursors of PA.

Walley, Metsala, and Garlock (2003) proposed the *Lexical Restructuring Model* to specify an indirect relationship, mediated by explicit segmentation ability, between oral language skills and word reading development. They claimed that vocabulary growth stimulates the reconstruction of lexical representation and leads to gradual refinement of phonological representations. The reconstruction is a precursor of acquiring phonemic awareness and consequently promotes later reading development. In turn, orthographic experience supports the development of explicit phonologcal awareness, e.g. segmentation within a cluster.

This lexical restructuring model has been supported by empirical work focusing on the role of vocabulary in PA development. For example, Carroll, Snowling, Hulme and Stevenson (2003) investigated the relationship between PA and vocabulary knowledge in 67 preschool English-speaking children (CA 3.10-4.9 years) and found a high correlation between the performances on larger-segment PA and receptive vocabulary tasks. Although this evidence suggests that vocabulary knowledge is closely related to early PA development, it is not so clear if this relationship continues as the child gets older.

Cooper, Roth, Speece, and Schatschneider (2002) investigated whether PA development, including blending and elision skills, through Grade 2 may be predicted by spoken language skills and background factors such as intelligence and primary language at the preschool stage (CA 5.2-6.3). They found that after letter and word knowledge were controlled, oral language skills, such as vocabulary, explained between 3 and 42 per cent of the variance in PA across three years. However, the predictive effect of background factors on PA was not significant.

PA is also a metalinguistic skill since it involves an ability to manipulate language itself. This metalinguistic aspect can be acquired as long as the phonological processing system develops. Stackhouse and Wells (1997) described how to investigate the development of children's phonological processing skills and how these are an important foundation on which to base their literacy development. Their phase model includes a 'metaphonological phase' when children are able to segment sub-syllable constituents, such as onset and rime, consciously. Children with persisting speech difficulties are described as being arrested in an earlier phase of their phonological development. This group of children is not ready for developing the small-segment PA, such as phonemic awareness, as they enter primary school. This statement is indirectly supported by a study of the later development of phoneme awareness in preschool children (CA 3.10-4.9 years) in which it is shown that the performance of phoneme awareness does depend on their articulation skills (Carroll et al., 2003). However, for school-age children, whether speech output skills remain crucial or correlate with PA performance might be another issue.

Given that PA has been investigated and defined by numerous studies, Anthony and Francis (2005) argued that various PA skills can be distinguished by how the task is performed and by the linguistic levels involved. Nevertheless, various PA skills were found to converge into a unified construct in a study of 258 preschool English-speaking children (Anthony, Lonigan, Burgess, Driscoll, Phillips, & Cantor, 2002). Another study with 945 English-speaking children from kindergarten to Grade 2 which adopted a PA battery with seven distinct tasks also indicated a single latent dimension of PA competence (Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999). However, there is still insufficient evidence on languages other than English to know whether a unified construct of PA is linguistically universal, particularly for tonal languages.

**The Sequence of PA Development and its Relationship with Literacy Skills**

As with the definition of PA, there are at least two dimensions to the description of the sequence of PA development. The first one is to describe the progress of PA among various linguistic levels or sizes of segments, such as syllable, onset/rime and phoneme. Some controversial findings on this issue will be addressed in more detail later in this chapter. The other dimension relates to the nature of processing required in PA tasks: whether it is an implicit or explicit task, that is, whether the task requires a sensitivity of perception only or a conscious awareness to manipulate among sounds and produce the outcome correctly. Seymour, Duncan and Bolik (1999) proclaimed the importance of distinguishing the requirement of a PA task on the implicit-explicit dimension. An implicit PA task is largely based on epilinguistic processing where recognition of a shared phonological unit is required. In contrast, an explicit task requires metalinguistic processing to identify and produce the shared phonological unit.

These two dimensions were included, for example, in a comprehensive phonological awareness measure designed to investigate the development of PA in German-speaking children and the predicting effect of speech and language processing skills in early literacy acquisition in German (Fricke, et al., 2008; Schaefer et al., 2009). These results examine and support the view that PA is a multi-level skill. It was also found that for the same PA process, such as blending, when being measured either implicitly or explicitly, their difficulty levels were not the same and may lead to different results. Thus it was suggested by Schaefer and her colleagues that the task design should be carefully controlled since it might affect the actual level of explicitness.

Therefore, the third dimension of two major sub-processes of PA, phonological analysis and phonological synthesis, also needs to be considered in a comprehensive PA battery. According to Castles and Coltheart's (2004) review, these two sub-processes are highly inter-correlated with each other in English-speaking children. However, only phonological analysis was found to have a unique effect on first grade reading; and only phonological synthesis had a unique effect on second grade reading.

By reviewing many related studies, Ziegler and Goswami (2005) concluded that there was a relatively fixed sequence of PA progression, at least among European languages, from larger to smaller units; for example, syllable PA in general is acquired earlier than onset-rime and phoneme PA. However, this sequence from larger unit PA to small unit PA is not necessarily discrete, and the two forms of PA are independent of each other, that is, children may acquire small unit PA before their large unit PA is fully developed. In a study of PA development of preschool children, Carroll et al. (2003) found no clear distinction between syllable and rime PA; children performed equally well on tasks at these two levels. Therefore, it is questionable whether this sequence implies that the PA which is developed later, such as small unit PA, can only develop on the foundation of PA at the large unit level acquired earlier. Moreover, even following the same or a similar sequence, the difficulty level of PA tasks at any linguistic level might not be the same in different languages. It depends on the property highlighted in various spoken language (Ziegler and Goswami, 2005). An example mentioned in this review is that children who speak a language with a simple syllable structure (such as Greek) perform better in syllable tasks than children who speak a language with a complicated syllable structure (such as English). Therefore, it is necessary to study the PA developmental sequence separately in each spoken language and then compare across languages.

By administering common unit PA tasks, where children listen to a pair of words and are asked to produce the shared sound, Duncan and Bolik (1999) found controversial results on the PA development sequence for early school-age children: children performed better on phonemic PA than on PA tasks at the body level (onset plus vowel) or the rime level. The result was attributed to the fact that children are explicitly taught to notice the link between grapheme and phoneme during the early stage of reading acquisition; therefore their attention had been explicitly drawn to this level. They assumed literacy instruction stimulates children to develop their meta-awareness at the phoneme level first; and with reference to Goswami and East's study (2000) they claim that further rhyming and analogy instruction is necessary for children to develop their meta-awareness of the large unit. However, Ziegler and

Goswami (2005) reviewed the same study (Goswami & East, 2000) but attributed the controversial results to a methodological issue:

> "These unusual findings (small to large pathway) may also reflect the cognitive demands imposed by the novel common unit task … once children understand the tasks they are being given, the developmental progression (large to small pathway) appears to be preserved." Ziegler and Goswami (2005), p. 6.

However, the impact of literacy instruction on the sequence of PA development has become an issue. Also, it seems that common unit PA tasks are able to reveal the impact of orthography experience on PA development at a later stage.

Goswami (2005) proposed that the sequence of PA development across languages is based on how the phonological representations are reconstructed. Before schooling, the sequence of PA development is linguistically universal (from large segment to small segment); but after school entrance, it becomes more linguistically specific and largely dependent on the orthography systems and teaching instructions.

Regarding the sequence of development of PA in the other dimension, implicitly or explicitly manipulating sounds, it has been found that PA develops continuously from tacit sensitivity towards explicit awareness as a cumulative result of hearing, speaking and reading experiences (Stackhouse & Wells, 1997). The distinction between implicit and explicit tasks is whether in order to answer a PA item the child has to manipulate (e.g. delete, segment, add-in or transpose) the sound structure (e.g. syllable, onset or rime) and produce the segment explicitly at the same time. For example, auditory tasks are implicit PA tasks since the answer can be acquired by detecting, pointing or repeating the option. In contrast, spoonerisms are explicit PA tasks because transposing onsets of syllables requires advanced skill to manipulate the sound structure and produce the result. In other words, output tasks tend to be more explicit than input ones.

Seymour et al. (1999) claimed that explicit awareness only develops after formal education which builds on the foundation of implicit awareness. For some researchers, PA of various sizes of linguistic segments and its explicitness are considered simultaneously. On the basis of their evidence, Carroll et al. (2003) stated that the implicit sensitivity to a large segment, such as a syllable, is a 'by-product' of linguistic development and interacts closely with receptive vocabulary knowledge. In addition, this implicit sensitivity and these articulation skills are both the foundation of the later development of explicit meta-awareness of phonemes.

**The Relationship between PA, Literacy and Speech Difficulties**

Castles and Coltheart (2004) explored the reciprocal link between PA and literacy in depth by systematically reviewing previous studies which carefully controlled the literacy skills and possible third factors, such as age, IQ and language ability. In addition to highlighting the importance of alphabetic skills in learning to read, they proposed that orthography ability may influence a child's response to a PA item and therefore lead to a better PA performance, which should not be attributed to genuine improvement on PA skills. More specifically, PA in children speaking an alphabetic language might actually reflect their awareness of the orthography at word level. Additionally, their review of relevant longitudinal data indicated that phonemic awareness is the most likely ability, compared to syllable or rime PA, to predict future reading and spelling skills in children speaking alphabetic languages.

Muter, Hulme, Snowling and Stevenson (2004) conducted a 2-year longitudinal study of British school entrants (CA 4;9) in order to verify whether phonemic awareness is a better predictor of word recognition than onset-rime skills. They also sought to clarify whether onset-rime skills provide a foundation for children to acquire phonemic skills and word recognition. Although it was found that phoneme sensitivity is more powerful in predicting word recognition at a later stage, different PA tasks adopted between phoneme and rime levels made the above result arguable. It was therefore suggested that identical stimuli and procedures should be used to assess both phoneme and onset-rime awareness. This study, however, did not find any direct causal link between rime awareness and later phoneme awareness.

Stackhouse and Wells (1997) claimed that both speech and literacy development depend on the same foundation, i.e. the speech processing system. Whether the system is intact or not would determine a child's PA performance. On the basis of the relationship between spoken and written language skills and the accumulated evidence of how PA links to literacy acquisition, speech and language therapists have become more and more concerned as to whether children with speech difficulty are more at risk of experiencing difficulty in reading (Hesketh, 2004). However, the heterogeneous nature of the group of children with speech difficulty and the substantial range of individual differences in literacy acquisition in typical children make it harder to prove a direct causal link between speech difficulty, atypical PA, and poor literacy performance (Dodd & Gillon, 2001). Peterson, Pennington, Shriberg and Boada (2009) carried out a longitudinal study to explore the link between speech output disorder and literacy acquisition in 120 English-speaking children (CA age 7-9). It was found that children with a history of speech output difficulty had a higher rate of reading difficulty at a later stage compared with the control group. Additionally, persisting speech output disorder, i.e., being unable to articulate correctly after entering schools, was closely linked to phonological deficit. Literacy skills were better predicted by preceding language skill, PA and other cognitive measures, such as IQ and rapid automitised naming, than PA alone. They concluded that, compared to the core phonological deficit view of reading difficulty, the co-morbidity view is more in line with their findings where children with speech output difficulty did reflect their phonological deficit, and this weakness would put them at risk of later reading difficulty by interacting with other risk and/or protective factors.

To conclude, PA is thought to be an advanced and metalinguistic skill which develops in the preschool years tacitly and might not be tested formally or explicitly until school age. In addition, PA may not be a single skill but a combination of skills in various grain sizes. A comprehensive PA measure, therefore, should comprise both implicit and explicit PA tasks at various key linguistic levels of the language to be measured. Tasks focused on phonological analysis are more sensitive for the school entrants. PA is a multi-level skill developed independently across various linguistic levels of children's spoken language. It is found that PA has a close relationship with other spoken language skills in alphabetic languages. Moreover, a reciprocal relationship between PA and literacy is observed, where phonemic awareness may predict literacy performance at a later stage, and later PA performance is possibly influenced by orthography skills. Whether the reciprocal relationship between PA and learning to read is a cross-linguistic phenomenon, particularly in Chinese acquisition, warrants further review. Moreover, which factors best predict literacy acquisition and how subsequent PA skills are influenced or predicted by preceding language and/or speech skills or orthography experience also require further clarification.

In the next section, PA development in Mandarin-speaking children and the link between PA and Chinese orthography will be introduced in depth. Studies focusing on PA skills before and after formal education starts will be separately reviewed to reveal the possible distinct features in each situation.

## 1.2.1 Phonological Awareness Development

**Preschool-age Children**

Sue, Peng and McBride-Chang (2008) investigated the development of PA in 146 Mandarin-speaking children at four age levels in Beijing. These age levels included three preschool levels (ages 3;3-3;11 [K1], 4;0-4;11 [K2], and 5;0-5;11 [K3]) and Grade 1 (age 6;0-7;6). They administered a receptive common unit task with only two options to measure children's PA at four linguistic levels: syllable, rime, onset and tone. It was found that syllable and rime PA develop early from K1 to K2, but that onset phoneme and tone PA improve significantly from K3 to Grade 1. This suggests that pinyin instruction during Grade 1 effectively facilitates pupils' PA on onset and tone levels only. The above results are in line with the 'grain size theory' proposed by Ziegler and Goswami (2005) on the sequence of PA development, where large unit PA, such as syllable, is normally acquired before schooling, but small unit PA, such as phoneme, develops later after receiving formal education. However, it is interesting that tone PA, a suprasegmental level, only improves significantly after schooling.

However, apart from the syllable task, the reliability of the other three tasks is less than 0.5 (rime: 0.49; onset: 0.28; tone: 0.37). This was attributed to the receptive design and high probability of guessing with only two options provided by the researchers. More options were suggested by the researchers to improve the reliability of the design. In addition, the stimuli of the PA tasks are real words with a picture. This means that the PA tasks do not totally eliminate the influence of lexical ability, which might be another reason for low reliability, since children's vocabulary span was not controlled and might be a confounding factor.

**School-age Children**

Xu, Dong, Yang and Wang (2004) investigated the trajectory of PA development in school-age Mandarin-speaking children in Mainland China through both longitudinal and cross-sectional studies. In the longitudinal study, 45 Grade 1 children were tested at the beginning (T1), middle (T2) and end (T3) of their first school year. The PA tests administered were odd one out tasks at the level of onset, rime and tone. A phoneme deletion task was not conducted until T2. At the beginning of schooling, accuracy scores were low (range 32-35%); and there was no significant difference in onset, rime and tone tasks. However, tone PA improved significantly across the three time points. But in contrast, onset and rime PA improved significantly only in the second half of Grade 1 between T2 and T3. The phoneme task tested at T2 and T3 is the most difficult task and performance lagged behind the other three PA tasks even though it improved significantly from T2 to T3. The cross-sectional part of the study investigated 89 children in Grade 1;114 in Grade 3 and 117 in Grade 5. The same tasks were presented in both the cross-sectional and longitudinal studies. It was found that the tone and rime PA reached their plateau (accuracy : 87 per cent) at Grade 3, while onset and phoneme PA continued to improve across the three time points, but were still less than the tone and rime PA at Grade 5 in accuracy level. The researchers argue that PA performance at tone, onset and rime levels were similar at the time of school entrance because of the syllable-based features of Mandarin. Therefore, sub-syllabic PA does not develop until well after the pinyin system is introduced in formal education. More specifically, instruction in the pinyin system provides orthography support, including tone marks, for children becoming aware of sub-syllabic PA symbols, and speedy development of tone PA. It is very possible that, during the instruction, some form of phonological awareness training is included.

Although the reliability of each task is high, the stimuli used in the tasks are all real words. Thus, it is impossible to eliminate the influence of lexical knowledge. In addition, only the phoneme level in the deletion task was an explicit task. Therefore, its result might not be comparable to the implicit PA tasks, i.e., odd one out tasks, at other linguistic levels. Unfortunately, no average age for the cohort was mentioned in the section on the participants, and the correlation between PA and reading was not investigated in the study.

Chan, Hu and Wan (2005) investigated phonemic awareness in 192 Mandarin-speaking Taiwanese children in Grade 4 (aged around 9;5) in order to know whether children speaking a syllabic language which does not follow the alphabetic principle in its written form would develop phonemic awareness. Sound oddity tasks were used to measure participants' onset-rime and phoneme (nucleus or coda) PA.

Participants were asked to select the odd one at the onset, rime or phoneme level from three monosyllabic words. It was found that the cohort performed better on the onset-rime task. Approximately 92 percent of the cohort performed above chance level on the phoneme PA task. Hu examined whether their phonemic awareness could be attributed to their English vocabulary skills, but only a moderate correlation was found between these two measures. Therefore, Hu argued that the development of phonemic awareness in Mandarin-speaking children might come from their experience of learning ZF, a semi-syllabic orthography system, rather than from their spoken language.

**PA of Mandarin-speaking Children with Speech Difficulties**

If PA is a measure of the integrity of the speech processing system underlying literacy acquisition (Stackhouse & Wells, 1997), then children who have difficulties within this speech processing system may show atypical patterns of PA development. A study of 410 preschool children aged between 5 and 6 years in Taiwan showed that around 6.1 per cent of the cohort had speech and/or language disorders (Cheng, Chen, Tsai, Chen, & Cherng, 2009). However, very few studies have focused on the PA performance of Mandarin-speaking children with speech and/or language difficulties.

One study by Yen (2005) adopted a matched pair design to compare the PA performance before and after a ten-week ZF course of 17 typically developing children and 17 children with phonological disorders in Grade 1 inTaoyuan, Taiwan. It was found that the children with a phonological disorder performed less well on syllable deletion, onset deletion and onset matching tasks than the controls, both before and after the intense ZF course. In addition, there were significant differences in ZF dictation, spelling and reading aloud at ZF letters, wordsand tones between the two groups.

The above results suggest that, compared to typically developing children, children with a speech difficulty may also have difficulties with PA at both large unit (syllable) and small unit (onset phoneme) level. It seems that for children with speech difficulty acquiring literacy skills of a semi-syllabic system, such as ZF, which highlights phonological analysis and synthesis processes might lead to a disadvantage. In addition, poor PA skills at the beginning of schooling may influence the performance on literacy tasks in ways which are not limited to specific linguistic levels. For example, in the above study, ZF dictation and marking of tones on ZF words were poor in the atypical group even though there was no significant difference in tone PA between the two groups.

In summary, Mandarin-speaking preschool children show varying levels of PA development, depending on their experience with literacy, the aspect of PA measured, and how it was measured. Some children in Mainland China might not acquire measurable PA at onset-rime level until they receive formal education. Given that Mandarin is a monosyllabic language, emergent phonemic awareness was found among school-age children and was attributed to the systematic ZF course at the time of school entrance. Moreover, Mandarin-speaking children with a speech difficulty perform less well on PA tasks than their typically developing peer group. More studies of the relationship between PA and spoken language skills in Mandarin-speaking children are necessary in order to reveal how children acquire literacy on the foundation of verbal competence.

### 1.2.2 The Importance of Phonological Awareness in Literacy Acquisition

A few studies have focused on whether PA is important in Chinese literacy acquisition. The link between PA and Chinese literacy acquisition was investigated by various studies. One caveat is worth noting here: the studies of PA in tonal languages started around the 1990s when few tests with local norms had been published.

Therefore, some of the studies in the following review have this methodological limitation.

**Preschool-age Children**

In a study focusing on the effect of PA on character acquisition in 202 preschool-age Mandarin-speaking children in Beijing, it was found that tone detection and syllable detection were independent markers of early reading performance prior to formal education or any instructionin a phonetic system (Sue, Peng & McBride-Chang, 2008). Researchers attributed the results to the nature of Chinese orthography: a morpho-syllabic system, in which a large amount of homophones can be distinguished only by their tone markers.

In Hong Kong, formal literacy instruction, including reading and writing characters, starts very early. More than 60% of preschool teachers reported that they would teach three-year-old children to read and write (Ho, Liu & Lau, 2002). Tong, McBride-Chang, Wong, Shu, Reitsma and Rispens (2011) investigated longitudinal predictors, including syllabic awareness, of very early Chinese literacy acquisition in 187 preschool children in Hong Kong who were tested at 4;4 (T1), 5;2 (T2) and 6;1 (T3). Although syllabic awareness at T1 was found to be consistently associated with character recognition and dictation skill at T1 and T2, this association was not found in the last year of preschool (T3). Moreover, this explicit PA at syllable level made only a 1% unique contribution to explaining the variance of character recognition at T2. This effect faded with development and was no longer significant at T3. Therefore, the researchers argue that syllabic awareness may not be as important a predictor as the reading experience accumulated. In other words, syllabic awareness in Cantonese, the most popular tonal syllabic language in Hong Kong, was limited as a predictor of Chinese character learning after the children had received more than two years of literacy education in kindergarten.

**School-age Children**

In 1997, Huang and Hanley published the preliminary results of their study focused on the relationship between visual skills, PA and character recognition, from the first three time points. It was found that visual skills ('Visual Paired Associates' in the 'Wechsler Memory Scale-Revised') and PA had no significant predictive effect on character recognition at the end of first grade when the effect of early reading scores was partialled out.

Taking the same cohort as the preceding study, Huang (1997) investigated longitudinally the relationships between PA and Chinese character recognition in 31 Mandarin-speaking children living in a lower economic status community in the middle of Taiwan. Although their native language was Taiwanese, all participants were able to speak Mandarin as well when they entered school. The cohort was assessed five times: a) at the beginning of Grade 1; b) later, after a ten-week ZF course; c) at the end of first grade; d) at the end of second grade; and e) at the beginning of Grade 4. The average ages at each of these time points were 6;54, 6;71, 7;26, 8;26 and 9;71, respectively. Their PA was measured in Mandarin by oddity tasks across the onset, medial or rime level for an overall score, and deletion tasks at the onset or rime level. Two kinds of stimuli were used: real words and nonwords. Stimuli for PA tasks all adopted the syllables whose sound structure were either CVVC or CVV. Initial, medial and syllable ending (see fig. 1.1) are the three target PA levels measured in this study. Tone of stimuli was controlled by keeping it as tone 1 across tasks. The character-naming test was designed for the purposes of this study, and comprised a range of word frequencies derived from popular publications.

Performance on all PA tasks improved substantially after the ten-week ZF course and had reached the ceiling by the end of Grade 2. There was no significant difference between tasks using true or pseudo-words. Performance on character recognition continuously increased. The biggest improvement was seen in the first two school years but there was a wide range of individual difference. Overall, correlations between character naming skill at different time points was high (r = 0.61—0.95), apart from the fourth time which is the end of the 2nd grade. However, no explanation of this unusual result was provided by the researcher.

The relationships between PA and character recognition were not consistent across the five time points. Furthermore, regression analysis showed no significant predictive relationship between PA and character recognition, although concurrent correlations were significant generally (see Table 1.4). In general, deletion PA had more significant correlations with character-naming skills. There was a stronger correlation between PA and character recognition after the 10-week intensive ZF course.

**Table 1.4 Concurrent correlations between PA and Chinese character recognition at five time points (based on Huang, 1997, p.280)**

| Correlations / Time point | Odd one out (real words) | Odd one out (pseudo words) | Deletion |
|---|---|---|---|
| 1 | .43* | .46** | .62*** |
| 2 # | .60*** | .62*** | .37* |
| 3 | .25 | .19 | .44* |
| 4 | .38* | .33 | .57*** |
| 5 | .58*** | .34 | .38* |

* p< .05   ** p< .01   *** p< .001   # :after the ZF course

To summarize, according to this study, onset-rime PA of Mandarin-speaking children at their school entrance is not an effective predictor of character recognition three years later. A relatively small sample size, limited literacy skills measured and the late starting age were mentioned by Huang as the main constraints of this study. In addition, only a limited range of linguistic levels of PA were taken into account. It would provide a more comprehensive view of the relationship between PA and character acquisition if syllable and tone PA tasks were included. Also, the study measured only the relationship between PA and reading of Chinese characters, it did not examine ZF reading. However, in spite of these limitations, as one of the earliest pieces of research investigating the relationship between PA and literacy acquisition in Mandarin-speaking children, this study makes an important contribution. It presents the impact of learning ZF on PA performance and provides no evidence for the role of visual skills being involved in acquiring the Chinese characters.

Ko and Lee (1996) conducted a similar longitudinal study of the relationship between PA and character recognition among 54 school entrants (average age: 6;4) in a southern central city in Taiwan. They repeatedly measured a range of variables related to literacy acquisition, including ZF letter naming, Chinese character recognition, ZF symbol synthesis, onset deletion task, receptive vocabulary and non-verbal intelligence. The five time points of the measurement included: a) the beginning of the first grade (CA 6;4 years) ; b) five weeks after entrance (CA 6;6 years); c) ten weeks after entrance (CA 6;7 years); d) the end of the first grade (CA 7;2 years); and e) the end of the second grade (CA 8;2 years).

It was found that onset PA measured at school entry consistently predicted character recognition up until the end of the first grade. However, it did not predict character recognition two years later. By extracting the common phonological processing factor in the three tasks – ZF letter naming, ZF symbol synthesis (i.e., producing the syllable synthesized by two or three ZF letter compounds) and onset deletion – and correlating it with character recognition, it was found that, after Grade 1, the level of correlation between the phonological processing factor and the character recognition changed. In general, the correlation between the phonological factor and the character recognition at the next time point decreased, but the level of correlation between the character recognition and the phonological factor at the next time point increased as time went by. For example, the correlation between the phonological factor at the 2$^{nd}$ time and the character recognition at the 3$^{rd}$ time was more than the correlation between the phonological factor at the 3rd time and the character recognition at the 4th time. That is, character-naming skill did not correlate with earlier phonological skills; but at the same time, knowing more characters might facilitate pupils' later phonological skills. The researchers argue that pupils in their early school years might use their phonological processing skills for naming characters, because of the experience of ZF learning.

He, Wang and Anderson (2005), in a study focusing on character acquisition and its relationship to PA of school-age children in northern Mainland China, found that, even in the early years of school (Grade 2), Mandarin-speaking children acquire the strategy of using the sound information, including syllable, onset or tone, provided by the phonetic radical to pronounce the whole syllable. PA was measured by oddity tasks at onset, final consonant and tone levels. In addition, competence in using the sound clues in various linguistic levels, such as syllable, tone, rime or onset level, is not always significantly correlated with its corresponding PA only but is also correlated with PA at different linguistic levels. For example, a child may be good at using syllabic clues based on a good tone PA. The results suggest that, in contrast to the role of PA in alphabetic languages, the overall PA across various linguistic levels in Mandarin-speaking children is more important than PA in any particular level in character acquisition.

Given the complicated language environment of spoken and written languages for Mandarin-speaking children in Taiwan, the extent to which the development of PA in the first years at school is influenced by its language background, both in spoken and written forms, warrants further investigation. Next, the question of whether PA might be a precursor of later literacy performance in Chinese has had contradictory answers in previous studies. The awareness of sound structure of children's spoken language and features of their orthography system might play a role in strengthening selected aspects of PA skills. Thus, knowledge of how Mandarin-speaking children acquire more advanced PA skills as well as their written languages would definitely expand our understanding on the issue, particularly when no systematic and comprehensive study has yet been conducted on the predictive power of early PA for later word-level reading in Chinese, and of early reading for later PA in Mandarin-speaking children.

## 1.3 Rapid Automatized Naming in Reading Acquisition

Rapid automatized naming (RAN) is defined operationally as the speed of naming aloud a series of familiar visual stimuli, such as digits, objects, colours, Zuyin Fuhao letters or Chinese characters, which are randomly and repeatedly presented. It is considered to be a measure of underlying cognitive skills that are also important for reading performance. As RAN tasks are relatively easy to administer they are often used in empirical studies of reading development; the belief being that performance on RAN tasks can differentiate between typical and at risk populations (Wolf, Bowers & Biddle, 2000).

Graphological and non-graphological RAN has been found to be a significant correlate of reading in nearly all languages studied so far. For instance, Tzeng, Chiu and Lin (2003) collected normative data for RAN from children in Taiwan, from preschool to Grade 3. They found better performance on RAN tasks correlated with better performance on the following literacy tasks: character recognition, reading comprehension and school literacy exams. Digit RAN had the highest correlation with all literacy measures.

RAN tasks were also found to be significant logitudinal predictor of reading acquisition: RAN measured early predicts later literacy achievement (Georgiou, Parrila & Kirby, 2006; Ho, Chan, Tsang & Lee, 2002; Tzeng, 2004). More specifically, graphological RAN was found to be a stronger predictor of reading performance than non-graphological RAN, such as colours or objects, after a year of formal literacy education (Wolf, 1991). Those relationships are particularly strong for reading speed/fluency, but weaker for reading accuracy (Liao, Georgiou & Parrila, 2008).

Although both PA and RAN were found to be good predictors of reading performance, PA and RAN seem to explain different, non-overlapping parts of reading variance (e.g., Cutting and Denckla, 2001). The relative importance of RAN and PA as predictors of reading might vary, depending not only on the aspect of reading being measured, such as reading accuracy or reading fluency, but also on language (e.g., stronger in more consistent alphabetic languages) and phase of acquisition (e.g., preschool or after formal education). For example, RAN as a predictor of reading in a transparent orthography, i.e.,Turkish, has been explored in Grade 2 and Grade 4 children (average age: 7;9 and 9;8). In the study, a composite of RAN digits and RAN letters was found to be a more powerful predictor of word reading fluency than PA or vocabulary (Babayiğit & Stainthorp, 2011).

Unlike the grapheme-phoneme link between phonological awareness and reading, the relationships between slow RAN and reading acquisition are still not fully understood (Bowers & Newby-Clark, 2002). The relationships may be attributed to a variety of linguistic and cognitive processes involved in completing RAN tasks, such as attention, visual processing, integrating visual features with orthographic knowledge, accessing related phonological representations, accessing lexical representations, and speech motor programming (Cutting & Denckla, 2001).The hypothesis that processes involved in RAN are also required for reading can be tested by comparing performance on RAN and reading tasks (Wolf, Bowers & Biddle, 2000).

Different competing theoretical models accounting for the relationship between RAN and reading have been advanced over the years. Each of them puts a particular emphasis on one of the processes listed above. For example, Wagner and Torgesen

(1987) considered RAN to be phonological retrieval from long-term memory and index of underlying phonological process), while Cutting and Denckla, (2001) thought it to be a measure of general speed of information processing. Further, studies of participants with dyslexia suggest RAN is a measure of effective integration of information across modalities (e.g.,Wolf & Bowers, 1999) and more recently, in studies of slow RAN performers, RAN was an index of difficulty in discriminating simple visual features (e.g., Stainthorp, Powell, Stuart, Quinlan, & Garwood, 2010).

The role of RAN in recoding written symbols into a sound-based represenational system was first investigated by Wagner and Torgesen (1987). RAN subtests are included in the 'Comprehensive Test of Phonological Processing' (Wagner, Torgesen, & Rashotte, 1999) with phonological awareness and (auditory) working memory as three measures requiring intact underlying phonological processing within the phonological core deficit framework (Wagner, Torgesen, & Rashotte,1999). However, whether slow RAN should be attributed to a core deficit in phonological processing or non-phonological processing, such as orthography processing, has been subject to debate.

Cutting and Denckla (2001) considered whether better RAN implied well-formed orthographic representations in typically developing children (7-to-9-year old) or whether both are correlated but distinct markers of reading skills. They used path analysis to test a model of how RAN and variables, such as orthography legality judgement, phonological awareness, memory span, processing speed and articulation rate, contribute to early word-reading skills. They found RAN, orthographic knowledge and phonological awareness were the only three measures that had a significant direct effect on word reading. Further analysis showed that RAN did not contribute to orthographic knowledge after processing speed was controlled. That is, processing speed might be a factor common to both RAN and orthographic knowledge. Moreover, the researchers indicated that slow RAN and poor orthographic knowledge might be derived from the same source.

Savage and Frederickson (2006) focused on clarifying whether a RAN deficit demonstrates a processing deficit specifically in a linguistic domain or in a more general domain in school-age children (average age 10;7), by examing evidence from patterns of handedness and working memory ability. Their results suggest that automaticity observed in graphological RAN tasks, i. e. automatically rapid processing of activation and retrieval of orthographic representations, reveals a specific effect in RAN rather than a general effect. They also investigated the effect of digit RAN to see whether poor readers and spellers (performing more than1 standard deviation below the population mean on a reading accuracy test) differed from average readers and spellers on this task. They found that poor readers and spellers performed worse than the average groups on a digit naming task, but not on an object naming task. This evidence implies that it is the cognitive processes that underlie graphological RAN that are specifically related to the automaticity of visual processing of script features. However, whether slow RAN is linked to poorer judgement of visual similarity/ difference or word-reading ability is still questionable.

Recent models of reading disability include RAN as a useful measure of possible reading dysfunction which is separable from phonological processing deficit (Bowers & Newby-Clark, 2002; Savage & Frederickson, 2006; Stainthorp, Powell, Stuart, Quinlan, &Garwood, 2010;Wolf & Bowers, 1999). This double-deficit hypothesis emphasizes that RAN has a unique role in demonstrating specific aspects of reading difficulty, such as reading fluency or the attention level required in reading. According to this hypothesis, a separate group of children whose PA is intact but who have poor RAN might have difficulty in reading. Thus, those children who have deficits in both PA and RAN would encounter the most difficulty in literacy acquisition. Powell, Stainthorp, Stuart, Garwood, and Quinlan (2009) carried out a large scale study of 1010 English-speaking children aged 7-10 to examine the double-deficit hypothesis and discover whether other processes apart from phonological processing would drive RAN performance and its link to reading. The results showed a dissociation between RAN and PA, reflecting two at least partly independent phonological processes. Further comparisons between the slow RAN group and the control group in the study showed that, after accounting for speed of processing and simple reaction time, RAN was still a significant predictor of reading. The results suggest that there are still unknown cognitive processes underlying RAN, in addition to generalized processing speed, which might account for the relationship between RAN and reading. Aside from those related to phonology, a group of nonphonological processes, such as visual information processing, lexical accessing and articulating a spoken response, were speculated and planned to investigate further.

More recently, Stainthorp, Powell, Stuart, Quinlan, and Garwood (2010) investigated directly the visual processing deficits in school-age children (age range 8-10 years) who performed slowly on graphological RAN tasks. A series of experiments investigated whether the processing speed deficit in children performing slow in RAN is specific to visual feature discrimination. The results not only indicated that the deficit of visual feature discrimination shown in RAN tasks might contribute to a reading difficulty, but also that the slow visual processing affected letter–sound correspondences developments in the early stage of literacy acquisition. The researchers argued that orthographic processing, such as visual discrimination, and RAN might share a common variance in predicting word reading. It was therefore thought to be possible that deficits in forming orthographic representations of words, such as learning to identify and discriminate letters, might be derived from difficulties in early visual discrimination.

**RAN and Reading in Chinese**

Following the review of studies investigating the links bewteen RAN and reading skills in English-speaking populations, the role of RAN in literacy acquisition of Chinese orthography in Mandarin-speaking children will now be addressed.

In a longitudinal study of Chinese character acquisition by Cheung, McBride-Chang & Chow (2005), four factors significantly predicted literacy outcome: phonological awareness, RAN, visual skills, and morphological awareness. In addition, deficits in phonological awareness and RAN are often found in Chinese children with developmental dyslexia.

Tzeng, Chiu and Lin (2003) used a RAN test battery to investigate the development of RAN from preschool to Grade 3 children from Taiwan. This battery included a range of stimuli such as colour, digit, Zuyin Fuhao letter, object, colour-object mixture and colour-digit-Zuyin Fuhao letter-object mixture. Four hundred and eighty children (average age 5;5-8;5) across four regions of Taiwan were recruited. Significant differences were found between the speeds of five kinds of stimuli between Grade 1 and Grade 2 children, i.e. digit, Zuyin Fuhao letter, object, colour and colour-digit-Zuyin Fuhao letter-object mixture rapid naming. However, between Grade 2 and Grade 3, only digit RAN had significant difference. The speed levels across 4 age groups (average age 5;5, 6;5, 7;5 & 8;5) were consistent in the following sequence: digit (fastest), Zuyin Fuhao letter (skipped in the preschool group), object and colour. The result was attributed to the different amount of exposure to the above stimuli and the complexity of processing. Furthermore, only the speed of digit RAN increased significantly across different age groups until Grade 3 (age 8;5), while the Zuyin Fuhao letter, object and colour RAN appeared to plateau earlier, at Grade 2 (age 7;5). A gender effect was only found at the preschool stage (age 5;5), when girls outperformed boys in the subtasks of digit, colour, object and colour-object mixture. It was suggested by the researchers that this RAN battery should be updated by using a computer program so that more accurate measurement is possible.

Tzeng, Chien, Chang, Chow and Lian (2005) investigated RAN in digit, object and colour for 79 preschool children (average age 5;7) at a city in south-eastern Taiwan. They followed the same cohort until Grade 4 (average age 10;6) in order to examine the predictive effect of RAN for pupils' later performance on character recognition and reading comprehension. It was found that individual differences on RAN in all three types (digit, colour and object) were highly stable over time for Mandarin-speaking children. In particular, digit RAN measured at the preschool stage was not only a good predictor of character recognition at Grades 2, 3 and 4, but also a good predictor of reading comprehension at Grades 3 and 4. The results were in line with the study of a transparent orthography by Babayiğit and Stainthorp (2011) where RAN was a good predictor of reading fluency, and positively linked to later reading comprehension.

McBride-Chang, F. Lam, C. Lam, Doo, Wong and Chow (2008) investigated preschool children (average age 5;1) with a high risk for dyslexia due to either language delay (language delayed group) or a family history of dyslexia (familial risk group). The children's cognitive profiles and word recognition performance were compared to chronological age and IQ control groups. The tasks from four cognitive domains, such as phonological awareness, RAN, visual skills and morphological awareness, were investigated in the study. Digit RAN was the only RAN task conducted.The language delay group performed significantly less well than both the control group and the family history group on all measures, including digit RAN. The family history group performed worse only on tone awareness and morphological awareness. Digit RAN accounted for no significant variance of concurrent word recognition.The results of the study, combined with previous studies showing that the RAN of digits in preschool children accounted for somevariance of later, but not concurrent, character word recognition (e.g. Tzeng et. al., 2005), revealed the developmental relationship between RAN and Chinese word recognition. The evidence that digit RAN lacks a concurrent predicting effect on word recognition might imply that recognizing Chinese characters requires higher-level processing, such as accessing orthographic knowledge or lexical representation, than digit processing (Wolf, 1991).

Hsieh and Tzeng (2004) compared the RAN performance of children with developmental dyslexia with both chronological age and reading age matched control groups. Each group comprised 31 children aged from 9 to 12 years who all lived in a southern county in Taiwan. The study also investigated the extent to which RAN related to character word recognition and reading comprehension. Statistically significant differences were found between the developmental dyslexia and chronological age groups for all RAN subtasks, including digit, Zuyin Fuhao letter, colour, object, digit-Zuyin Fuhao letter mixture, colour-object mixture and colour-digit-Zuyin Fuhao letter-object mixture. Statistically significant differences were also found between developmental dyslexia and reading age groups in the following three subtasks: Zuyin Fuhao letter, colour and colour-object mixture. Moreover, on all the subtasks involving digit or Zuyin letters (digit, Zuyin Fuhao letter, digit-Zuyin Fuhao letter mixture and colour-digit-Zuyin Fuhao letter-object mixture), the chronological age matched controls performed better than the reading age matched controls. The researchers attributed this to the amount of practice because the chronological age group comprised older children than the reading age group and so they had had more exposure to Zuyin letters or digits at school. Another possible explanation of the results mentioned above is that the common underlying deficit of orthographic present in the developmental dyslexia group might lead to poorer performance on both RAN and reading (Cutting & Denckla, 2001).

Additionally, in the above study, for the developmental dyslexia group, it was found that performance on most RAN subtasks, except object RAN, had moderate correlations with children's character recognition, but not with their reading comprehension. Similar patternswere observed in the chronological age and the reading age groups. For the chronological age group, the object and digit RAN had significant correlations with character recognition, where the digit RAN accounted for up to 21 per cent of the variance. The researchers argue that RAN deficit might be a common feature of children with developmental dyslexia and that it is more closely related to their character recognition ability than their reading comprehension. In other words, RAN was consistently found to be associated more with character reading accuracy than character reading fluency in the study. This appears inconsistent with previous studies of children using alphabetic orthography (e.g. Babayiğit & Stainthorp, 2011). A possible explanation of the contradictory findings might be attributed to the generally opaque mapping of Chinese characters: the shared feature of fast visual-verbal pairing in both RAN and character word recognition.This common process between RAN and reading accuracy could not be found for those orthographic systems that require decoding for accessing phonological representation of stimuli.

More recently, the relationship between RAN and character reading has been investigated further. Liao, Georgiou and Parrila (2008) used four RAN tasks (colours, digits, ZF, characters) to analyse each of their concurrent contributions to reading performance, i.e. character recognition and word fluency tasks, in Grade 2 and Grade 4 children (average age: 8 and 10, respectively) in Taiwan. RAN was associated with both accuracy and fluency in character reading; the relationship was higher in Grade 4 children than in Grade 2 children. Moreover, three graphological naming measures (digit, Zhuyin and characters RAN) accounted for the unique and common variance of reading fluency and accuracy, which indicates that RAN involving graphological stimuli may predict concurrent reading better than the RAN tasks with non-graphological stimuli. The researchers attributed the link between RAN and reading accuracy to the automaticity of lexical access in character reading which might be importantin Chinese reading fluency. They also suggested more cross-linguistic studies to understand why the role of RAN varies as a function of the writing system. In other words, whether there is any difference in the predictive power of RAN for reading characters as opposed to reading ZF would be worth exploring.

To conclude, studies reviewed in this section suggest RAN is a relatively stable measure predicting literacy performance across various orthography systems, with some advantages, such as being easy and quick to conduct. Rapid naming measures reflect the level of automaticity of alphanumeric or graphological stimuli processing across visual-verbal modalities. The fact that performing RAN tasks requires the integration of a range of cognitive processes which are also important for reading (such as recognizing words or identifying symbols, accessing phonological information, speech motor programming, and attention) makes the link between RAN and reading even more complicated, not mentioning the changing nature of the link over time. Thus, more studies are needed of different orthographic systems, focussing on the underlying cognitive processing of RAN and investigating its link to the development of orthographic knowledge and its developmental role in literacy acquisition. More specifically, whether RAN, or any of its components, is an important predictor of both reading accuracy and comprehension, is still not clear. Moreover, whether its predictive effect is equally found in Zuyin Fuhao and character literacy, or whether it may predict the acquisition of orthographic knowledge, all warrants further investigation.

## 1.4 Spoken Language Skills in Reading Acquisition

A robust finding in the literature is that children's written language skills are generally acquired on the foundation of their oral language ability, whatever language(s) they speak. For example, Puolakanaho, Ahonen, Aro, Eklund, Leppänen, Poikkeus, Tolvanen, Torppa and Lyytinen (2008) found a highly stable link between very early phonological and language skills and reading outcome at Grade 2 in Finnish-speaking children. Using structural equation modeling they demonstrated that the link between early phonological and language processing and later reading accuracy was stronger than that with reading fluency. Early phonological and language processing was assessed by a battery of key predictive measures, including PA, RAN, short-term memory, expressive vocabulary and pseudo-word repetition. Apart from RAN, the measures commonly shared great variance with the early phonological and language processing, in which PA was the strongest contributor. This section will explore further what oral language skills, apart from PA, are related to reading outcome and how they are related.

The developmental link between spoken language skills, such as oral comprehension and vocabulary, and reading comprehension has been shown in previous studies by Nation and Snowling (2004), Reynolds and Turek (2012), and Ricketts, Nation and Bishop (2007). In addition to reading comprehension, the role of oral language skills in single word recognition has also been investigated. Nation and Snowling (2004) investigated the role of oral language skills in developing word recognition in typically developing children between the ages of 8.5 to 13 years. In this study, broader language skills beyond phonological skills, such as listening comprehension, vocabulary and semantic skills, accounted for unique variance of word recognition, both concurrently and four years later, even after the powerful effects of decoding ability and phonological skills were controlled. Further comparisons showed that general language skills, represented by listening comprehension and vocabulary, contributed more to word recognition than knowledge of specific semantic features tapped by semantic fluency tasks. In addition, vocabulary was found to relate to reading of exceptional words (with inconsistent orthographic-phonological mapping).

Ricketts, Nation, and Bishop (2007) interpreted the above results as consistent with the prediction from the dual-route framework which highlights the interactive but distinctive phonological and semantic pathways to word recognition. They then investigated further the role of vocabulary as a predictor of reading comprehension, decoding and word recognition skills. The results showed that the link between vocabulary and word-level recognition was significant only with irregular words, excluding non-words or regular words. The study also supported the view that the role of underlying vocabulary knowledge was to 'drive the association' between reading comprehension and exceptional words.

The reciprocal relationships between spoken language skills and reading outcome has also been explored. To analyze further the relationship between language skills and learning to read, Nation and Snowling (2007) investigated vocabulary acquisition in8- to 9-year-old English-speaking children who had poor comprehension but intact phonological skills. They trained all participants to acquire four pseudo-words, and monitored children's learning outcomes in their definition knowledge, recall of names and word recognition. Vocabulary acquisition was found to correlate with non-phonological aspects of language skills and reading comprehension, and not with word-level decoding or phonological skills. Furthermore, the ability to learn and remember phonological and semantic information of new vocabulary items in poor comprehenders and in the control group was compared. Although poor comprehenders were found to take a similar number of trials to the control group to learn phonological forms of new words, their knowledge of the meaning of the new vocabulary appeared weaker and they had difficulty in recalling the names. Given that weakness with the non-phonological aspects of language skills is not obvious, the study raised concern about the educational difficulties across school years for those poor comprehenders.

Previous studies of the link between spoken language and reading in Chinese have focused more on the mediating effect of PA and its development (e.g., Cheung, Chen, Lai, Wong & Hills, 2001). Very little is known about the role of spoken language skills in Chinese reading comprehension, and the reciprocal links between them. The consensus appears to be that a similar process occurs in reading Chinese as in other languages (McBride-Chang, Lin, Fong & Shu, 2010).

To conclude, given the wide range of oral language skills, the role of spoken language skills in reading acquisition is various and complicated according to which aspects of reading skills are concerned. For example, the relationship between vocabulary and reading accuracy is potentially different from the link between vocabulary and reading comprehension. Furthermore, these relationships could be different according to whether they mostly concern phonological skills or non-phonological language skills. Thus, although it is difficult to dismiss the possibility that various oral language skills might be linked to Chinese reading acquisition, how phonological and/or lexical aspects of oral language skills relate to specific reading outcomes is still less clear and warrants more investigation.

## 1.5 Toward a Model of Reading Development in Taiwan

The direction of early reading development is from learning to read toward reading to learn. The understanding of how children acquire the skills of decoding the written form of their language(s) and apply them to encode the lexical message of a written script for reading comprehension is essential, and will provide a contextual and global knowledge basis for exploring early literacy development.

According to the meta-analysis research by Gough, Hoover, and Peterson (1996), reading was significantly correlated with both decoding skills and language comprehension. Moreover, the correlations between decoding and reading tended to decline with grade level, and the correlations between comprehension and reading tended to increase with grade level. By presenting the view, rather than a model, in the form of a cross (see Figure 1.9), the *Simple View of Reading* is intended to indicate the two independent dimensions of becoming a skilled reader: word recognition and language comprehension (Catts, Adlof, & Weismer, 2006; Gough, et. al., 1996; Stuart, Stainthorp & Snowling, 2008).

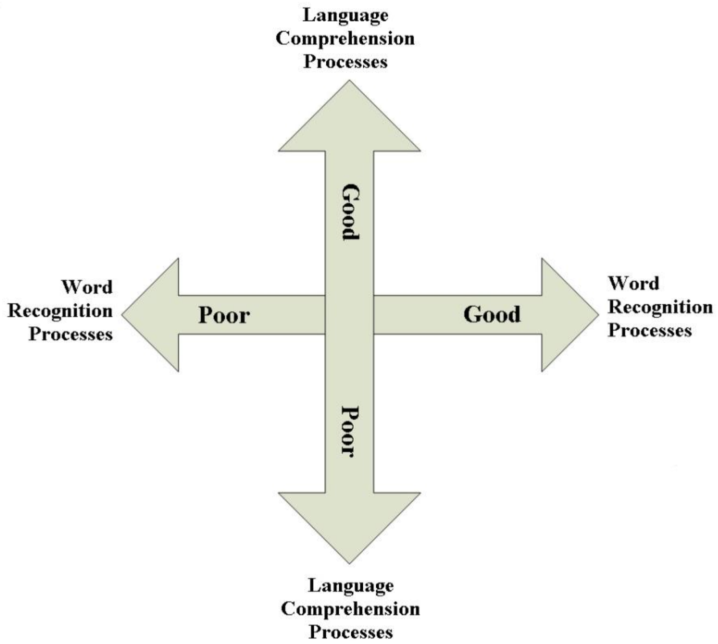


**Figure 1.9 The Simple View of Reading**

(Based on Stuart, Stainthorp, & Snowling, 2008, p. 62)

The comprehension skills elaborated in the *Simple View of Reading* include not only oral language competence, such as vocabulary and syntactic and semantic structures, but also the relevant real-world knowledge for developing reading comprehension (Gough et al., 1996; Stuart et al., 2008).

Moreover, as reviewed in section 1.4, oral language competence may also relate to word recognition at the very beginning of reading development. Catts, Adlof, and Weismer (2006) investigated the language deficit in both poor comprehenders and poor decoders in secondary schools. They then retrospectively traced their performance on reading achievement (reading comprehension and word recognition) and language (language comprehension and phonological processing) in their early school years. They found the distinction between poor comprehenders and poor decoders is in line with predictions derived from the *Simple View of Reading*: (a) poor comprehenders might have similar decoding skills as the typical group but worse general language comprehension; (b) although poor decoders had better discourse comprehension skills than the typical group and compensated for their limited decoding skills, their vocabulary and grammatical understanding were held back compared to typical readers. Thus, deficit in language in early school years seems to have a negative association with and/or impact on both reading comprehension and word recognition.

There are various developmental models focusing on sight word recognition in alphabetic orthographic systems. The underlying changes from pre-reading to fluent reading were described by successive phases. These models highlighted the use of a decoding strategy for beginning readers and the influence of phonological awareness on reading fluency and comprehension (e.g. Ehri, 2005; Nation and Snowling, 2004). Ehri proposed four phases in the development of word reading skills: pre-alphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic (Ehri, 2005; Stuart et al., 2008). However, the theories focusing on the connection between sound and letter strings are unlikely to apply in the same way to the development of word-reading skills in non-alphabetic orthographies, such as Chinese characters.

The only theoretical framework for reading development taking various orthographies into account was proposed by Seymour (2006). This model, which integrates stage models, decoding models and connectionist approaches, assumes that literacy acquisition involves a developmental interaction between linguistic awareness systems and orthographic systems. The model comprises three phases: foundation, orthographic, and morphographic. Both the alphabetic process (decoding skills) and logographic process (sight word recognition) are acquired in the foundation phase. Seymour particularly refers this function to the Oriental orthographies with more arbitrary script-sound mappings (Seymour, 2006). The two diverse orthography systems taught in the first school year in Taiwan (see section 1.1.3) seem to be in line with both of the key skills acquired in the foundation phase. However, the impact and/or outcome of literacy instruction underlying two diverse processes on early reading development are still unclear, and warrant further investigation.

To conclude, a model of early reading development which takes into account the Chinese language/script, and the education context in Taiwan is needed. In order to present the developing link between orthographic forms of words and their pronunciation/meaning, the model would include the two sets of processes of early literacy acquisition: (a) phonically based decoding processes; b) sight word recognition (Stuart et al., 2008). According to previous studies (see sections 1.2.1 and 1.3), these two processes are closely associated with phonological awareness and/or rapid naming in either alphabetic or non-alphabetic orthographic systems, apart from the contextual and semantic information derived from oral language skills. Therefore, it is plausible to investigate early reading development in Mandarin-speaking children in their specific linguistic and orthography context, with three key components, namely phonological awareness, rapid naming and spoken language skills.

## 1.6 Research Topics

The present study focuses on the critical transitional period of learning to read two diverse orthographies during the first school year in Mandarin-speaking children and aims to fill in some of the gaps reported in this literature review. It systematically investigates the trajectory of literacy acquisition and the different effects of instruction in ZF and CH in addition to how literacy acquisition links to the development of its critical cognitive factors, such as PA and RAN, and spoken language skills.

Thus, five research topics and their subordinate research questions are listed as follows:

1. Development of Phonological Awareness and How it Relates to Speech and Language Measures

    1a. What is the development of PA in the first school year?

    1b. How does PA relate to spoken language skills at this stage?

2. Development of Literacy and Rapid Automatized Naming

    2a. How do literacy and rapid naming skills develop in the two orthography systems?

    2b. How does the development of literacy skills depend on the writing system used?

3. The Predictors of PA and Literacy Acquisition

    3a. How are literacy skills in Grade 1 and 2 predicted by measures of PA, RAN and spoken language?

    3b. How is PA in Grade 1 and 2 predicted by measures of spoken language, literacy skills and RAN?

4. Differences in Literacy, PA, RAN and Spoken Language between Typically and Atypically Developing Children in speech output skills

4a. Do children with atypical speech or reading development at the 1st grade continue to perform less well on PA and/or literacy a year later?

4b. Does that depend on the writing system used?

5. Differences in Literacy, PA, RAN and Spoken Language between Typically and Atypically Developing Children in reading

5a. Can atypical literacy performance at the 2nd grade be traced back to a poor performance on spoken language skills, PA, RAN and/or literacy at school entrance?

5b. Do those differences between children with typically and atypically developing reading skills depend on the writing system of the tasks?

The results relating to the five major topics will be presented in the four later chapters of research results in sequence. The fourth and fifth topics will be combined in a single chapter due to the similarity in their methodology. The next chapter will first present the methodology adopted in the study.

# Chapter 2 Methodology

## 2.1 Research Design

A one-year longitudinal design was adopted; data collections were conducted from September to November in 2009 and 2010. In the first year of the study, the children were in Grade 1 at school; and in the second year of the study, they were in grade 2. Similar data were collected twice, at the beginning of Grades 1 and 2, in order to investigate how literacy, PA and naming skills develop during the first year of learning to read and write. The overview of the design is shown in Figure 2.1. The detailed timetable of when each measure was conducted will be introduced later, in the procedure section.

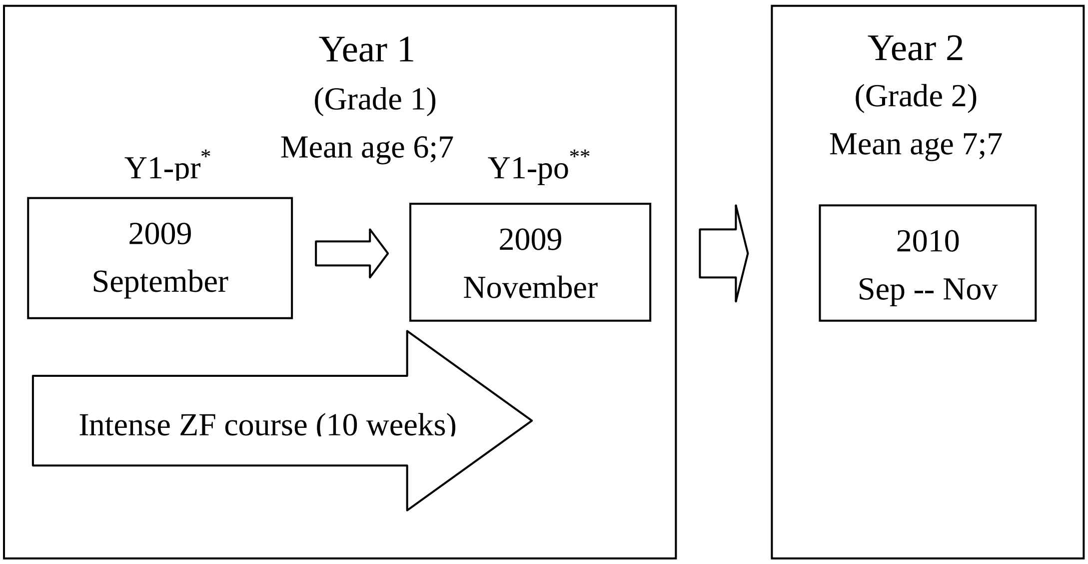


**Figure 2.1 Overview of study time frame**

* Y1-pr: Year 1 before ZF course

** Y1-po: Year 1 after ZF course

The following baseline competences were investigated during the first ten weeks of schooling in year 1 (average age 6 years and 7 months: PA, speech and language, literacy skills, RAN, and non-verbal intelligence. These competences were followed up in year 2 (average age 7;7), except for the ZF accuracy task.

The ZF accuracy task was carried out twice in Year 1, at the beginning and the end of the ten-week intensive ZF course (Y1-pr and Y1-po), in order to trace the development of ZF decoding skill in this short period of intensive teaching. It was conducted again in Year 2.

Ethical approval for the study was granted separately for Year 1 and Year 2 by the Departmental Ethics Committee of the Department of Human Communication Sciences, University of Sheffield (see Appendix 2:1).

## 2.2 Participants

All participants were recruited from one elementary school in Taipei, Taiwan (S). Originally another school (W) was randomly chosen, but it had fewer Grade 1 pupils than expected. There were sixty-five classes with 1731 pupils in total in the S elementary school. In Taipei, the capital of Taiwan, sixteen per cent of public elementary schools are very large, i.e. they have more than 1200 pupils (Department of Statistics of Ministry of Education in Taiwan, 2010).

By conducting a power calculation, the target number of participants must be over 74 to have a sufficiently large sample for the implicit PA tasks. The researchers invited five out of ten Grade 1 teachers who were in charge of a class with 20-25 pupils each to take part in this longitudinal study. With the help of the Grade 1 head teacher, an instruction meeting for the researcher to explain the study to all the teachers involved was held before year 1 started. Then the five teachers introduced the researcher to all parents of their pupils on a parents' visiting day. The researcher then gave a presentation of the study to parents and therefore recruited enough participants at the beginning of schooling. Subsequently, the five teachers were asked to distribute the information and consent letters to their pupils' parents.

Ninety seven pupils (nearly 80%) in the five classes were able to participate in this study with their parents' consent in Year 1. All of the participants and teachers were informed in Year 1 that there would be a follow-up in the next school year. The follow-up was carried out around one year later, during September, October and November 2010. All the parents of the previous participants were invited to agree to their child taking part in this study again. Ninety-two of them remained in the cohort one year later, in Year 2 (shown in Table 2.1).

**Table 2.1 Parental consent rate in Year 1 and Year 2**

| Year | | Class | | | | | Total |
|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | |
| Year 1 | No. of students | 24 | 25 | 22 | 26 | 26 | 123 |
| | Consent obtained | 22 | 18 | 15 | 22 | 20 | 97 |
| | Percentage (%) | 92 | 72 | 68 | 85 | 77 | 79 |
| Year 2 | Consent obtained | 20 | 17 | 15 | 20 | 20 | 92 |
| | Percentage (%) of Year 1 cohort | 91 | 94 | 100 | 91 | 100 | 95 |

Regarding consent to audio-recording and/or the playing of audio recordings in public, in Year 1, two parents agreed for their children to take part in the study, but did not agree to their children being audio-recorded. One of the two children was later identified by the researcher as having a speech difficulty. At the second year, parents of five children refused to let their child be audio-recorded. Another two parents consented to the audio-recording of their children only if these recordings would not be played in public.

The 'Child's family information and development' questionnaire (see Appendix 2:2) was given to parents who agreed to their child taking part in this project in Year 1. The outline of the questionnaire includes:

- date of birth

· parents' nationality

· parents' education

· family's general income per month

· family language

· special concerns regarding the child's speech and language development

· whether the child has received speech and language intervention before schooling

Two parents, however, did not return the questionnaire after two reminders. The findings from this questionnaire and other demographic data reported in the questionnaire will be presented in detail here to contextualise the participants in the study.

Firstly, the range of ages in this group was from 6;0 to 7;0 with almost equal number of boys (48) and girls (49). In Taiwan, children are enrolled at school after their 6th birthday so the average age of all participants was 6;7 with 3.42 (month) standard deviation. No significant interaction between these two variables (sex and age) was found.

**Socioeconomic Status (SES)**

The distribution of income in the study sample is summarized in Table 2.2. It diverged somewhat from the income distribution in the general Taiwan population, with poorer families being under-represented. This divergence was statistically significant: $\chi^2$ (3) = 9.10, $p < .05$. This result was not surprising since the cohort was recruited from the capital of Taiwan where the socioeconomic status is above the national average.

**Table 2.2 Participants' family income per month compared to families in Taiwan**

| Family income per month | Families in the study 2009 | | | Families in Taiwan 2008-09 ** | | |
|---|---|---|---|---|---|---|
| | No. | Percentage(%) | Cumulative percentage | No. | Percentage (%) | Cumulative percentage |
| below NT*50,000 | 11 | 11.6 | 11.6 | 1719196 | 22.8 | 22.8 |
| NT50,000 to NT100.000 | 50 | 52.6 | 64.2 | 3022362 | 40.1 | 62.9 |
| NT100,000 to NT200.000 | 28 | 29.5 | 93.7 | 2355207 | 31. 2 | 94.1 |
| above NT200,000 | 6 | 6.3 | 100.0 | 447864 | 5.9 | 100.0 |
| 777(missing data) | 2 | | | | | |
| Total | 97 | 100.0 | | 7544629 | 100.0 | |

*NT= Unit of Taiwanese Dollar

** Source: Directorate-General of Budget, Accounting and Statistics, Executive Yuan, 2009

**Parental Education**

The educational level of participants' parents is given in Table 2.3 below. More than eighty per cent of parents held a degree; the figures were similar for mothers and fathers.

**Table 2.3 Educational level of parents**

| Level of education | Mother | | Father | |
|---|---|---|---|---|
| | Number | % | Number | % |
| Masters or PhD | 8 | 8.5 | 17 | 18.3 |
| University* | 33 | 35.1 | 31 | 33.3 |
| College** | 35 | 37.2 | 29 | 31.2 |
| Secondary school | 18 | 19.1 | 16 | 17.2 |
| Not specified or missing data | 3 | | 4 | |

* University: Four-year academic study after secondary school

** College: Two or four-year technically oriented training degree after secondary school

**Parents' Nationality**

Up to ninety per cent of parents were Taiwanese. Only five mothers and one father were immigrants from other Asian countries. The nationality of participants' parents is given in Table 2.4 below.

**Table 2.4 Nationality of parents**

| Nationality | Mother | | Father | |
|---|---|---|---|---|
| | Number | % | Number | % |
| Taiwan | 89 | 94.7 | 93 | 98.9 |
| Mainland China | 4 | 4.2 | 0 | 0 |
| Vietnam | 0 | 0 | 1 | 1.1 |
| Burma | 1 | 1.1 | 0 | 0 |
| Not specified or missing data | 3 | | 3 | |

**Languages Spoken at Home**

Around sixty per cent of children were growing up in a bilingual environment, namely Mandarin and Taiwanese. In nearly seventy per cent of the families, Mandarin was used more than three-quarters of the time. It was a dominant language in the community where the data were collected. The next most popular language was Taiwanese. Nearly ten per cent of children had learnt three languages. Table 2.5 presents information on languages spoken by the cohort.

**Table 2.5 Overview of languages used at home**

| Languages used in family | Number | Percentage (%) |
|---|---|---|
| Mandarin: 100% | 27 | 27.8 |
| Mandarin: 75%$^{+*}$, Taiwanese: 25%$^{-}$ | 38 | 39.2 |
| Mandarin: 50%$^{+}$, Taiwanese: 50%$^{-}$ | 18 | 18.6 |
| Mandarin: 50%, Taiwanese: 50% | 3 | 3.1 |
| Mandarin: 50% , Taiwanese and Others: 50% | 8 | 8.2 |
| Mandarin: 50%$^{-}$, Taiwanese: 50%$^{+}$ | 1 | 1 |
| Missing | 2 | 2.4 |
| Total | 97 | |

* +/-: equal or more / less

In order to clarify whether the above familial factors are independent of each other, a chi-square test was conducted. It was found that SES depended on father's and mother's level of education (father: $\chi^2(9) = 18.7$, $p<.05$; mother: $\chi^2(9) = 31.1$, $p<.001$). Moreover, father's educational level was also not independent of mother's educational level, $\chi^2(9) = 60.5$, $p<.001$. However, further analysis found that languages used in families were completely independent of SES and parents' educational level. This result indicates indirectly how common it is for children in Taiwan to live in a multilingual environment.

Lastly, a proportion of parents reported concerns and treatment in the questionnaire about their child's low speech intelligibility or language delay. Regarding this atypically developing group of children, further details will be presented altogether in the Chapter Six.

## 2.3 Measures

Where available and appropriate, the measures used in the study were published tests. There were six of these in the study. Another case is the school-wide exams which were designed by teachers and used only in the S primary school. The rest thirteen measurements were designed by the researcher and developed their procedures. These are indicated as 'experimental' in the list below. All twenty measures used were categorized into five groups as follows:

1. Nonverbal intelligence:
    - 'Test of Nonverbal Intelligence' (TONI) (Brown et al., 1996).

2. Speech and language measures:
    - Picture naming (Experimental)
    - Peabody Picture Vocabulary Test (PPVT) (Dunn et al., 1981)

- Auditory memory (Lin & Chi, 2002)
- Semantic fluency (Experimental)
- Pseudo-word memory span (Experimental)

3. Phonological Awareness (PA) (Experimental)
   - Implicit PA (ImPA): syllable, phoneme, onset, rime and tone
   - Explicit PA (ExPA): syllable, phoneme, onset, rime and tone

4. Literacy measures included tests of the following:
   - ZF reading accuracy task (Experimental)
   - Character reading accuracy task (Experimental)
   - ZF letter knowledge (Experimental)
   - Character recognition (Huang, 2001)
   - ZF spelling task (Experimental)
   - School-wide literacy examination* (Taipei Municipal Shilin elementary school, 2008 & 2009)
   - Legality of Chinese character task (Wang, Perfetti & Liu, 2005)
   - The test of reading comprehension (Chang & Yang, 2005)

5. Rapid automatized naming (RAN) (Experimental)
   - Digit naming
   - Object naming
   - ZF naming
   - Character naming

* Administered by the school teachers

Six of the twenty tasks listed above were repeated in Year 2. These were:

- ZF reading accuracy
- Character recognition

- Implicit phonological awareness
- Explicit phonological awareness
- Digit naming
- Object naming

The remaining fourteen tasks were administered only once, for a variety of reasons. The speech and language tasks were only used once since speech and language development was not the main theme of the study. The same applied to non-verbal intelligence. Another reason for using certain measures just once was participants' rapid progress in literacy. Since ZF was learnt at the beginning of Year 1, ZF letter knowledge and the ZF spelling test were administered during that period of time only. However, character reading accuracy, the legality of Chinese character task, ZF naming and character naming were tested in Year 2 when children had been learning both ZF and characters for more than nine months.

Table 2.6 indicates when each task was administered. ZF spelling task, reading comprehension and two school-wide literacy examinations were administered to a whole class. Only the test of nonverbal intelligence was administered to groups. The remaining tasks were administered to individuals.

**Table 2.6 The time when each task was administered**

| Task | Year 1 | Year 2 |
|---|---|---|
| 1. Nonverbal reasoning | | |
| Test of Nonverbal Intelligence | ✔ | |
| 2. The speech and language measures | | |
| Picture Naming | ✔ | |
| Peabody Picture Vocabulary Test | ✔ | |
| Auditory memory | ✔ | |
| Semantic Fluency | ✔ | |
| Non-word memory span | | ✔ |
| 3. Phonological Awareness | | |
| Implicit PA | ✔ | ✔ |
| Explicit PA | ✔ | ✔ |
| 4. The literacy measures | | |
| ZF Reading accuracy* | ✔ | ✔ |
| Letter Knowledge of ZF | ✔ | |
| ZF Spelling task | ✔ | |
| Character Reading accuracy | | ✔ |
| Character recognition | ✔ | ✔ |
| School-wide literacy examination (different content in Year 1 and Year2) | ✔ | ✔ |
| Chinese Character Legality task | | ✔ |
| Reading Comprehension | | ✔ |
| 5. Rapid automatized naming (RAN) | | |
| Digit naming* | ✔ | ✔ |
| Object naming* | ✔ | ✔ |
| ZF naming | | ✔ |
| Character naming | | ✔ |

* Tasks repeatedly measured in year 1 (see figure 2.1): Y1-pr marks its first conduction; Y1-po marks its second conduction.

A detailed description of each task follows. It covers five aspects:

- the skills that the task was intended to measure
- the content of the task
- its previously established reliability and validity (if available in published sources)
- task administration procedure
- task scoring procedure.

### 2.3.1 Nonverbal Intelligence

The published and standardized 'Test of Nonverbal Intelligence' (TONI) (Brown et al., 1996) was administered in Year 1 in order to discover if participants' non-verbal intelligence affected their performance across the broad range of cognitive tasks. In addition, the result of TONI would identify those participants with high or low IQ so that further analysis of their performance might be possible.

There were two Mandarin versions of TONI. The one for younger children (CA: 4 to 7;5) was used in the project. The test has been adopted and standardized nationwide for the Taiwan population (Wu, Tsai, Hu, Wang, Lin & Kao, 2006). The test manual reports internal consistency of .86 and test-retest reliability of .83. Children were presented with a series of abstract/figural content, each including an empty cell, and had to point to one element (out of six provided) that would fill that cell. Identification of the right element required one of nine principles: *sameness*, *similarity*, *adding in*, *taking away*, *changing the direction*, *changing the pattern*, *categorization*, *crossing addition* and *gradually changing*.

TONI can be administered to groups of up to five children or individually. In the study, TONI was used in both ways according to practical arrangements at the moment. Considering the possible difficulties 6-year-olds may have with using a pencil to fill in the sheet, it was decided to ask participants to mark the answer by sticking a piece of paper on their chosen answer. It took around thirty to forty minutes per child to complete the TONI. Testers, who will be introduced in detail in the later procedure section, would then transcribe those marks onto a sheet. The number of correct answers was noted and converted into a standard score.

### 2.3.2 Speech and/or Language Measures

There were five speech and language tasks in this study. Four of them were conducted in Year 1; only the non-word span task was conducted in Year 2.

**Picture Naming**

This picture-naming task was specifically designed for this study to assess children's speech output skills (see Appendix 2:3). It was administered at both year 1 and 2 to assess or follow up children's speech output skills. It comprised a picture with thirty target items in it. All the items were high frequency words for grade one pupils according to grade-one teachers' comments. The pronunciation of these items included all possible speech sounds in Mandarin. In addition, the thirty words were high-frequency words for school entrants, e.g. 'butterfly', 'birthday cake'.

Participants were asked to name items in the picture in the same sequence as directed by the tester. If participants produced an alternative name for the target word, they were phonologically or semantically cued by the tester to provide the right word. On some rare occasions when a participant could not get the target name, the tester would supply the target and ask the child to repeat it. If the child could imitate it correctly, the response was allowed. Children's answers were recorded by an external microphone connected to a laptop for transcription and analysis. Only atypical speech outputs would be transcribed and analysed. The number of words pronounced correctly was noted as the raw score.

**Receptive Vocabulary**

The Peabody Picture Vocabulary Test (PPVT) (Dunn et al., 1981) was administered in Year 1, to assess participants' receptive vocabulary skills. This test has been standardised nationwide on Taiwanese children in the age range of 3 to 12 years old (Lu & Liu, 1998). Its test manual reports split-half reliability of .90 to .97, and test-retest reliability of .84.

Participants were shown four pictures on the laptop screen in front of them and heard a target word spoken by a tester. A child was asked to point to the picture corresponding to the word spoken by the examiner. The scoring is defined in the manual of this published test and was strictly followed in the study.

**Auditory Memory**

The auditory memory task was taken from the input subtasks of the Oral Comprehension test (Lin & Chi, 2002), which is a standardized test used for assessing oral comprehension skills in children aged from 6 to 11 years. The other subtasks in this test are syntactic comprehension, semantic judgement, and discourse comprehension. All these subtasks may be carried out separately. The auditory memory subtest is intended to assess auditory processing, working memory capacity, sentence comprehension and the comprehension of spatial terms (Lin & Chi, 2002). Its test manual reports the internal consistency of auditory memory tasks as 0.75, and test-retest reliability as 0.74.

In the auditory memory subtask, children were shown a picture and asked to point to the target(s) in a certain order according to the tester's instructions: for example, an English translation would be 'Point to the butterfly next to the dark car on the bottom line'. All of the instructions included only spatial and/or superlative terms which may be properly used in a testing environment (Lin & Chi, 2002). There were eighteen items in this subtask. The formal testing was preceded by a brief training phase. The raw scores (the number of correct responses) were converted into T scores according to the table of norms in the test manual.

**Semantic Fluency**

The test is a Mandarin translation of the English language semantic fluency task which forms a part of the 'Phonological Assessment Battery' (PhAB) (Frederickson, Frith & Reason, 1998).

Participants were asked to say as many names of foods as possible within twenty seconds (part one). They were then asked to produce as many names of animals as they could within twenty seconds (part two). The interval between these two parts was less than twenty seconds. One practice trial was performed in order to familiarize participants with the task. The number of correct responses was noted as the raw score. The average of the raw scores from the two subtasks (parts 1 and 2) was calculated afterwards.

**Pseudo-word Memory Span**

The pseudo-word memory span task was a task designed by the researcher in order to discover the capacity of working memory in processing and repeating a string of sounds without lexical or visual information. This capacity is necessary for implicit phonological awareness tasks, particularly at the syllable level. A memory span of at least four syllables is required for this. Therefore, the pseudo-words used in this task were all derived from the PA test battery designed by the researcher (introduced in 2.3.3), and covered as much phonological variety at onset, rime or tone levels as possible. The level of word span in this task started from three pseudo-words and ended at nine. There are two items at each level. It took around five to ten minutes to complete this task (see Appendix 2:4).

Children were asked to repeat all syllables (or pseudo-words) they heard in the audio recording, retaining the order. Instruction and three practice trials with one to three syllables preceded the formal task. The testing stopped when the child failed on both items at the same span level. No second chance, except self-correction, was allowed. Children's utterances were recorded and transcribed. Only fully accurate repetitions were scored as correct. In addition, in order to reflect the difficulty level, the scoring of this test weighted the number of syllables as in the Digit Span test in the 'Wechsler Intelligence Test for Children' (Chen & Hung, 2004). Each correct three-syllable answer scored four points, and two more points were added for each additional syllable; i.e. a correct four-syllable answer scored six points, and eight points were given for a correct five-syllable answer.

### 2.3.3 Phonological Awareness

The battery of phonological awareness designed by the researcher included both implicit phonological awareness (ImPA) and explicit phonological awareness (ExPA) tasks (defined in section 1.3). All the stimuli used in the test are pseudo-words with sound structures typical of Mandarin, except for four per cent of the stimuli (7 words), which were low-frequency words in Mandarin or Taiwanese. The stimuli were selected by the researcher to cover as much of a variety of combinations of consonants, vowels and tones in Mandarin as is possible. The original version of the PA test battery was piloted on three Mandarin-speaking children (aged 12, 9 and 6 years), following which the instructions were modified to make them shorter and understandable for school-aged children.

To achieve efficiency and decrease misjudgement by testers, a software version of the PA battery was developed by a professional designer collaborating with the researcher. This PA software tool provides a graphical user interface for the following functions: a) presenting visual and auditory stimuli simultaneously; b) recording the speech output of a participant; c) repeating a selected item when necessary; d) recording the responses to implicit PA tasks, matching each of them against a list and then producing the raw score. The PA software was repeatedly tested before use to make sure the method of demonstrating stimuli was suitable to enable a child to respond without distraction.

PA skill was tested both implicitly and explicitly at five levels (defined in section 1.1.1.1): syllable, rime, onset, phoneme and tone (see table 2.7). At each level, there were ten items, except for onset where there were fifteen items. The extra five items focused on the onset units which exist only in Mandarin. They were specifically designed to investigate whether pupils from Taiwanese-speaking or non-Mandarin-dominant families would have any disadvantages in PA development or literacy acquisition.

**Table 2.7 Number of items for each PA subtask in the PA battery**

| Linguistic Levels | Implicit PA | Explicit PA |
| --- | --- | --- |
| Syllable | 10 | 10 |
| Rime | 10 | 10 |
| Onset | 15 | 15 |
| Phoneme | 10 | 10 |
| Tone | 10 | 10 |
| Total | 55 | 55 |

**Implicit PA vs Explicit PA Tasks**

Implicit PA tasks are detection tasks where children have to detect a common unit between the target word and the correct option. There were two foils in each item so the chance level was 33%. Explicit PA tasks were segmentation production tasks where children had to pronounce the common unit; for example, the child had to say /ai/ when hearing /bai/ and /tai/. Therefore, neither foils nor chance were involved in explicit PA tasks.

For all implicit PA tasks, the presentations (see Figure 2.2) were as follows:

1. An animal appeared and said something.
2. Three girls or boys then appeared and said something one after another. A number was shown on each girl or boy's body; the bodies were dressed in different colours.
3. Children were asked to indicate which girl or boy had said something (target unit) that matched part of what the animal had just said. They could respond by pointing or giving a number.

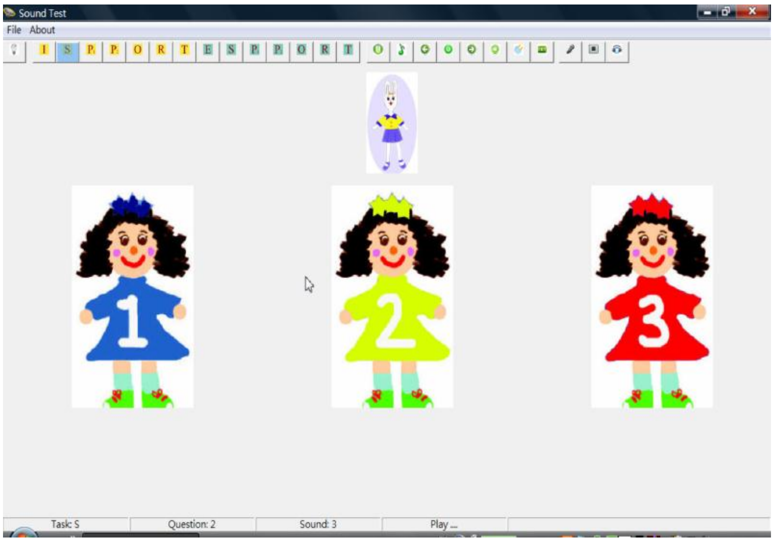

**Figure 2.2 The presentation of an implicit PA test**

For all explicit PA tasks, the presentations (see Figure 2.3) were as follows:

1. Two girls or two boys appeared and said something one after another.
2. Children were asked to say aloud the shared unit in between two stimuli.

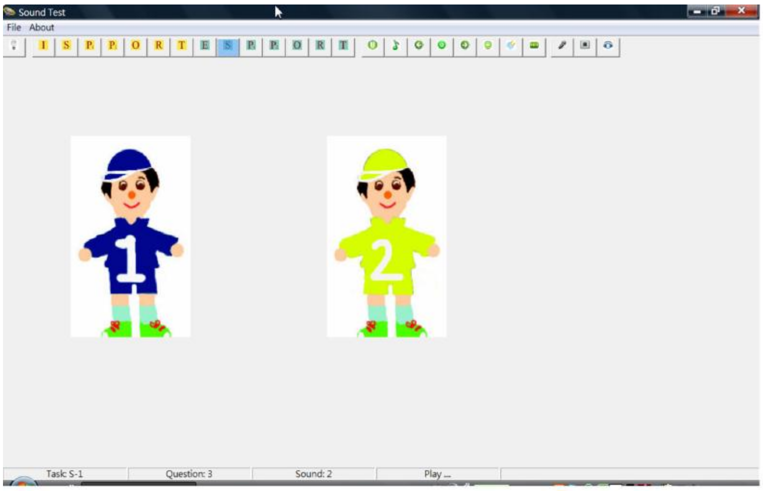

**Figure 2.3 The presentation of an explicit PA test**

Five phonological levels were covered in this PA test: syllable, onset, rime, phoneme and tone. Four tones were included and distributed randomly across items. In the

Implicit PA tasks, the placement of answers was evenly distributed among three options. Overlapping phonemes shared between the matched pair (target sound and correct option) and the remaining two foils were avoided as much as possible; but phonemes shared between two foils (e.g. /u/ in the onset example in Table 2.7) are allowed. The full set of stimuli is presented in Appendix 2:5. Table 2.8 demonstrates an example of each level of implicit PA tasks.

**Table 2.8 Examples of implicit PA tasks at five levels**

| Level | Target | Option1 | Option2 | Option3 |
|---|---|---|---|---|
| Syllable | xo˨˩˦tsi˥ | nɛ˨˩˦tsi˥ | tʃʰɛ˨˩˦pə˥ | tsʰy˨˩˦fə˥ |
| Rime | ɹ̪a˥ | pɛ˥ | tə˥ | na˥ |
| Onset | tʰei˥ | nou˥ | lua˥ | tʰio˥ |
| Phoneme1 | tsʰyo˨˩˦ | fua˨˩˦ | pʰə˨˩˦ | lyɛ˨˩˦ |
| Phoneme2 | tʰin˨˩˦ | sə˨˩˦ | pʰan˨˩˦ | pʌŋ˨˩˦ |
| Tone | tsə˥ | tʰɛ˥ | lo˧˥ | pʰy˨˩˦ |

The same syllable pattern was used across all stimuli in the same item, including the tone level. The only exception is the tone tasks where all stimuli in an item shared a same syllable pattern only. Further details of syllable pattern and design in each level are presented as follows:

- Syllable tasks: Syllables of CV, CVC and CMV structure were used (M: medial; similar to /i/ in ‘fiat’; a single vowel). These three syllable structures are rather typical in Mandarin. Each pseudo-word stimulus consisted of two syllables which were not similar to any real word in Mandarin or Taiwanese. The placement of the target syllable (the first or the second syllable of a two-syllable pseudo-word) was balanced across the test items.
- Rime tasks: CV and CMV syllables were used. Thus, the rime which the children were asked to process was always in an open syllable. This was because the majority of words in Mandarin end in a vowel.

- Onset tasks: CV and CMV syllables were used. Thus, the onsets which children were asked to process were always consonants. This was because the majority of words in Mandarin start with a consonant.
- Phoneme tasks: In the first six items, the sound structure of CMV was kept the same for all the stimuli except one foil where CV is its sound structure. In the last four items, CVC was the only chosen sound structure except one foil where CV is its sound structure. The target phoneme which the children were asked to process was the medial (i.e. /i/, /u/ or /y/) in the first six items and final nasal consonants in the last four items.
- Tone tasks: CV and CVC syllables were used. Four tones of Mandarin were the target units which the children were asked to process.

**Administration and Scoring of PA Test**

All tasks were presented on a laptop, using prerecorded audio stimuli. This battery was designed specifically for this study, using a computer software program, in order to standardize the presentation for each participant and to record a child's response easily and simultaneously. Another advantage of this IT program was to offer visual input beyond auditory input. The visual input was to support participants' understanding of the task and to reduce the memory loading, especially on implicit PA tasks. In addition, different animal figures were used to represent various phonological units so that children might be more aware of what was being tested and not be confused between different tasks.

Because items were matched across the explicit PA test and the implicit PA test, it was necessary to administer the implicit PA test first and to set a certain interval of at least forty minutes between these two tests.

The stimuli were generally presented just once, except when: (a) any sudden noise or interruption prevented the child from hearing a stimulus properly; (b) a child did not respond at all for five seconds or more; (c) a child asked for repetition, or otherwise indicated that s/he would like a repetition. If a child responded correctly following the second presentation, the answer was scored as correct.

The first three items for each subtask were training trials in which, following the child's response, the researcher would explain why their answer was correct or not. This was to make sure every child received the same amount of pre-test instruction. After three training trials, if a child appeared to have no insight into what was being tested on the fourth item, the rest of the items were not administered. This was to ensure that the PA task would not cause any distress to children.

In order to ensure that a child was processing each stimulus equally, the instruction did not explicitly mention the segment and/or linguistic unit under test except in the tone tasks. Tones were particularly mentioned in the instruction for the tone tasks in order to avoid any confusion about what was the target unit to be matched.

Each response was scored as correct or incorrect. A 'no response' was also scored as incorrect. The maximum score for each task was 10, except in the onset tasks, where the maximum score was 15.

### 2.3.4 Literacy Measures

**ZF Letter Knowledge**

All thirty-seven ZF letters were printed on a sheet of A4 paper in a random sequence (see Appendix 2:6). The ZF letter knowledge task was conducted individually. Participants were asked to read out the letter name of any letters they knew one after another in the order shown on the sheet. Participants' responses were recorded with an external microphone on a laptop. The number of correct names, either letter names or sounds, was recorded on the answer sheet. The articulation of the letter names or sounds was not strictly examined as long as the pronunciation of each letter was recognizable and distinguishable from similar letters.

**ZF Reading Accuracy Task**

The ZF reading task was specifically designed to assess the accuracy rate of picture-to-word matching. It was a speed test for a participant was asked to respond as quickly as possible within the time limit of thirty seconds. Black and white line drawings represented two-syllabic ZF words in Mandarin which were all high-frequency vocabulary for children of this age. The full set of stimuli is presented in Appendix 2:6. Each child was presented with a picture under which were three words written in ZF. The child was asked to point to the word that was the name of the picture. The presentation of the ZF reading accuracy task is shown in Figure 2.4 where the correct answer is the second option.

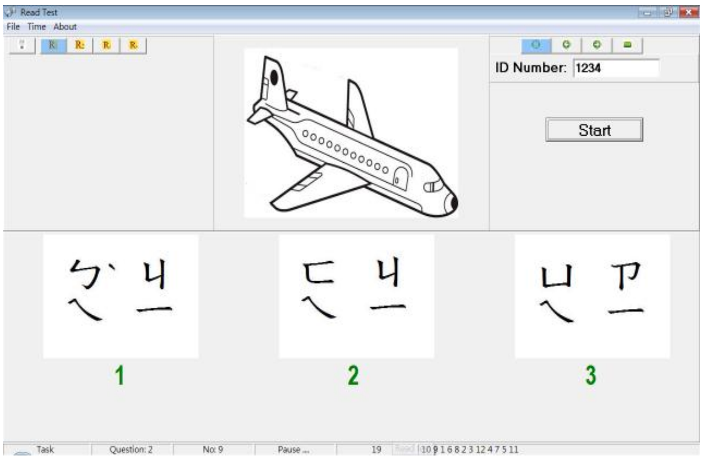


**Figure 2.4 The presentation of the ZF reading accuracy task (Correct answer: 2)**

The task comprised two 12-item subtasks. In each subtask, there were two practice trials and twelve different items. The twelve items were presented randomly in each subtask so that, even if children were tested twice in a short interval, the practice effect was minimized. Correct answers were distributed evenly over three different positions in each subtask. In each item, one of the foils was visually similar to the correct answer. This foil and the correct answer differed in the first or last letter. Foils included pseudo- or real letters or characters that were visually similar to the target, according to the judgement of an English native speaker who did not know ZF and Mandarin. The other kind of foil was a phonological-lexical one: that is, it was a true written word that shared the same first or second syllable and/or meaning with the answer. In Figure 2.4, options 1 and 3 are phonological-lexical and visual foils respectively. The full set of stimuli is presented in Appendix 2:7.

Before starting the task, participants were informed there would be a picture on the screen of a laptop and three options for its written ZF word. They were asked to point to or say the number of their answer as quickly and accurately as possible. As soon as the children answered, the tester would press a button and present the next item. Each subtask lasted 30 seconds. The interval between two subtasks was shorter than 20 seconds. The number of correct responses was recorded. In addition, the number of phonological-lexical and visual errors was noted for later analysis.

**Character Reading Accuracy Task**

In order to compare the reading accuracy rate between the two orthography systems used in schools, the character reading accuracy task was designed to mirror the ZF reading task above (see Figure 2.5; options 2 and 3 are visual and phonological-lexical foils respectively). All the words used in this task were chosen from Grade 1 literacy textbooks, so the vocabulary and their written forms should be familiar to participants. The full set of stimuli is presented in Appendix 2:8.

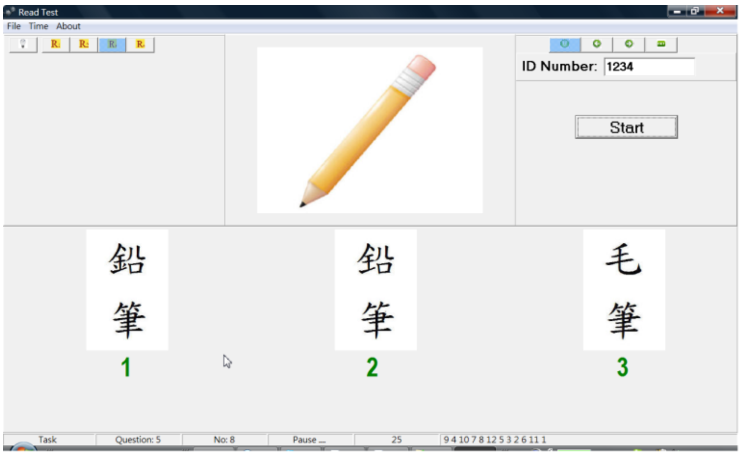


**Figure 2.5 The presentation of the character reading accuracy test**

**ZF Spelling Task**

The ZF spelling task was designed to examine the effect of speech processing and regularity in spelling for school entrants. This task is a paper-pencil task administered to the whole class at Y1-po only (see fig. 2.1). It had twenty dictation items for the children to write down. The presentation of the task was pre-recorded in a quiet room with a digital recorder by the researcher.

Ten items of the task were real monosyllabic high-frequency words. The other half items were monosyllabic pseudo-words. Half of all words and pseudo-words had regular spelling, and the other half had irregular spelling. All the stimuli shared the same sound structure, namely either CMV or CVC, and covered more than seventy per cent of ZF letters. In addition, each pair of stimuli, such as pseudo–real or regular–irregular, was similar in manner or placement of articulation. Four tones in Mandarin were also included and distributed as evenly as possible across the task. Each correctly spelt item should composed three ZF letters plus a tone mark. The full set of stimuli is presented in Appendix 2:9.

The audio presentation of the task was played through a pair of speakers connected to a laptop at the front of the classroom. The volume was adjusted so that each child could hear it easily. Participants stayed at their desks. They were given an answer sheet and asked to write their own name on it. Before this task started, participants were told that each item would be played three times with five-second intervals. They were guaranteed to have enough time to write down each word. The test returned spelling accuracy scores for: (1) real words; (2) pseudo-words; (3) regular words; (4) irregular words. In each dimension (regular–irregular or real–pseudo) the maximum possible score was 10.

### Character Recognition

The Graded Chinese Character Recognition Test is a standardized test for screening school-age children for character recognition difficulties. It was standardized nationwide for children aged 6;1 to13;11. The test manual reports its internal consistency as .99 and test-retest reliability from .81 to .95 (Huang, 2001). Two hundred characters in total are presented on two pages.

Each participant was asked to read out each character in the sequence provided. As the difficulty level of characters increases, the test is discontinued after twenty characters in succession are incorrectly pronounced or if the participant fails to respond. The number of correct responses was noted as the raw score. The corresponding standardized T score was then obtained from the test manual.

### School-wide Literacy Examination

In Taiwan, conventionally, there are two or three school-wide paper-pencil exams during each semester on each main course, such as literacy or mathematics, to monitor pupils' progress. The sheet is designed by one of the same-grade teachers and administered by pupils' teachers. In year 1, after the ten-week ZF course, the first school literacy exam is written only in ZF. In year 2, the script of the school literacy exam is changed to characters but with ZF spelling (in smaller font size) at the side. The full set of exam sheets in year 1 and year 2 is presented in Appendix 2:10.

### Radical Judgement Task

The character legality judgement task was used in year 2 only, to investigate the character knowledge of children learning Chinese characters after a year of instruction, particularly in the placement and the form of radicals. This task was adopted from Wang, Perfetti & Liu (2005). It is a forced choice and speed task with twenty items in two subtasks: radical placement and radical form. The stimuli were changed by the researcher from the simplified to traditional radicals in order to match the orthography used in Taiwan.

In the radical placement subtask, the foil contains an illegal position of a radical within a character. The child has to indicate which of the two options looks more correctly presented by pointing to the character or giving a number. Figures 2.6 and 2.7 present examples of the radical placement and form subtasks.

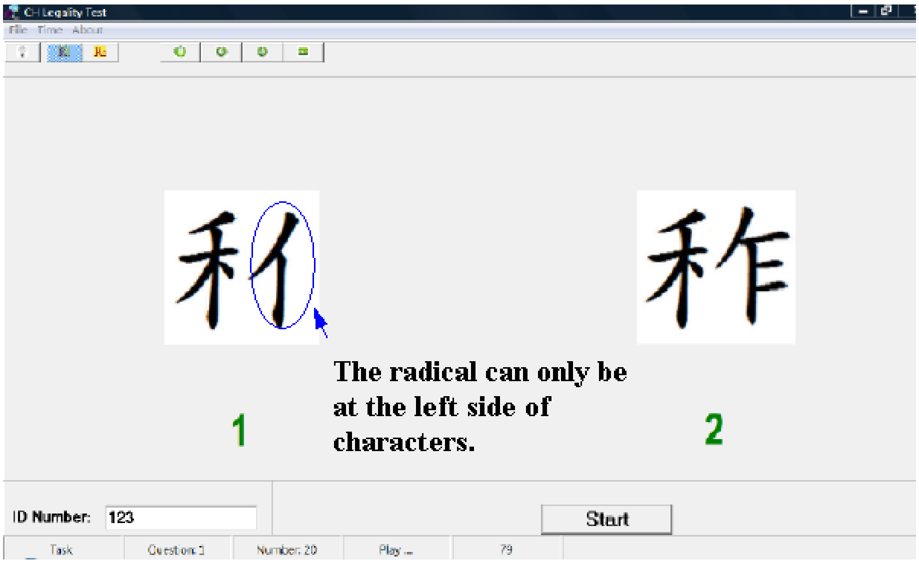


**Figure 2.6 The presentation of the radical judgement task: placement (answer: 1)**


**Figure 2. 7 The presentation of the radical judgement task: form (answer: 2)**

Both accuracy rate and time taken were recorded. After a training of five trials, children were asked to make each judgement as fast as possible. It took about ten minutes for Grade 2 children to complete this task. The number of correct responses and the time in seconds to finish each subtask were noted.

**Reading Comprehension**

Reading comprehension was a paper-pencil task from a published 'Test of Reading Comprehension' (Chang & Yang, 2005) which is designed particularly for Grade 1 pupils and written in characters accompanied by ZF compounds. The full set of stimuli is presented in Appendix 2:11. It was chosen because participants in the study were assessed during the first two months of Grade 2. It was a group test and took around thirty minutes to complete. The test manual reports an internal consistency of .86 and test-retest reliability of .74. The reading comprehension test contained seventeen items on a two-sided sheet. Each item was preceded by a few sentences or a paragraph followed by four options. Children had to read and understand the meaning of sentences or paragraphs in order to choose the correct option.

The participants received the test in their own classroom within a week of the agreement of the teachers. The researcher herself was the only tester for this measure. A general introduction was given before two trials. Feedback or further instruction from the tester was also given to individual participants when needed before the formal test. The number of correct responses was noted as a raw score. The corresponding standardized T scores were then obtained from the test manual.

### 2.3.5 Rapid Automatized Naming

Rapid automatized naming (RAN) was administered individually at both Year 1 and Year 2 in order to assess how children performed at speed when they had to integrate visual, phonological and lexical processing and then express the result through speech. RAN digit naming and picture naming were conducted in Year 1, since earlier research found these two subtasks are more closely related to Chinese literacy competence than other RAN subtasks (Tzeng, 2006). Two more subtasks (ZF and character) were added in Year 2 to assess children's rapid word-naming skill after a year of literacy education. The full set of stimuli is presented in Appendix 2:12.

The alignment of the digits and/or pictures is the same as in the rapid naming subtests of the English Phonological Assessment Battery (PhAB) (Frederickson et al., 1998), except that the pictures were changed by the researcher in order to include all four tones of Mandarin; for example, 'box' and 'hat' are changed to 'hand' and 'rice', respectively, in Mandarin. In the ZF and characters RAN tasks, the alignment of ZF letters or characters was randomly arranged within and between a set of five letters or characters. All of the five one-syllabic names of pictures were high-frequency words or very familiar to school entrants.

There were two practice trials before each naming subtask, which allowed the split-half reliability to be calculated. Participants were asked to read out all possible numbers or drawings a few times. This warming-up exercise was to make sure participants were familiar with the name and pronunciation of items and in a similar state of preparation. In each subtask, fifty digits, or drawings, or ZF letters or characters were presented on the screen of a laptop. Any self-corrections or pauses during reading out were allowed and counted. The speech output of naming and the total time to complete fifty items were recorded. The interval between two subtasks was shorter than twenty seconds. The response accuracy and naming time were recorded for each subtask.

## 2.4 Procedures

### 2.4.1 Group Study in Year 1

Three research helpers were recruited to administer all assessments with the researcher in Year 1. One of them was a third-year graduate student in the Department of Speech and Hearing Disorders and Sciences, National Taipei College of Nursing, who had worked as a speech and language therapist for two years after qualifying with a bachelor degree. The other two helpers were third-year graduate students in the Department of Linguistics, National Chenchi University, who had experience of data collection and transcribing. They were recruited via – e-mail announcement and Internet interview when the researcher was still in the UK. These helpers were trained by the researcher to use all tasks and procedures before starting data collection. The training included the explanation of manuals, the demonstration of each task, practice in administering tasks, feedback from the researcher, and procedures and guidelines for interacting with teachers and pupils in schools. It took six to eight hours to complete the training. During their administration of assessments, the helpers were accompanied and supervised by the researcher all the time through individual or group meetings and discussion.

All the participants were assessed in a quiet meeting room or the library of the school, except when performing the Reading ZF task in the tenth week, which took place in each classroom. Participants were brought to either place by a tester during a class break and assessed during class time with their teacher’s permission. Children were told they would be doing an interesting activity rather than a formal test when they were pulled out from the class.

Both the meeting room and the library were familiar to all the participants and they behaved very naturally in these two areas. Participants were assessed individually or in a group over seven sessions (September to November, 2009). In these sessions, the order in which those tasks were administered was fixed for all participants.

In order to minimize the effect of literacy instruction on the baseline performance of participants, some tasks which were most likely to be influenced by the above effect were tested first during the first month of data collection. They were: letter knowledge of ZF, Implicit PA and Explicit PA. The details of each session, including the tasks to be done in each session, how were they assessed, and the time to complete those tasks, are listed in Table 2.9.

**Table 2.9 Tasks in each assessment session in Year 1**

| Session | Method | Task1 | Task2 | Task3 | Time (min) |
|---|---|---|---|---|---|
| 1(Sep) | Individual Assessment | Implicit PA tasks | ZF Letter Knowledge | -- | 40-50 |
| 2(Sep); Y1-pr | | Explicit PA tasks | ZF Reading Accuracy before ZF course | Picture naming | 40-50 |
| 3(Oct) | | Auditory memory subtask in 'Oral comprehension' (Lin & Chi, 2002) | 'Character Recognition' (Huang, 2001) | -- | 40-50 |
| 4(Oct) | | PPVT (Dunn, et al., 1981) | RAN | Semantic Fluency | 40-50 |
| 5(Oct) | Small group/ individual | TONI (Brown et al., 1996) | -- | -- | 30-40 |
| 6(Nov) | Class-wide | Spelling_ZF | -- | -- | 30 |
| 7(Nov); Y1-po | Individual assessment | ZF Reading Accuracy after ZF course | -- | -- | 2-4 |
| 13(Nov) | Class-wide | ZF school-wide literacy exam* | -- | -- | 40 |

* It was held by the school.

In the first and second sessions, the tasks were administered in a random order. This was to minimize the proactive interference in executing five Implicit PA or Explicit PA tasks. Other small tasks, such as ZF letter knowledge, were also carried out among those PA subtasks in a fixed order. In total, there were seven small tasks administered in each session.

Except for the paper-pencil tasks, all sessions were recorded on a laptop with an external microphone while examiners wrote down participants' responses on an appropriate scoring sheet. These audio files were used to complete or verify the written record afterwards for scoring and encoding.

### 2.4.2 Group Study in Year 2

Two research helpers were recruited to administer all assessments with the researcher in Year 2. One of them had a master's degree in Infant and Child Care, and the other a master's degree in Linguistics. They were recruited via Internet interview when the researcher was still in the UK. These helpers were trained by the researcher to use all tasks and procedures before starting data collection. During the administration of assessments, the helpers were accompanied and supervised by the researcher through individual or group meetings and discussion.

The procedures for conducting the individual assessment and procedure were generally the same as in Year 1. In these sessions, there was a fixed order for administering the tasks. All the participants were assessed in a quiet meeting room or the library of the school, except when taking the reading comprehension test, which took place in each of five classrooms with the teachers' consent. Most of the children looked forward to their turns and asked the researcher when they could go with her.

The details of each session in Year 2 (including the tasks to be done in each session, how were they assessed, and the time to complete those tasks) are listed in Table 2.10. For those children with a speech difficulty identified in Year 1, a picture-naming task was repeated during one of the individual sessions.

**Table 2.10 Tasks in each assessment session in Year 2**

| Session | Method | Task1 | Task2 | Task3 | Time (min) |
|---|---|---|---|---|---|
| 1st (Sep) | Individual assessment | IMPA | 'Character Recognition' (Huang, 2001) | Legality task | 40-50 |
| 2nd | | Explicit PA | Reading accuracy | Non-word span | 40-50 |
| 3rd (Oct) | | RAN | Picture naming for children with speech difficulty* | -- | 20 |
| 4th (Oct) | Class-wide | 'Reading Comprehension' | -- | -- | 30-40 |

* It could be tested in 1st, 2nd or 3rd session.

### 2.4.3 Coding Explicit PA Performance

Unlike the all-or-none scale (1 or 0) used in ImPA tasks, a three-point scale (0, 1 or 2) was used to code children's performance on the explicit PA tasks. Correct responses were given two points and wrong answers were given no points. However, in some cases, relying on the production itself might under-estimate pupils' explicit PA skills. In order not to give penelty for having a speech difficulty or accent production, one point was given for responses that were partially accurate, as follows:

1. Speech output problems: Some children with a speech difficulty could not pronounce clearly the answers they wished to produce. In these cases, one point was given. In order to decide whether a distorted answer could really be attributed to speech output problems, performance on ImPA tasks was compared with the performance on the picture-naming task (see section 2.3).

2. Taiwanese dialect effect: As mentioned earlier (section 2.1.1), post-alveolar sounds were frequently replaced by alveolar ones, and tone 2 and tone 3 were pronounced in a very similar way in Taiwan Mandarin. Those answers influenced by the Southern Min phonological system were given one point to distinguish them from standard or wrong answers. For example, if /ɹ̺/ was replace by /l/ in the onset task, which happened frequently for those children who spoke only

Taiwanese, one point was given.

3. Approximate processing effect: A lot of children produced responses that were not fully correct but which did show some PA processing skill. One point is given to distinguish these responses from the obviously incorrect responses. A difference of one phonetic feature was allowed in this case for the onset, phoneme and rime tasks, and two phonetic features were allowed for the syllable task. For example, one point was given for the answer /$p^h$ə/ when the correct answer should be /$p^h$/ [a difference of adding a neutral vowel after the correct consonant].

A detailed quantitative coding system to code explicit PA responses is presented in the Appendix 2:13.

## 2.5 Summary

In this chapter, a unique test battery for Mandarin-speaking children has been described, along with the research design, participants and procedures for this study. In the next chapter (Results and Discussion I), the analyses concerning the relationship between spoken language skills and PA development will be presented.

# Chapter 3 Results and Discussion I:

# Development of Phonological Awareness and Its Relationship with Spoken Language Skills

This chapter addresses the first research topic, including two research questions:

1a. What is the development of PA in the first school year?

1b. How does PA relate to spoken language skills at this stage?

The chapter will conclude with a discussion of PA development of Mandarin-speaking children, a comparison with alphabetic languages, timing of literacy instruction, and the distinction between suprasegmental and segmental PA.

## 3.1 Development of PA between Year 1 and Year 2

### 3.1.1 The Mastery of PA Tasks in Year 1 and Year 2

Tables 3.1 and 3.2 present the descriptive statistics of children's performance on the PA battery in Years 1 and 2, respectively.

**Table 3.1 Children's performance on the PA battery in Year 1**

| Measure | No. of items (Max score) | Mean (Percentage) | SD | Min—Max | No. of sample |
|---|---|---|---|---|---|
| ImPA_syllable | 10 (10) | 8.27 (83%) | 1.55 | 4-10 | 94 |
| ImPA_phoneme | 10 (10) | 4.54 (45%) | 1.70 | 1-9 | 94 |
| ImPA_onset | 15 (15) | 8.85 (59 %) | 3.10 | 0-15 | 93 |
| ImPA_rime | 10 (10) | 6.46 (65%) | 2.23 | 0-10 | 94 |
| ImPA_tone | 10 (10) | 4.65 (47%) | 2.61 | 0-9 | 94 |
| ExPA_syllable | 10 (20) | 15.69 (78%) | 3.02 | 0-19 | 95 |
| ExPA_phoneme | 10 (20) | 5.87 (29%) | 4.34 | 0-18 | 94 |
| ExPA_onset | 15 (30) | 14.31(48%) | 6.60 | 0-29 | 95 |
| ExPA_rime | 10 (20) | 11.46 (57%) | 6.35 | 0-20 | 95 |
| ExPA_tone | 10 (20) | 11.40 (56%) | 5.78 | 0-18 | 95 |

Note: Im: Implicit; Ex:Explicit

**Table 3.2 Descriptive statistics of the PA battery in Year 2**

| Measure | No. of items (Max score) | Mean (Percentage) | SD | Min—Max | No. of sample |
|---|---|---|---|---|---|
| ImPA_syllable | 10 (10) | 9.10 (91%) | 1.21 | 4-10 | 92 |
| ImPA_phoneme | 10 (10) | 4.74 (47%) | 1.66 | 0-9 | 92 |
| ImPA_onset | 15 (15) | 11.46 (76%) | 2.66 | 5-16 | 92 |
| ImPA_rime | 10 (10) | 7.60 (76%) | 1.72 | 2-10 | 92 |
| ImPA_tone | 10 (10) | 7.36 (74%) | 1.78 | 3-10 | 92 |
| ExPA_syllable | 10 (20) | 17.84 (89%) | 1.46 | 13-20 | 92 |
| ExPA_phoneme | 10 (20) | 9.18 (45%) | 4.50 | 0-20 | 92 |
| ExPA_onset | 15 (30) | 19.68 (66%) | 7.07 | 0-30 | 92 |
| ExPA_rime | 10 (20) | 15.29 (77%) | 5.38 | 0-20 | 92 |
| ExPA_tone | 10 (20) | 17.12 (86%) | 2.50 | 8-20 | 92 |

Note: Im: Implicit; Ex:Explicit

The mean accuracy rate clearly varied across the tasks. Before we explore those task-related differences, let us examine performance improvements between Year 1 and Year 2.

**Improvements in PA Performance between Year 1 and Year 2**

In order to know if there was any significant improvement in children's performances between Year 1 and Year 2, a paired t test was taken for those children who completed the PA battery twice. Significant improvements were observed on all tasks except implicit PA at the phoneme level, and the effect sizes of the improvement were moderate or large (see figure 3.1). The only exception was the implicit PA task; its low reliability and high guessing rate showed pupils at their early school years could not do it. Therefore, its improvement was non-significant.

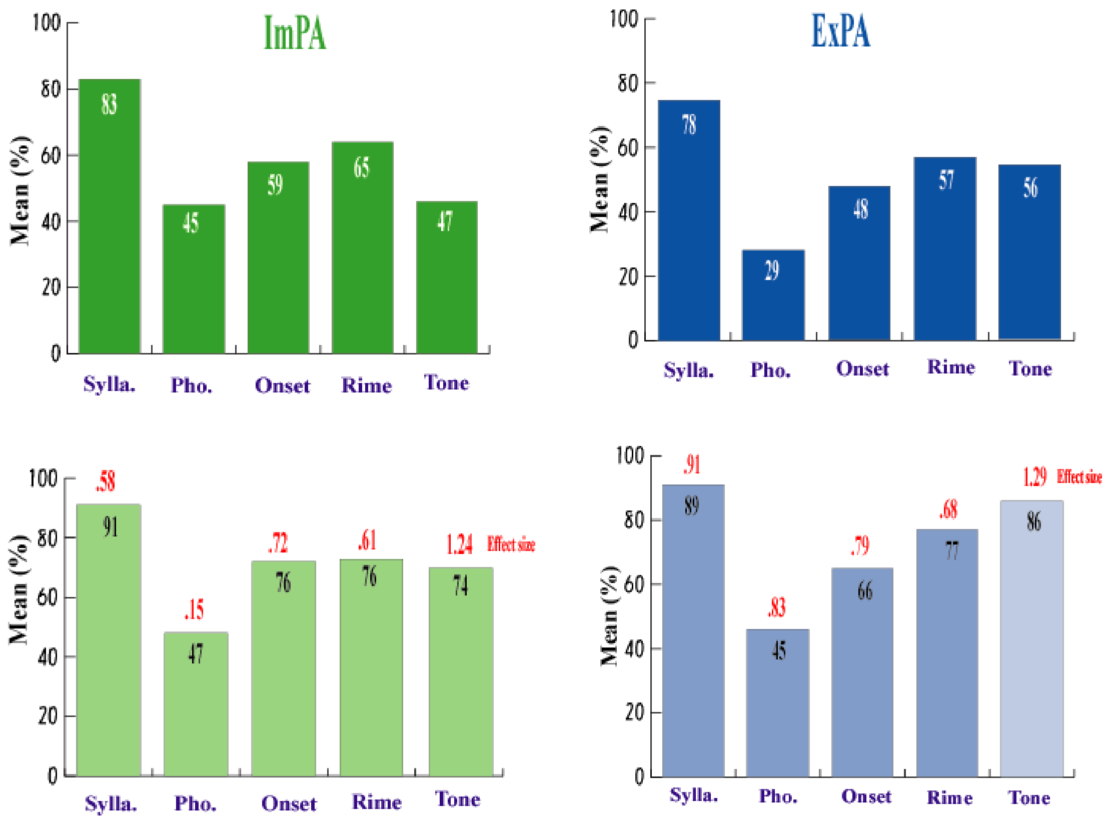


**Figure 3.1 Comparison of mean accuracy rate on PA subtasks between Year 1 (upper panel) and Year 2 (lower panel). Effect size (Cohen's d) of the observed differences is indicated in red.**

The above results show that, between Years 1 and 2, children's performance on the PA battery improved moderately or substantially, on most of the linguistic levels. The most impressive improvements were observed on the implicit and explicit tone task. It is worth noting that the three other subtasks which showed the largest improvements were all explicit tasks.

**Reliability of PA Battery**

Henson (2001) recommended various standards of reliability. In the case of pilot studies, a reliability score of 0.5-0.6 was thought to be sufficient. However, a later cutoff point is necessary when developing an instrument: 0.7. Any reliability above 0.9 is thought to be robust enough for adopting a clinical diagnosis. Henson particularly emphasized many factors that might potentially affect the internal consistency of a measure, such as single or multiple testers, or a level of heterogeneity in the sample. Hammond (2006) suggested that the reliability of a measurement as a research tool should be higher than 0.7. According to his criterion, reliability below 0.5 is thought to be low; 0.5-0.7 is satisfactory; 0.7-0.9 is good; above 0.9 is excellent.

In order to know whether the PA battery designed for the purpose of this study is able to elicit consistent and reliable responses across individuals, its reliability was examined. Firstly, Cronbach's Alpha was calculated in order to discover the internal consistency of PA measurement. The results for both implicit and explicit PA at two time points are shown in Table 3.3.

**Table 3.3 Reliability of PA battery**

| **PA battery** | Reliability | evaluation* | Reliability | evaluation |
|---|---|---|---|---|
| | Year 1 | | Year 2 | |
| Im_Syllable | 0.46 | low | 0.58 | satisfactory |
| Im_Phoneme | 0.22 | low | 0.48 | low |
| Im_Onset | 0.65 | satisfactory | 0.57 | satisfactory |
| Im_Rime | 0.58 | satisfactory | 0.45 | low |
| Im_Tone | 0.68 | satisfactory | 0.48 | low |
| Ex_ Syllable | 0.54 | satisfactory | 0.31 | low |
| Ex_ Phoneme | 0.67 | satisfactory | 0.59 | satisfactory |
| Ex_ Onset | 0.93 | excellent | 0.85 | good |
| Ex_ Rime | 0.86 | good | 0.84 | good |
| Ex_ Tone | 0.92 | excellent | 0.62 | satisfactory |

*According to Hammond's criterion (2006)

Note: Im: Implicit; Ex:Explicit

Generally speaking, implicit PA showed lower reliability than explicit PA. In Year 2, the majority of the implicit PA tasks, such as phoneme, rime and tone implicit PA tasks, showed low reliability.

In addition, the low reliability of the implicit phoneme task in Years 1 and 2 may reflect its high level of difficulty (see section on ‘Pass rate of Implicit PA’). Up to 86% and 88% of the cohort for Years 1 and 2, respectively, performed this task by guessing. Consequently, the measure of this task was not quite reliable.

The only explicit PA task with low reliability was the syllable task in Year 2. Its average accuracy rate was 89.2%, which was very close to one hundred per cent. In addition, the accuracy for more than 70% of the cohort is above 90%. Therefore, the ceiling effect might be the main reason for its low reliability.

**Inter-rater Reliability**

Since a transcription and coding process was involved in explicit PA tasks, inter-rater reliability had to be established. In order to establish the inter-rater reliability, 20% of all explicit PA results collected were scored both by the researcher and by a research helper. The agreement was 95 % in Year 1 and 96% in Year 2, which is highly acceptable.

**Relative Difficulty of Different PA tasks**

A Friedman ANOVA test was applied to check whether any significant difference exists between all PA tasks[2]. The result showed that there was a statistically significant difference in performance depending on which PA task was conducted, $\chi^2(19) = 891.90$, $P = 0.00$. A Wilcoxon Signed-Rank Test was then administered to explore the differences between each pair of subtasks. The order of relative difficulty is presented in Table 3.4.

[2] All raw scores were converted to % accuracy to ensure comparability among tasks of different length.

**Table 3.4 Relative difficulty level of PA tasks at various linguistic levels in Year 1 and Year 2**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **ImPA**_Year 1 | | | | | | | | |
| Phoneme | >ns | Tone | >.000 | Onset | >.05 | Rime | >.000 | Syllable |
| **ImPA**_Year 2 | | | | ns | | | | |
| Phoneme | >.000 | Onset | >ns | Tone | >ns | Rime | >.000 | Syllable |
| **ExPA**_Year 1 | | | | .05 | | | | |
| Phoneme | >.000 | Onset | >.05 | Rime | >ns | Tone | >.000 | Syllable |
| **ExPA**_Year 2 | | | | | | .001 | | |
| Phoneme | >.000 | Onset | >.000 | Rime | >.01 | Tone | >ns | Syllable |

Note: Im: Implicit; Ex:Explicit; ns: the difference is not statistically significant.

The rank order of task difficulty differed rather little between Year 1 and 2, and between implicit and explicit tasks. Phoneme tasks were consistently the hardest, while syllable tasks were consistently the easiest. However, the relative difficulty of onset, rime and tone tasks did differ between explicit and implicit tasks. For tones, the explicit tasks were relatively easy, while the implicit tasks were relatively difficult. This may be attributed to the easier production of tone numbers compared with the production of other segments, such as rime, onset or phoneme. The reverse was the case for onsets, where the implicit task was relatively easy but the explicit one relatively difficult. This result implied that the output skill of the onset (single consonants) in Mandarin might not be as easy as the other linguistic levels for young school-age children since syllable-initial consonants are acquired latest (children have most of the phonemes till 4;6 ) than vowels or tones (Zhu, 2008).

### Pass Rate of Implicit PA

Because of the forced choice design applied on Implicit PA tasks, correct responses could be produced by guessing. Therefore, one sample t-test was carried out to examine whether, on average, children's performance was above chance on the implicit tasks. The results were significant for all implicit tasks; thus the null hypothesis that the children responded by guessing only can be rejected. This suggests that, as a group, a number of children knew what was being tested in implicit PA and responded accordingly. Nevertheless, it is still possible that some children were merely guessing. A binomial probability indicates that, on a task comprising ten items, when a child gave **seven** correct answers or more, his/her performance was above chance level ($p < .05$). This criterion was applied to syllable, phoneme, rime and tone tasks. On a task comprising fifteen items, the above-chance level ($p < .05$) would be **nine** items, and this criterion was applied to the onset task. Table 3.5 presents the percentage of children performing above these chance levels in both years.

**Table 3.5 Number of participants (with percentages in brackets) scoring above the guessing criterion on Implicit PA tasks**

| No. of children (Percentage) | Syllable | Phoneme | Onset | Rime | Tone |
|---|---|---|---|---|---|
| Year 1 | 79 (84%) | 13 (14%) | 55 (59%) | 52 (55%) | 24 (25%) |
| Year 2 | 90 (98%) | 11 (12%) | 88 (96%) | 66 (72%) | 66 (72%) |

As shown in Table 3.5, a similar percentage of above the guessing criterion on implicit PA at the phoneme level between year 1 and 2 was found. Otherwise, the cohort was more aware of what was being tested on the other levels of implicit PA in Year 2. The most substantial improvement in the percentage above the guessing criterion was in implicit PA at the tone level. The results might suggest: a) tone PA is majorly facilitated by formal education; b) implicit PA at the phoneme level might not be sensitive or improved through ZF and/or CH orthography experience. In other words, tone PA was not stimulated to develop by pre-school verbal experience but only facilitated by orthography experience. Given that tone level is suprasegmental, this implies that suprasegmental PA develops independently from other segmental PA, such as onset-rime or phoneme PA. Regarding the implicit PA at the phoneme level, the result showed that the cohort had difficulty in identifying this unit in a syllable via auditory input. This situation continued even though pupils tried to capture the target unit by slowly repeating and segmenting auditory stimuli in mouth, as the researcher observed. The result indicates that this level of PA is not required alongside Mandarin spoken experience. Particularly in the case of final nasal consonants, such as /n/ or /ŋ/, no corresponding ZF script exists. The above results will be further discussed later in this chapter.

**Family Language Effect in the Implicit and Explicit Onset Subtasks**

In order to clarify whether the degree of exposure to Mandarin has an impact on processing onset consonants which were spoken only in Mandarin, not in Southern Min, five extra items were specifically designed and included in the PA test battery. The five extra items include the phonological contrasts which exist only in Mandarin, including four post-alveolar/alveolar and one labiodental/velar pairs. This is the reason why the onset tasks in the PA battery include five more items than the other tasks. These extra items were included in the analysis reported above. The differences in PA performance on the onset tasks between children brought up in Mandarin-dominant families and those in non-Mandarin-dominant families were examined.

The performances on these extra five items (nos. 1, 11, 13, 14 and 15) were compared with performances on another ten items separated into two five-item groups (nos. 3, 5, 7, 9 and 12, and nos. 2, 4, 6, 8 and 10). If there was a significant difference in accuracy among these three groups of tests for the cohort, particularly if children in the non-Mandarin- dominant group performed less well in the extra five items, it might be attributed to the effect of Taiwanese as the main family language.

A Mann Whitney test was used to compare the performance on those three groups of items of Mandarin-dominant and non-Mandarin-dominant groups. No significant difference was found for the explicit PA at the onset level in Year 1 and Year 2, or for the implicit PA at the onset level in Year 1. However, a significant difference was found in the implicit PA at the onset level in Year 2. Children in non-Mandarin-dominant families performed less well (Mdn=3) than their peers whose families spoke Mandarin more than three quarters of the time (Mdn=4, U=757, $p < 0.05$).

The above results show the advantage of the mainstream language and the effect of family language. This effect might reveal itself after a year of schooling. Therefore, it was important to follow up this effect in another study for those children whose family language was not the mainstream one in a society where PA and literacy had proved to interact closely. In addition, although this small effect was observed in the onset tasks where the contrast between languages was deliberately designed in advance, it is uncertain if this effect is limited to onset levels only.

### 3.1.2 The Relationship between Tasks in the PA Battery

This section is going to describe the relationship among the linguistic levels in the PA battery, using correlation and factor analysis. However, as IQ can impact on PA performance generally, this will be examined first.

**Non-verbal Intelligence**

The mean performance of this cohort on the non-verbal intelligence test (TONI) was 102.47 on the Wechsler scale and the standard deviation was 11.03. The maximum score was 135 and the minimum was 79, so no children fell within the impaired range of performance.

**Correlation Analysis**

Zero-order correlations (Pearson’s r) between PA tasks (below the diagonal) and partial correlations controlling for nonverbal intelligence (above the diagonal) are reported for Year 1 in Table 3.6 and Year 2 in Table 3.7.

On the whole, controlling for nonverbal IQ reduced the number of significant correlations among tasks. This implies that the effect of non-verbal intelligence on PA performance could not be dismissed. The following description is based mainly on the results from the partial correlation analysis carried out to uncover the relationship between any pair of PA tasks in Year 1.

**Table 3.6 Correlations among PA subtasks in Year 1 (below diagonal) and partial correlations controlling for non-verbal intelligence (above diagonal)**

| | ImPA _S | ImPA _P | ImPA _O | ImPA _R | ImPA _T | ExPA _S | ExPA _P | ExPA _O | ExPA _R | ExPA _T |
|---|---|---|---|---|---|---|---|---|---|---|
| ImPA _S | -- | *.00* | *.06* | *-.03* | *.29** | *.31*** | *-.07* | *.03* | *.04* | *.19* |
| ImPA _P | .02 | -- | *.15* | *.09* | *.09* | *-.06* | *.11* | *-.01* | *-.08* | *-.05* |
| ImPA _O | .08 | .17 | -- | *.25** | *.11* | *.09* | *.40*** | *.25** | *.26** | *.08* |
| ImPA _R | .00 | .16 | .28** | -- | *.02* | *-.09* | *.25** | *.09* | *.33*** | *.26** |
| ImPA _T | .28** | .15 | .15 | .10 | -- | *.30** | *.07* | *.05* | *.08* | *.15* |
| ExPA _S | .30** | .02 | .13 | -.01 | .34** | -- | *.10* | *.19* | *.22* | *.16* |
| ExPA _P | -.07 | .14 | .40** | .28** | .11 | .12 | -- | *.34*** | *.45*** | *.30** |
| ExPA _O | .04 | .04 | .28** | .14 | .19 | .22* | .35** | -- | *.28** | *.27** |
| ExPA _R | .03 | .00 | .28** | .36** | .21 | .24* | .47** | .35** | -- | *.18* |
| ExPA _T | .20 | .05 | .13 | .33** | .26* | .24* | .33** | .34** | .27* | -- |

** Correlation is significant at the 0.01 level 2-tailed.   * 0.05 level 2-tailed.

Note: Im: Implicit; Ex:Explicit

In general, the correlations between different aspects of phonological awareness were weak or even non-significant. This could be due to the low reliability of some tasks, such as implicit PA task at the phoneme level – but it could also reflect genuine dissociations between different aspects of phonological awareness in Mandarin.

Correlations were generally stronger among explicit PA tasks than implicit PA tasks. These results seem to imply that PA processing among various implicit tasks could be more dissociated than among the explicit tasks.

**Table 3.7 Correlations among PA subtasks in Year 2 (below diagonal) and partial correlations controlling for non-verbal intelligence (above diagonal)**

| | ImPA _S | ImPA _P | ImPA _O | ImPA _R | ImPA _T | ExPA _S | ExPA _P | ExPA _O | ExPA _R | ExPA _T |
|---|---|---|---|---|---|---|---|---|---|---|
| ImPA _S | -- | *-.12* | *.15* | *-.01* | *.14* | *-.18* | *-.08* | *.05* | *-.13* | *.24** |
| ImPA _P | -.12 | -- | *.11* | *.12* | *.06* | *.10* | *.15* | *.09* | *.19* | *.04* |
| ImPA _O | .15 | .12 | -- | *.24** | *.20* | *-.22** | *.36*** | *.17* | *.22** | *.19* |
| ImPA _R | -.01 | .16 | .24* | -- | *.14* | *.08* | *.28** | *.12* | *.33*** | *.08* |
| ImPA _T | .13 | .08 | .21* | .17 | -- | *-.12* | *.16* | *.09* | *.26** | *.36*** |
| ExPA _S | -.18 | .09 | -.22* | .07 | -.12 | -- | *-.09* | *-.16* | *.08* | *-.13* |
| ExPA _P | -.07 | .16 | .37** | .29** | .17 | -.09 | -- | *.14* | *.44*** | *.13* |
| ExPA _O | .06 | .13 | .19 | .21* | .13 | -.17 | .18 | -- | *.24* | *.20* |
| ExPA _R | -.12 | .21* | .23* | .39** | .29** | .07 | .45** | .32** | -- | *.15* |
| ExPA _T | .23* | .07 | .20 | .16 | .38** | -.13 | .15 | .28** | .22* | -- |

** Correlation is significant at the 0.01 level 2-tailed. * 0.05 level 2-tailed.

Note: Im: Implicit; Ex:Explicit

In addition, in Year 1 and in Year 2, both implicit PA and explicit PA at the syllable level had negative correlations with other tasks. For example, in Year 2, the implicit PA at the onset level had a weak negative correlation (r = - 0.22) with the explicit PA at the syllable level task. The results might imply that a child may have a superior syllable PA skill, but still not be able to perform smaller unit PA tasks, such as rime, onset, phoneme and tone. However, it is also possible that the negative correlations reflect a ceiling effect on the easiest syllable PA tasks (shown in figure 3.1). When there is a ceiling effect, there is little variance. An unusual performance by just a handful of children may skew the correlations.

### Factor Analysis

To explore the underlying construct of PA in Mandarin-speaking children further, and to identify which sub-skills were specifically measured by this PA battery, a factor analysis was performed. The Alpha Factoring extraction method was used. In addition, an oblique (Direct Oblimin) rotation method was adopted since it allowed the intercorrelation between factors to be measured.

Data screening confirmed the adequacy of factor analysis for the presented cohorts; i.e., the Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis: KMO = .69 (Year 1) and .71 (Year 2). In addition, all KMO values for individual items were > .61 (Year 1) and .62 (Year 2), which were all well above the acceptable limit of .50 (Field, 2009). High KMO values (between 0.5 and 1) indicate the factor analysis had an appropriate number of common factors.

The structure matrix of the factors extracted is shown in Table 3.8, which provides information about the correlation between a variable and a factor. Three factors could be extracted which explained 34% of total variance for Year 1 and 33.6% for Year 2.

**Table 3.8: Structure matrices - Alpha factoring for the PA battery**

| *Variables* | | *Year 1* | | | *Year 2* | | |
|---|---|---|---|---|---|---|---|
| | | *Factor 1* | *Factor 2* | *Factor 3* | *Factor 1* | *Factor 2* | *Factor 3* |
| ImPA | Syllable | | .58 | | | -.35 | .38 |
| | Phoneme | | | .46 | .34 | | |
| | Onset | .45 | | | .42 | -.43 | |
| | Rime | .46 | | .41 | .50 | | |
| | Tone | | .58 | | | | .44 |
| ExPA | Syllable | .34 | .59 | | | .61 | |
| | Phoneme | .72 | | | .59 | | |
| | Onset | .51 | | | .36 | | |
| | Rime | .64 | | | .75 | | |
| | Tone | .47 | .37 | | | | .77 |
| % Variance explained | | 21.20 | 9.03 | 4.09 | 20.05 | 8.93 | 4.62 |
| Cumulative % | | 21.20 | 30.23 | 34.32 | 20.05 | 28.97 | 33.60 |

Note: Weak loadings (less than 0.3) are not shown in the table. Im: Implicit; Ex:Explicit

*Factor 1* represented primarily all explicit PA and onset-rime implicit PA variables. In total it represented seven variables and left out only three implicit PA tasks, two of which had low reliability (syllable and phoneme). It explained 21.2% of total variance. Hence, it could be interpreted as the *General PA Factor* in Mandarin for it encompassed all that is common across different PA tasks. Also, 9% of total variance was explained by *Factor 2* which represented mainly syllable PA combined with suprasegmental (tone) awareness. It could be interpreted as the *Syllable and Tone PA Factor*. *Factor 3* only reached 4% of total variance and was unrelated to the other two. It comprised only implicit PA at rime and phoneme levels and seems not to be a coherent entity. Therefore, *Factor 3* was expected to fade as time went by and this hypothesis was proved to be true in Year 2.

The correlations between the above factors were all positive in Year 1. The highest correlation was between *Factors 1* and *2* (r = 0.27), followed by *Factors 1* and *3* (*r* = 0.18). The last pair, *Factors 2* and *3,* had the weakest relationship (r=0.003).

There was a different pattern of results in Year 2. Given that all small segmental PA variables clustered together under *Factor 1*, this factor could be interpreted as the *Small segmental PA Factor,* which explained 20% of total variance. The constitution of *Factor 2* is a mixture of highly positive (explicit PA at the syllable level) and moderately negative loadings (implicit PA at the syllable level and implicit PA at the onset level). Since it represented mainly the syllable variables, *Factor 2* was counted as a *Syllable PA Factor*. It explained around 9% of total variance. Lastly, the explicit PA at the tone level and implicit PA at the tone level made up *Factor 3*.This factor could be named as a *Tone PA Factor,* which explained 4.6% of total variance.

In Year 2, the relationships between the three factors were totally different. *Factor 2* had a negative correlation with *Factor 1* (r = -.033) and *Factor 3* (r = -.34) while the correlation between *Factors 1* and *3* was 0.25.

In summary, it was found that in Year 1, apart from the *General PA Factor*, there was a syllable-tone factor which explained nearly 10% of overall PA variance. In Year 2, this two-layer pattern changed to a more elaborate three-layer construct which reflects various linguistic levels (small unit, syllable and tone) of Mandarin PA. Figure 3.2 presents the transition of the PA construct between Year 1 and Year 2.

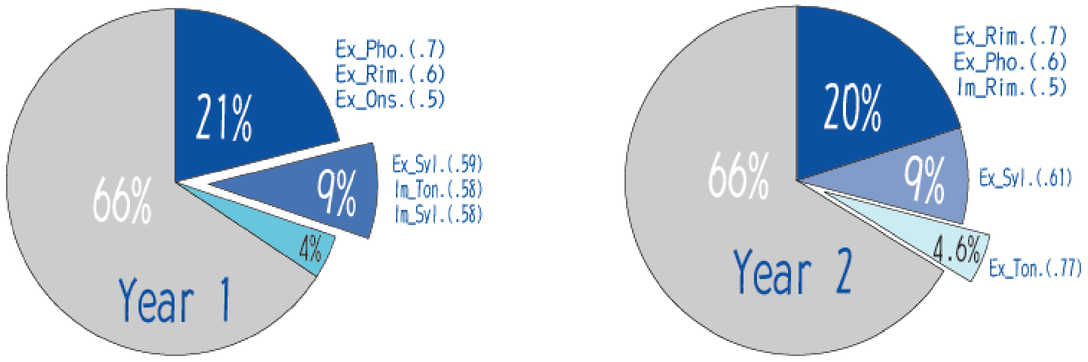


**Figure 3.2 PA factors in Year 1 and Year 2 (with 66% variance unexplained)**

The factors that were extracted explained only one third of overall PA variance. This was a relatively small amount. It might be attributed to the low reliability of individual PA tasks and/or the weak relationships among various aspects of PA in the PA battery.

In addition, the negative correlation between *Factors 1 and 2* in Year 2 indirectly implies that the relationships among various segments of PA might follow the pattern of growth and decline, that is, after a year of literacy education including both ZF and CH, pupils generally developed their small unit PA which may replace their previous proficiency in large unit PA, such as implicit PA at the syllable level and explicit PA at the syllable level.

## 3.2 The Relationship between PA and Spoken Language Skills

Five measures were chosen to investigate the relationship between oral language skills and PA: a) Semantic Fluency; b) Peabody Picture Vocabulary Test (PPVT); c) Auditory Memory; d) Picture naming; and e) Pseudo-word memory span. Since the measure of auditory memory involves auditory comprehension (see 2.3.2), it was included in the spoken language skills. The non-word span task was also used to check whether the design of implicit PA tasks relied on participants' auditory working memory. Before exploring the relationship between PA and oral language skills, it is necessary to present the descriptive statistics of oral language measures.

### 3.2.1 Spoken Language Skills

In Year 1, four oral language tasks were conducted. Two of them were input tasks: 'Peabody Picture Vocabulary Test' (Dunn et al., 1981) and 'Auditory Memory Task' (Lin & Chi, 2002). The other two were output tasks: picture naming and semantic fluency tasks. In Year 2, only the pseudo-word memory span task was conducted. Table 3.9 presents all the descriptive statistics for the above measures.

**Table 3.9 Children's performance on the spoken language measures in Year 1 and Year 2**

| | Measure | Mean | SD | Min—Max | N |
|---|---|---|---|---|---|
| Year 1 | Semantic Fluency | 13.03 | 4.42 | 3 – 31 | 92 |
| | PPVT* | 112 | 7.88 | 87 –126 | 94 |
| | Auditory Memory (18) | 9.92 (55%) | 2.66 | 4 – 18 | 95 |
| | Picture Naming (30) | 28.36 (95%) | 3.71 | 8 – 30 | 95 |
| Year 2 | Pseudo-word memory span | 11.33 | 4.48 | 4 – 22 | 92 |

Note: Maximum score and accurate percentage of mean score for each measure are presented in parentheses when they are available.

* Wechsler score

**Picture Naming**

A ceiling effect was found in this task based on its high mean accuracy rate (95%). Excluding seven children with persisting speech difficulty, i.e. being not able to pronounce utterances accurately after school age, there were eighty-nine participants. In order to know if this typically developing group made speech errors, further analysis was carried out. The most frequent five error sounds and their error rates are presented in Table 3.10. Four of these sounds were post-alveolar onset phonemes.

**Table 3.10 Five most frequent error sounds of typically developing group**

| Correct sound | Produced sound | Error rate (%) |
|---|---|---|
| /ɹ̪/ | /l/ | 19 |
| /tʃ/ | /ts/ | 12 |
| /tʃʰ/ | /tsʰ/ | 12 |
| /pʰ/ | /p/ | 10 |
| /ʃ/ | /s/ | 7 |

Phonemic errors were identified when the correct sound was replaced by another consonant or vowel in a word. Apart from the five examples in Table 3.10, phonetic errors occurred in only three participants.

Four of these sounds were post-alveolar ones, which are more difficult for children at this age (6;6) to produce (Zhu, 2008). This may also be due to the Taiwan Mandarin accent in which post-alveolar sounds are frequently replaced by alveolar ones, which consequently delays the acquisition of these sounds for the younger generation growing up in a Taiwan Mandarin community.

**Pseudo-word memory span**

In the task, children were asked to repeat multi-syllabic (ranged from 3 to 7) pseudo words. Only six children correctly repeated five-syllabic pseudo-words once; the rest of the responses were limited to three- or four-syllabic pseudo-words. The average score of the cohort was 11.33, with SD equal to 4.48. On the other hand, on average, children correctly responded on 2.49 items range between 3 to 5 syllables. In order to clearly present the estimated pseudo-word memory span at Grade 2, children were categorised into various levels according to whether both items in that level were correctly repeated. There were 81.5% of children on the three-syllabic level, but only 9.8% of the cohort on the four-syllabic level. However, no-one repeated correctly both items on the five-syllabic level. The floor effect of this level was obvious. The remaining 9.8% of the cohort are those with randomly correct responses who therefore cannot be categorised. Figure 3.3 presents the distribution of the preceding results.

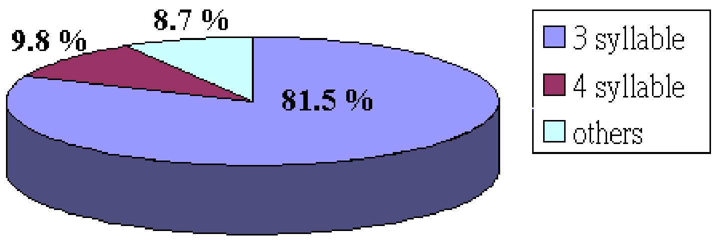


**Figure 3.3 The distribution of performance on pseudo-word memory span task**

**Linking pseudo-word memory span to PA performance**

The above results suggest that most of the Mandarin-speaking children are able to repeat 3-syllabic new words at Grade 2. Given the design of Implicit PA tasks, children might be required to rehearse the target sound in order to identifying the right option sharing a common syllable. Thus, the implicit PA at the syllable level task where children had to compare a two-syllabic target with three two-syllabic options may have overloaded children's working memory capacity. However, given that implicit syllable tasks had a relatively high percentage of children passing the criterion of guessing at both years, it was not likely that this task did overload children's working memory capacity. In other words, the design of the implicit tasks is acceptable for children in the first years at school.

**Correlations among Spoken Language Measures**

Zero-order correlations (Pearson's r) among oral language measures are reported in Table 3.11 below the diagonal; and partial correlations r controlling for nonverbal intelligence were also conducted and shown above the diagonal.

**Table 3.11 Correlations among oral language measures (below diagonal) with partial correlations controlling for non-verbal intelligence (above diagonal)**

| Measures | Semantic fluency | PPVT | Auditory memory | Picture naming | Pseudo-word span |
|---|---|---|---|---|---|
| Semantic fluency | -- | .02 | -.03 | -.04 | .07 |
| PPVT | .08 | -- | .17 | .05 | .33** |
| Auditory memory | .06 | .27* | -- | .25* | .23* |
| Picture naming | .04 | .16 | .26* | -- | .18 |
| Nonword span | .10 | .32** | .26* | .19 | -- |

** Correlation is significant at the 0.01 level 2-tailed.    * 0.05 level 2-tailed.

This result shows that greater vocabulary span (PPVT) had a moderate positive link with pseudo-word repetition skill. The result indirectly implied that speech rehearsal skills required in learning new vocabulary might also be required in the pseudo-word span task. Similarly, auditory memory span correlated mildly with pseudo-word span, which shows that these two skills both involve a product of speech rehearsal which relies on auditory working memory span. The mild correlation between auditory memory span and picture naming might be explained by the possibility that storing or rehearsal accurate representations of words would help a child to name them correctly.

### 3.2.2 The Correlations between PA and Spoken Language Skills

In order to learn whether PA may reflect the integrity of the speech processing system which underlies spoken language skills, the correlations between PA tasks and spoken language measures were analysed by partially controlling the influence of non-verbal intelligence. The zero-order correlations and the partial correlations controlling for nonverbal intelligence are presented in Table 3.12 and Table 3.13 respectively.

**Table 3.12 Correlations between oral language measures and PA subtasks**

| | Semantic fluency | PPVT | Auditory memory | Picture naming | Pseudo-word memory span |
|---|---|---|---|---|---|
| Year 1 | | | | | |
| ImPA_S | .13 | .06 | .02 | -.06 | -.08 |
| ImPA_P | -.06 | .05 | .00 | .21* | .06 |
| ImPA_O | -.05 | -.08 | .19 | .33** | -.07 |
| ImPA_R | .17 | .07 | .12 | .07 | -.04 |
| ImPA_T | .17 | .08 | .22* | .23* | .16 |
| ExPA_S | .19 | .13 | .24* | .25* | .14 |
| ExPA_P | .15 | .12 | .28** | .27** | .21 |
| ExPA_O | .20 | -.10 | .21* | .19 | .11 |
| ExPA_R | .22* | -.01 | .23* | .18 | .14 |
| ExPA_T | .23* | .11 | .31** | .13 | .07 |
| Year 2 | | | | | |
| ImPA_S | -.12 | .13 | -.07 | -.14 | -.10 |
| ImPA_P | .10 | -.03 | .08 | .17 | .06 |
| ImPA_O | -.03 | .08 | .27** | .13 | .14 |
| ImPA_R | .11 | .03 | .20 | .16 | .16 |
| ImPA_T | -.01 | .01 | .16 | .09 | -.04 |
| ExPA_S | .16 | .18 | -.01 | -.05 | .08 |
| ExPA_P | .16 | -.08 | .13 | .12 | -.02 |
| ExPA_O | .05 | .12 | .19 | .26* | .09 |
| ExPA_R | .22* | -.01 | .23* | .35** | .15 |
| ExPA_T | .13 | .17 | .11 | .12 | .14 |

Note: Im: Implicit; Ex:Explicit; S: syllable; P:phoneme; O:onset; R:rime; T:tone

**Table 3.13 Correlations between oral language measures and PA subtasks with partial correlations controlling for non-verbal intelligence**

| | Semantic fluency | PPVT | Auditory memory | Picture naming | Pseudo-word memory span |
|---|---|---|---|---|---|
| Year 1 | | | | | |
| ImPA_S | .14 | -.03 | -.06 | .01 | -.12 |
| ImPA_P | -.13 | -.04 | -.05 | .04 | .05 |
| ImPA_O | -.09 | -.13 | .24* | .30* | -.08 |
| ImPA_R | .09 | -.05 | -.01 | -.11 | -.14 |
| ImPA_T | .08 | -.07 | .14 | .13 | .18 |
| ExPA_S | .12 | .10 | .12 | .33** | .21 |
| ExPA_P | .08 | .08 | .19 | .23* | .19 |
| ExPA_O | .11 | -.21 | .05 | .10 | .08 |
| ExPA_R | .14 | -.13 | .14 | .05 | .16 |
| ExPA_T | .15 | .00 | .23* | .00 | .05 |
| Year 2 | | | | | |
| ImPA_S | -.13 | .11 | -.10 | -.15 | -.07 |
| ImPA_P | .04 | -.06 | .02 | .15 | .12 |
| ImPA_O | -.08 | .04 | .21 | .17 | .17 |
| ImPA_R | .01 | -.04 | .10 | .08 | .16 |
| ImPA_T | -.08 | -.01 | .12 | .06 | -.05 |
| ExPA_S | .21 | .26* | .04 | -.16 | .05 |
| ExPA_P | .09 | -.19 | .09 | .00 | -.04 |
| ExPA_O | -.08 | -.10 | .01 | .14 | .04 |
| ExPA_R | .11 | -.07 | .18 | .23* | .17 |
| ExPA_T | .08 | .15 | .04 | .02 | .17 |

Note: Im: Implicit; Ex:Explicit; S: syllable; P:phoneme; O:onset; R:rime; T:tone

As shown in Table 3.13, none of the PA tasks was significantly associated with semantic fluency and pseudo-word memory span although both of them are output tasks. The result indicates that PA is not necessarily involved in any speech output tasks in Mandarin-speaking children. However, being a speech output task as well, picture naming had the most significant correlations with PA sub-skills, such as implicit PA at the onset level, explicit PA at the syllable level and explicit PA at the phoneme level in Year 1 and explicit PA at the rime level in Year 2, although the strength of correlations is only mild to moderate.

To conclude, the results showed surprisingly weak and inconsistent correlations between PA and spoken language measures in Mandarin-speaking children, particularly in Year 2. This suggests that PA is more of a metalinguistic and/or cognitive skill than a primary linguistic skill. In addition, pseudo word memory is more like a cognitive skill than a primary spoken language skill.

**Summary of Results**

In this chapter, the results from various linguistic levels of PA, both implicit and explicit, are described. Some but not all PA sub-skills improved substantially during the first school year, such as explicit PA at the onset level and explicit PA at the tone level. In addition, the development of suprasegmental and segmental PA were very different from each other. The common factors of PA in Mandarin-speaking children were found to develop in a multi-level way where suprasegmental PA separates itself from a syllabic-tone PA factor after a year of schooling. Lastly, the relationships between PA and spoken language skills were weak or negligible in general. Only picture naming had close associations with many PA sub-skills.

## 3.3 Discussion of Results

### 3.3.1 Development of Segmental Phonological Awareness

The difficulty level and the accuracy rate among four segmental PA, i.e. syllabic, onset-rime and phoneme, might reflect the sequence of its development in

Mandarin-speaking children. More specifically, any level acquired earlier would show a higher accuracy rate and lower difficulty level. Even though most PA sub-skills improved between Year 1 and Year 2, the general patterns of segmental PA performance (see figure 3.1) remained the same and corresponded to the sound structure of Mandarin (see figure 1.1) from the larger unit PA to the smaller unit PA, for example the syllable level was acquired earlier than the rime-onset level which was followed by the phoneme level. The results are in accord with the fixed sequence of PA progression before schooling in various European languages proposed by previous studies (e.g. Ziegler & Goswami, 2005). In addition, this pattern remains the same after the first year of schooling. Therefore, the results not only support the argument that the sequence of segmental PA development is cross-linguistically universal but also demonstrate that orthography systems and teaching instruction in Taiwan do not improve the phoneme PA more than PA at other levels.

Compared to studies investigating alphabetic scripts such as German where phonemic PA and onset-rime level PA improves more than syllabic PA between nursery (5;11) and Grade one (6;11) (e.g., Fricke et. al., 2008), the limited PA improvement of Mandarin-speaking children during their first school year may be attributed to the syllabic or semi-syllabic characteristics of either spoken language (Mandarin and/or Taiwanese) or written languages (ZF or CH) where phonemic contrast is less important (Fon et. al., 2011).

Another important theoretical issue of PA development is whether PA at small unit levels can only be acquired once formal education starts and literacy instruction begins. In other words, it is proposed in some studies (e.g. Seymour, et. al., 1999) that small unit PA could be triggered by orthography experience, such as grapheme-phoneme mapping. Given that the sound structure of Mandarin adopted in this study is different from alphabetic languages, a discussion of the range of small unit PA in Mandarin is necessary.

Firstly, small unit PA should be segmental and should exclude the syllable level. Therefore the onset-rime level (or initial-final level: see figure 1.1) is included in small unit PA even though an onset consonant in Mandarin is always a single phoneme rather than a cluster. The smallest unit level might be the third level and may include three medial vowels and two final nasal consonants. However, this so-called phoneme level is not very much emphasized in Mandarin, particularly Taiwan Mandarin, for two reasons: (a) the medial vowels are normally pronounced at a shorter length and strength, more like a glide bridging an onset to a compulsory nucleus than an independent unit; (b) as mentioned earlier (see section 1.1.1: 'Bilingual environment in Taiwan'), merging of the two final nasal consonants was observed. It might imply that this small unit is not necessarily contrast to each other in order to retrieve correct meaning of utterances; consequently, the replacement with a similar consonant, such as /in/ → [iŋ], /iŋ/→ [in], became acceptable. Therefore, although it is clear that the small unit PA of this study includes the onset-rime and phoneme levels, it would be interesting to discuss further whether PA at these two levels was acquired in a similar pattern.

As shown in figure 3.1, PA at most of the small unit levels improved significantly, except implicit PA at the phoneme level. Formal education facilitates all explicit PA at small unit levels and implicit PA at onset-rime level at least. In other words, both implicit and explicit PA at the onset-rime level was assisted by literacy education, including ZF and character orthographies. However, PA at the smallest unit level (phoneme) showed contradictory results after a year of schooling. Implicit PA at the phoneme level continued to have a high guessing rate at both years and did not show any improvement after a year of schooling. In contrast, explicit PA at the phoneme level had an effect size of up to 0.83, which demonstrates a significant development of phoneme awareness. The result also implies that implicit phonemic awareness is not a foundation of explicit phonemic awareness in Mandarin-speaking children.

A possible interpretation of the contradictory results is that it is very difficult to acquire phoneme PA in Mandarin via auditory input. There might be only a limited proportion of children who are gifted to attain it through spoken language experience. In addition, the phoneme level in Mandarin might not be significantly important in retrieving lexical messages from utterances. Therefore, in Year 1, not only did implicit PA at the phoneme level have a high guessing rate, but also the accuracy rate of explicit PA at the phoneme level was only 29%. The significant improvement of explicit PA at the phoneme level between Grade 1 and Grade 2 implied that it was facilitated by the ZF instruction of symbolizing the medial vowel and syllable ending with ZF letters. In other words, by using ZF letters to annotate words comprising a medial and/or final nasal coda, the skills required to respond an explicit PA at the phoneme level task were improved. In addition, the implicit PA design might reduce the influence of orthography experience as it does not require any output response which involves majorly ZF letter knowledge or spelling skills. Consequently, performance of explicit PA at the phoneme level would improve significantly but implicit PA at the phoneme level would not.

The different demands made by implicit and explicit PA tasks may require different skills to respond correctly. For example, implicit tasks of the PA battery might easily overload children's memory span, particularly when they have to segment less obvious and/or abstract units, such as a phoneme segment. The implicit PA at the phoneme level might not be stimulated to develop during the first school year. Therefore, it is suggested that implicit PA at the phoneme level should be excluded from the PA battery until a child is beyond the 2$^{nd}$ year of school. The implicit PA at the phoneme level task might not be sensitive or reliable enough to measure the phoneme PA of children at this age. More discussion of how literacy instruction interacts with PA development will be examined further in later chapters.

Another issue is whether small unit PA at the onset-rime level was similarly facilitated during the first year of school. A previous study of children learning Pinyin instead of ZF showed that PA at the syllable and rime level is acquired before schooling, whereas small unit PA, such as onset phoneme, develops later, when the child is receiving formal education (Sue, et. al., 2008). Similar results were found in this study, where syllable and rime PA had a higher accuracy rate at school entrance in both implicit and explicit tasks, although the difference between explicit PA at the rime level and explicit PA at the onset level is not statistically significant. In addition, PA at the onset level had consistently higher effect size than at the rime level in both implicit and explicit designs (see Fig. 3.1); the performance of implicit PA at the onset even caught up with implicit PA at the rime level after a year of schooling. Therefore, it seems that learning a phonetic system, whether a ZF or a pinyin system, did help pupils' small unit PA, in particular their onset PA. This may be attributed to regular corresponding relationships between onset phoneme segments in Mandarin and the phonetic ZF letters. Thus, children are alerted to the onset segments by mapping them to their written form. Therefore, the alphabetic rule may be applied to explain why the onset phoneme PA is hugely facilitated after schooling, although the same finding is normally observed in an alphabetic languages background using a transparent orthography (Ziegler & Goswami, 2005).

### 3.3.2 Development of Supra-segmental Phonological Awareness

Previous studies have shown that supra-segmental PA skill improves significantly and continuously during the first year of learning a phonetic orthography system, such as pinyin (e.g. Xu, et. al., 2004). In this study, performance on both implicit PA at the tone level and explicit PA at the tone level improved most substantially with an effect size of 1.24 and 1.29 respectively among all PA tasks during the first school year (see Fig 3.1). In addition, the results of factor analysis showed that after tone PA improves following the start of formal education, it has its own features which distinguish it from the syllable-tone factor at Grade 1 (see figure 3.2). In other words, tone PA in

Mandarin shares a common factor with large unit PA (PA at the syllable level) before the ZF training course which provides visual symbols of suprasegmental messages in utterances. Taking a syllable unit to shape a tone contour makes the suprasegmental unit easily been identified as a feature attached to a large segment. In addition, it seems to be impossible for children to identify or pronounce a tone apart from a syllable unit on the basis of only spoken language experience. This feature might explain why suprasegmental PA would be attained only after the phonetic instruction starts.

To conclude, the results of this study are in general consistent with previous PA studies of Mandarin-speaking children. The development of PA in both implicit and explicit aspects during the first year of schooling improves comprehensively across various linguistic levels. Although the relative pattern of performance among levels in segmental PA is consistent, each level was found to have its own particular features and seemed to be greatly influenced by ZF orthography experience.

### 3.3.3 Relationships between PA and Spoken Language Skills

Given that previous studies of English-speaking preschool children showed that vocabulary and articulation skills are very much linked to large unit PA and small unit PA respectively (e.g. Carroll, Snowling, Hulme & Stevenson, 2003), the relationships between PA and spoken language skills were further examined. Although none of the five spoken language skills had a strong link with PA, it was found that vocabulary did have a weakly significant correlation with explicit PA at the syllable level in Year 2. In addition, picture naming which focused on speech output skills had the most significant correlations with PA sub-tasks, including implicit PA at the onset level, explicit PA at the syllable level and explicit PA at the phoneme level in Year 1 and explicit PA at the rime level in Year 2 (see Table 3.13).

These results indicate that, even after schooling, those children who had better receptive vocabulary span would perform better on explicit syllable PA. The results imply that continuous expansion of vocabulary requires large unit PA in children using a morpho-syllabic written language, unlike children using an alphabetic language. A similar situation was observed in the speech output skill. Children who had better picture-naming performance not only performed better in small unit PA tasks, but also in explicit PA at the syllable level. This is the major difference from previous studies focusing on children speaking alphabetic languages.

## 3.4 Conclusion

In this chapter, the trajectory of PA development at various linguistic levels is presented and its theoretical and practical implications are widely discussed. Further reflection on why certain PA tasks improved most after the first year of schooling requires a detailed review of the orthography experience at this stage. Two orthography systems might require and/or stimulate different linguistic levels of PA which might predict concurrent or longitudinally achievement of literacy. Thus, particular PA skills might easily fade away after the morpho-syllabic orthography is introduced at a later stage.

In the next chapter, the development of literacy and naming skills between the beginning of grade one and two will be presented, followed by a discussion of both theoretical and practical aspects.

# Chapter 4 Results and Discussion II:
# Development of Literacy and Rapid Automatized Naming

This chapter presents the development of literacy and RAN in the first year of school. It addresses the two research questions in this research topic:

2a. How do literacy and rapid naming skills develop in the two orthography systems?

2b. How does the development of literacy skills depend on the writing system used?

Discussion will include: the relationship between ZF and CH literacy acquisition and the developmental pattern of various RAN tasks.

## 4.1 Development of Literacy

### 4.1.1 Performance on Literacy Measures: Year 1

In Year 1, a number of literacy skills, mainly in ZF script, were assessed, including ZF letter knowledge, ZF reading accuracy before and after the intensive ZF course, ZF spelling, ZF school-wide literacy exam and the only CH task, namely character recognition. Table 4.1 presents the descriptive statistics of each literacy task in Year 1.

**Table 4.1 Descriptive statistics of the literacy measures in Year 1**

| Measure | Mean | SD | Min—Max | N |
|---|---|---|---|---|
| ZF letter knowledge (37) | 33.82 (91%) | 3.01 | 21-37 | 95 |
| ZF Reading accuracy_pr* (24) | 9.03 (38%) | 3.25 | 2-16 | 92 |
| ZF Reading accuracy_po ** (24) | 12.13 (51%) | 3.40 | 5-20 | 94 |
| Character recognition*** | 51.78 | 18.48 | 0-95 | 91 |
| ZF spelling (20) | 12.15 (61%) | 2.98 | 5-19 | 91 |
| School-wide literacy exam (100) | 92.94 (93%) | 6.51 | 69-100 | 96 |

Note: Maximum score and accurate percentage of mean score for each measure are presented in parentheses when they are available.

* pr: Before ZF course ; ** po: After ZF course; ***: T score (Mean = 50, SD = 10)

## ZF Letter Knowledge

For ZF letter knowledge, the average correct rate was 91%, showing that most of the cohort has learned the majority of ZF letter-sound mapping rules before they enter primary school. In order to discover what processing challenges they met when naming a letter, an analysis of children's errors was conducted. ZF letters with a high error rate (higher than 15%) are listed in Table 4.2. The type and rate of errors are also presented in the same table.

The most common errors made by the cohort may be categorized into three types:

- Segment substitution: the correct letter name is replaced by another letter name, or a similar segment is used in its letter name.
- Similar symbols: the correct letter name is replaced by the name of a ZF or English letter which looks similar to the target letter.
- Error on the sound structure level: the difference between the error and the correct answer is a missing segment, segments pronounced in reverse order, or a different level of grain size; children gave an incomplete letter name, or reversed the order of phonemes in the letter name, or added an extra medial before a syllable ending.

**Table 4.2 Error type and rate on ZF letter knowledge task**

| No | Letter | IPA | Errors<br>Segment substitution (Sub);<br>Similar symbol (Sy); Structure (St) | Error rate (%) |
|---|---|---|---|---|
| 1. | ㄝ | /ɛ/ | St: /ei/, /ie/ | 34 |
| 2. | ㄡ | / ou / | St: /o/, /io/ | 34 |
| 3. | ㄔ | / tʃʰɘ/ | Sub: / tsʰɘ/, /tsɘ/ , /tʃɘ/ | 21 |
| 4. | ㄘ | / tsʰɘ/ | Sub: / tʃʰɘ/, /tsɘ/, /sɘ/ | 19 |
| 5. | ㄢ | / an / | Sub:/aŋ/,/ən/, / ɛn/<br>Sy: ㄞ<br>St: /a/, /ə/ | 18 |
| 6. | ㄗ | / tsɘ / | Sub: / tsʰɘ /,/ tʃɘ/ | 16 |
| 7. | ㄦ | /ɤ/ | Sub: /ə/ | 16 |

In addition, a large proportion of the cohort misarticulated the letter sound /ɹ̺/. This was therefore not counted as an error during the scoring, since it is not atypical for this age group to misarticulate it. Only 1% of the responses to letter naming could be attributed to speech difficulties or were hard to classify.

### ZF Reading Accuracy

For the ZF reading accuracy task, which was measured twice with an eight-week interval, the average correct performance increased from 9.03 (Pr) to 12.13 (Po) (see Table 4.1). The paired samples t-test showed this difference was both statistically and practically significant, with a high effect size: $t(91) = 9.63$, $p < .001$, $d = 0.999$. This result indicated that ZF reading accuracy did tend to improve after the ten-week intensive ZF course.

In addition, in the ZF reading accuracy tasks, two kinds of distracters were embedded: phono-lexical and visual distracters. The phono-lexical distracters are true words with a phonological and/or lexical similarity to the target. The visual distracters are pseudo-words that are visually similar to the target. The descriptive statistics are presented in Table 4.3.

**Table 4.3 Descriptive statistics of choice of distracters on ZF reading accuracy in Year 1**

| Choice of distracters | Mean | SD | Min—Max | N |
|---|---|---|---|---|
| Pr_ phono-lexical | 1.17 | 1.45 | 0-6 | 88 |
| Pr _ visual | .91 | 1.29 | 0-7 | 88 |
| Po _ phono-lexical | .96 | 1.44 | 0-7 | 90 |
| Po _ visual | .47 | .93 | 0-5 | 90 |

Note: pr: before ZF course; po: after ZF course

Further analysis shows that children made fewer visual than phono-lexical errors, both before ZF course ($Z = 2.08$, $p < .05$) and after ZF course ($Z = 3.58$, $p < .01$) (data analysed using Wilcoxon signed-rank test). There was no significant difference between the number of phono-lexical errors at before and after ZF course but the number of visual errors decreased significantly from before to after ZF course ($Z=3.24$, $p < .01$). The above results imply that the intensive ZF course might effectively strengthen children's ZF reading accuracy in ZF orthography processing. The fact that recognition of ZF symbols improved within such a short period of time might be partly attributed to the high accuracy rate of ZF letter knowledge. Moreover, it may also be attributed to the relatively fewer strokes of each letter and consistent grapheme-phoneme mapping. Since it was evident that pupils were familiar at recognizing ZF words after the intensive ZF course, their correct ZF writing was expected.

**ZF Spelling**

The ZF spelling task comprising real and pseudo words in either regular or irregular spellings was the only writing task used in this study. In order to make sure children had developed sufficient writing skills to complete this task, it was not carried out until the 11$^{th}$ week. Five students who failed the task completely (with a score of zero) were excluded from the analysis. This group of students was from the same class and happened to sit close to each other. They misunderstood the instruction and wrote only onset letters, instead of whole words.

The average spelling accuracy was 61%. Table 4.4 presents descriptive statistical results separately for each of the four categories of items. The accuracy was significantly better on true words than on pseudo-words ($t(90) = 7.12$, $p < 0.01$), and for items with regular rather than irregular spellings ($t(90) = 2.57$, $p < 0.05$). In addition, no writing error, such as unrecognised ZF or no ZF scripts, was found in the ZF spelling task.

**Table 4.4 Accuracy of spelling on true vs pseudo-words, and on regular vs irregular spellings in Year 1**

| Measure (max) | Mean | SD | Min—Max |
|---|---|---|---|
| True word (10) | 6.82 | 1.80 | 3-10 |
| Pseudo-word (10) | 5.33 | 1.79 | 1-10 |
| Regular spelling (10) | 6.33 | 1.90 | 1-10 |
| Irregular spelling (10) | 5.82 | 1.62 | 1-10 |

The above results show that for these children (average age 6.7), after intense learning of ZF, activating the top-down lexical knowledge (true words) to spell out what they heard was easier than the bottom-up processing (pseudo-words) relying on phonological information and online sound-letter mapping process. The results suggest that children are not capable of generalising the spelling skill to novel words after the intensive ZF course. In other words, if the target of ZF training includes applying the spelling skill to write down novel words or utterances rather than only reading ZF words, then further training would be needed in order to achieve this.
In addition, the difference in the accuracy rate between regular and irregular spellings is reasonable; regular spelling items were combined by serial letters in which sound-letter was consistently mapped to each other, which was easier for the cohort than irregular spellings which required more item-specific lexical and orthographic knowledge to complete the correct spelling.

However, the above results might also be due to the different difficulty level. The lack of a lexical route or sound-letter mapping makes pseudo- or irregular words less familiar and harder.

**School-wide Literacy Exam**

The first school-wide literacy exam (see 2.3.4 for details) was intended to test the results of children's ZF learning after the intensive ten-week course. All the items were written in ZF and all students across classes took the same examination. According to the result, the average accuracy was high, up to 93% (standard deviation = 6.51). Thus, most of the students performed well in this school-wide exam.

### 4.1.2 Performance on Literacy Measures: Year 2

Table 4.5 presents the descriptive statistics of the measures administered in Year 2.

**Table 4.5 Performance on literacy tasks in Year 2**

| Measure | Mean | SD | Min—Max | N |
|---|---|---|---|---|
| Reading accuracy of ZF_Y2 (24) | 12.72 (53%) | 3.26 | 3-21 | 92 |
| Reading accuracy of character (24) | 13.51 (56%) | 2.93 | 5-21 | 91 |
| Character recognition* | 55.45 | 13.76 | 29-90 | 92 |
| Character legality judgement_speed (sec) | 58.69 | 13.27 | 32-110 | 92 |
| Character legality Judgement_accuracy (20) | 17.29 (86%) | 1.98 | 9-20 | 92 |
| Reading comprehension | 60.49* | 6.09 | 32-66 | 92 |
| School-wide literacy exam (100) | 94.98 (95%) | 5.33 | 62-100 | 92 |

Note: Maximum score and accurate percentage of mean score for each measure are presented in parentheses when they are available.

*: T score (mean = 50, SD = 10)

**ZF and Character Reading Accuracy**

In Year 2, both the ZF reading accuracy task and the character reading accuracy task sharing the same design were administered. Both are speed-accuracy tasks. Accuracy performance on the Chinese character task was slightly yet significantly better than on the ZF task: $t(90) = 2.57$, $p = .012$. Since materials in both ZF and character tests were pictures of high-frequency nouns, this difference may possibly be attributed to the accessing and/or processing of the diverse orthography systems; that is, processing semi-syllabary ZF letters into words took a longer time than processing morpho-syllabic characters.

Table 4.6 presents the descriptive statistics of two types of errors, visual and phono-lexical, on ZF and CH reading accuracy tasks in Year 2. Comparisons of the errors between two types of distracters, visual and phono-lexical, on the ZF and CH reading accuracy tasks by the Wilcoxon signed ranks test showed significantly more visual errors than phono-lexical errors on both tasks (ZF: $Z = 3.91$, $p < .001$; CH: $Z = 3.80$, $p < .001$).

**Table 4.6 Errors on ZF and CH reading in Year 2**

| | Mean | Std. Deviation | Min- Max | N |
|---|---|---|---|---|
| ZF_ phono-lexical | .47 | .81 | 0-4 | 91 |
| ZF_visual | .92 | .91 | 0-5 | 91 |
| CH_ phono-lexical | .77 | 1.01 | 0-5 | 91 |
| CH_visual | 1.47 | 1.41 | 0-5 | 91 |

Moreover, comparisons of phono-lexical and visual errors between ZF and CH reading accuracy tasks were conducted. The results showed that both phono-lexical and visual errors were made significantly more often on the CH task than on the ZF task (phono-lexical: $Z = 2.42$, $p < .05$; visual: $Z = 3.73$, $p < .00$). The results imply that Grade 2 children (average age: 7.7), after a year of literacy education, were more easily distracted by visual than phonological input, no matter what kind of orthography they read. Phonological decoding seemed to be no longer an influential processing. In addition, more errors were made, no matter which type of errors, in the CH reading accuracy task than the ZF task. This implies that CH is a relatively more difficult orthography to identify correctly than ZF for children at Grade 2.

ZF reading accuracy was the only task which was measured three times: at the very beginning of the ZF course (Y1_pr), after the ten-week ZF course (Y1_po), and a year later (Year 2). Table 4.7 presents the mean and effect size across these three measurements.

**Table 4.7 Mean and effect size of ZF reading accuracy (Max=24) across three time points**

| Time point | Mean | SD | Cohen's d |
|---|---|---|---|
| Year 1 before ZF course | 9.03 | 3.25 | |
| Year 1 after ZF course | 12.13 | 3.40 | |
| Year 2 | 12.72 | 3.26 | |
| Compare Y1_pr* & Y1_po** | | | 0.93 |
| Compare Y1_pr & Year 2 | | | 1.13 |
| Compare Y1_po & Year 2 | | | 0.18 |

* Y1_pr: Year 1 and before ZF course ; ** Y1_po: Year 1 and after ZF course

In order to know whether these changes were statistically significant or not, repeated measured ANOVA was taken to examine the difference in ZF reading accuracy at the three time points. Mauchly's test indicated that the variances of differences among the above measurements at three time points were not significantly different ($\chi^2$ (2) = 1.08, p > .05). In addition, the results showed that performance on ZF reading accuracy was significantly influenced by the length of time of schooling (F (2,172) = 59.86, p < .00). Post hoc tests showed that performance on ZF reading accuracy after ZF course ( Y1_po) and T3 were statistically better than performance on ZF reading accuracy before ZF course(p < .001). However, no difference was observed between performance on ZF reading accuracy after ZF course in Year 1 and Year 2 (p =.53).

According to the above results, the children's ZF reading accuracy improved significantly after completion of the ten-week ZF training but then it remained at the same level for a year whilst they were continuously exposed to ZF orthography in literacy education.

**Character Recognition**

For the Character recognition task, the cohort performed moderately better (M = 55.45) and showed greater variability (SD = 13.76) compared to the population norms (M = 50, SD = 10) (d = 0.45).

According to the average score, children performed better on character recognition in Year 2. A paired t-test was used to compare the difference in performance within individuals. It showed a significant but small improvement from Year 1 to Year 2: $t = 3.08$, $p < .01$, $d = .23$.

**Character Legality Judgement**

Performance on the legality judgement task in the year 2 sample (M = 86.45%) was very similar to that reported by Wang, Perfetti and Liu (2005) in their Grade 2 sample (M = 86.6).

The design of the tasks included two subtasks: (a) position of radicals, and (b) stroke arrangement of radicals. Table 4.8 presents the descriptive statistics related to these subtasks. A paired samples t-test showed that children did better on judgements about form (b) than judgements about position (a), both in terms of accuracy ($t = 7.66$, $p < .01$) and speed ($t = 8.56$, $p < .01$). The results suggest that the sequence of character knowledge acquisition is that the form of radicals is acquired before the structure of characters.

**Table 4.8 Descriptive statistics for the subtasks of character legality judgement**

| Measure | Mean | SD | Min—Max | N |
|---|---|---|---|---|
| Position_speed (sec) | 64.24 | 17.62 | 32-136 | 92 |
| Form_speed (sec) | 53.14 | 10.90 | 31-83 | 92 |
| Position_accuracy (20) | 16.20 (81%) | 2.42 | 9-20 | 92 |
| Form_accuracy (20) | 18.38 (92 %) | 2.40 | 4-20 | 92 |

Note: Maximum score and accurate percentage of mean score for each measure are presented in parentheses when they are available.

**Reading Comprehension**

The published test adopted for reading comprehension was originally designed for year 1 pupils (average age 6.7) since this task was administered only one and a half months after the beginning of the second school year. This may explain partly why the average performance of the cohort was higher than the norm by more than 1 SD. However, in another way, for those children performing at the lower end of this cohort, it was even more possible that they did lag behind and might have some difficulty on those literacy skills related to reading comprehension. This issue will be discussed in more detail later in Chapter 6.

### 4.1.3 The Impact of Background Factors on Literacy Measures

Given the non-normal distribution of performance in literacy measures generally, non-parametric tests will be used to analyse the impact of background factors such as age, non-verbal intelligence, and school environment. It is notable that family and language environment showed no impact on the literacy measures by Kruskal Wallis Test (all $p > .05$) in this study.

**Age**

In order to check the impact of age within each year, Spearman's correlation was adopted to find out if literacy measurements changed with participants' age. The results with statistical significance are presented in Table 4.9. Only performance on school-wide exams in year 1 and 2, and on ZF reading accuracy post ZF course in year 1 significantly correlated with age. These results suggest that younger children performed less well in the exam situation regardless in Grade one or Grade two.

**Table 4.9 Significant correlations between literacy measures and age in Year 1 and Year 2**

| No | Year 1 | | Year 2 | |
|---|---|---|---|---|
| | Measurement | $r_s$ | Measurement | $r_s$ |
| 1. | School exam | .21* | School exam | .34 ** |
| 2. | ZF reading accuracy before ZF course | .10 | ZF reading accuracy | .09 |
| 3. | Character recognition | .18 | Character recognition | .17 |
| 4. | ZF letter knowledge | -.07 | | |
| 5. | Spelling | -.06 | | |
| 6. | ZF reading accuracy after ZF course | .26* | | |
| 7. | | | Character reading accuracy | .11 |
| 8. | | | Comprehension | .17 |
| 9. | | | Radical_place_RT | .10 |
| 10. | | | Radical_place_accuracy | -.04 |
| 11. | | | Radical_form_RT | -.01 |
| 12. | | | Radical_form_ accuracy | .12 |

** $p<0.01$, * $p<0.05$

### Non-verbal intelligence

Six literacy tasks correlated with non-verbal intelligence (see Table 4.10). The strength of the relationships was weak to moderate. For this reason, it may be worth controlling for non-verbal intelligence in the subsequent analyses.

**Table 4.10 Correlation between non-verbal intelligence (TONI) and literacy variables in Year 1 and Year 2**

| No | Year 1 | | Year 2 | |
|---|---|---|---|---|
| | Measurement | $r_s$ | Measurement | $r_s$ |
| 1. | School exam | .29** | School exam | .25* |
| 2. | ZF reading accuracy before ZF course | .25* | ZF reading accuracy | .28** |
| 3. | Character recognition | .32** | Character recognition | .28** |
| 4. | ZF letter knowledge | .31** | | |
| 5. | Spelling | .18 | | |
| 6. | ZF reading accuracy after ZF course | .17 | | |
| 7. | | | Character reading accuracy | .42** |
| 8. | | | Comprehension | .33** |
| 9. | | | Radical_place_RT | -.05 |
| 10. | | | Radical_place_accuracy | .05 |
| 11. | | | Radical_form_RT | -.15 |
| 12. | | | Radical_form_ accuracy | .11 |

** p<0.01, * p<0.05

## 4.2 Development of Rapid Automatized Naming

### 4.2.1 Descriptive Statistics of RAN: Year 1

Table 4.11 presents the descriptive statistics of the digit and object naming tasks administered at the first year. The average speed of the digit RAN was significantly faster (t = 18.9, p <0.01) than that of the object task. In addition, a negative moderate correlation was found between age and object RAN in speed (r = -.30, p < .01). That is, younger children perform slower than their older peer group.

**Table 4.11 Descriptive statistics for RAN in Year 1**

| Measure | Mean (sec) | SD | Min—Max(sec) | N |
|---|---|---|---|---|
| Digit | 37.1 | 12.18 | 16 – 78 | 94 |
| Object | 59.8 | 16.86 | 31 – 118 | 94 |

It is noteworthy that many children would make a few self-corrections spontaneously and/or slowed down naming speed to increase the accuracy rate during the naming tasks. It implied that the auditory monitoring skill, such as online checking the consistency between their speech target and production, had developed for school aged children to enable the above adjustment.

### 4.2.2 Descriptive Statistics of RAN: Year 2

Apart from the digit and object RAN tasks, ZF and character RAN were added in Year 2. Table 4.12 presents the descriptive statistics of all RAN tasks in Year 2.

**Table 4.12 Descriptive statistics for RAN in Year 2**

| Measure | Mean (sec) | SD | Min—Max (sec) | N |
|---|---|---|---|---|
| Digit | 31.32 | 9.18 | 16-66 | 91 |
| Object | 53.07 | 12.36 | 30-89 | 91 |
| ZF | 39.87 | 9.32 | 24-67 | 90 |
| Character | 34.24 | 7.41 | 19-60 | 91 |

The average speeds on digit, ZF and character naming tasks were similar, while naming of objects took considerably longer. A paired t-test was administered to check the relative speed for these four subtasks (see Table 4.13). Spontaneous self-corrections were observed. Participants tended to restart and repeat a few letter names while self-correcting.

**Table 4.13 Speed measured in seconds of RAN subtasks in Year 2**

| Speed (sec) | | | | | | |
|---|---|---|---|---|---|---|
| Digit | $<^{.00}$ | Character | $<^{.00}$ | ZF | $<^{.00}$ | Object |

Regarding the development of RAN, a comparative analysis of digit and object RAN between Year 1 and Year 2 was conducted. The results showed a statistically significant and moderate improvement in the speed of naming digits ($t = 6.63$, $p < 0.00$, $d = 0.56$). However, there was no significant improvement in the speed of naming objects. This indicates that the first year of schooling was quite helpful in improving the fluency of reading on digits, but not objects.

It is noteworthy that during the ZF naming task, many children pronounced two consecutive letters together, or even combined the target letter with its previous letter as a syllable. The results indicate that in ZF, a phonetic orthography, a series of ZF letters would automatically trigger syllabic synthesis both backwards and forwards, which was not found in the character task as its scripts were only processed individually. Moreover, some of the children mistakenly named a ZF letter in English more than once in a single task because of visual or phonological similarity between ZF letters and English letters. The results show that pupils at Grade 2 were easily confused by the situation where the same letter can be mapped to more than one sound.

After demonstrating the descriptive statistics on literacy and RAN, this chapter will present the intrinsic relationships among literacy or RAN tasks. The raw scores were converted to normalised scores for further comparison across various measurements by using Blom’s proportion estimation formula.

## 4.3 The Correlations among Literacy Measures

Zero-order correlations (Pearson's r) among literacy measures in Year 1 and Year 2 are reported in Table 4.14 and 4.15 below the diagonal. Given that non-verbal intelligence was correlated with a few literacy tasks, partial correlations r between literacy tasks, controlling for non-verbal intelligence, were also carried out and presented above the diagonal. The following description is based mainly on the partial correlations.

In Year 1, the majority of the tasks shown in Table 4.14 had a moderate to strong relationship with each other and all correlations were positive. To see if these literacy measures are testing the same set of literacy skills, a factor analysis was conducted. Data screening confirmed the adequacy of factor analysis for the presented cohorts, i.e., the Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO= .79; all KMO values for individual items were > .51. Single construct of the above literacy measures was identified as contributing 47% variance.

**Table 4.14 Correlations between literacy measures in Year 1 (below diagonal); partial correlations controlling for non-verbal intelligence (above diagonal)**

| | ZF letter knowledge | School exam | Spelling | ZF reading accuracy_pr# | ZF reading accuracy_po## | Character recognition |
|---|---|---|---|---|---|---|
| ZF letter knowledge | -- | *.36*** | *.26** | *.27** | *.19* | *.13* |
| School exam | .39** | -- | *.20* | *.43*** | *.40*** | *.41*** |
| Spelling | .32** | .27* | -- | *.31*** | *.11* | *.15* |
| ZF reading accuracy_pr# | .26* | .48** | .31** | -- | *.50*** | *.54*** |
| ZF reading accuracy_po## | .21 | .42** | .18 | .49** | -- | *.39*** |
| Character recognition | .23* | .50** | .18 | .61** | .39** | -- |

** Correlation is significant at the 0.01 level 2-tailed. * 0.05 level 2-tailed.

# ZF reading accuracy_pr: ZF reading accuracy before ZF course

## ZF reading accuracy_po: ZF reading accuracy after ZF course

However, a few pairs of non-significant correlations are noteworthy. Firstly, ZF letter knowledge correlated with ZF reading accuracy at Y1 before ZF course only and had no significant correlation with ZF reading accuracy at Y1 after ZF course and CH recognition. The results indicate that the individual variation of ZF letter knowledge decreased quickly or there was a ceiling effect on ZF letter knowledge after the ten-week intense ZF course. In addition, ZF spelling did not correlate to the ZF school exam, reading accuracy at Y1 after ZF course and CH recognition, but had a moderate correlation with reading accuracy at Y1 before ZF course. Since the ZF spelling task relies heavily on auditory processing, segmenting and sound-letter mapping skills, the results might imply that the longer the formal education received by children, the more independent processing there is between spoken and written language.

In Year 2, literacy tasks were not closely correlated with each other. In particular, the character legality variables did not significantly correlate with school exam, character recognition and reading comprehension results. Therefore, further factor analysis was necessary. In addition, reading comprehension did not correlate with either ZF or CH reading accuracy. This result might imply that decoding ZF and CH words had reached a level of fluency which is sufficient for reading comprehension among Grade 2 children.

**Table 4.15 Correlations between literacy measures in Year 2 (below diagonal); partial correlations controlling for non-verbal intelligence (above diagonal)**

| | School exam | ZF reading accuracy | CH reading accuracy | CH recog-nition | Reading compre-hension | Radical_place_RT | Radical_place_accuracy | Radical_form_RT | Radical_form_accuracy |
|---|---|---|---|---|---|---|---|---|---|
| School exam | -- | *.37*** | *.22** | *.35*** | *.47*** | *-.15* | *-.07* | *-.16* | *-.01* |
| ZF reading accuracy | .24* | -- | *.49*** | *.22** | *.13* | *-.26** | *.06* | *-.35*** | *.00* |
| CH reading accuracy | .11 | .54** | -- | *.40*** | *.09* | *-.31*** | *.10* | *-.30*** | *.03* |
| Character recognition | .22* | .27** | .46** | -- | *.26** | *-.20* | *-.09* | *-.21* | *.04* |
| Reading comprehension | .52** | .21* | .21* | .34** | -- | *-.12* | *-.02* | *-.02* | *-.02* |
| Radical_place_RT | -.03 | -.26* | -.30** | -.19 | -.12 | -- | *-.07* | *.72*** | *.24* |
| Radical_place_accuracy | -.09 | .07 | .10 | -.06 | .00 | -.05 | -- | *-.08* | *.30*** |
| Radical_form_RT | -.05 | -.37** | -.33** | -.21* | -.05 | .73** | -.07 | -- | *.19* |
| Radical_form_ accuracy | .02 | .03 | .07 | .08 | .03 | .26* | .31** | .21* | -- |

Data screening of all literacy tasks in Year 2 was adequate for factor analysis. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis: KMO

= .65. In addition, all KMO values for individual items were > .59. Not surprisingly, two factors, character legality measures and other literacy tasks, contributing 54% variance in total were found, 19% and 35% for the above two factors of variance contribution, respectively. This result suggests that character legality judgement is probably an implicit skill acquired later when sufficient orthographic knowledge is established.

**Stability of Literacy Scores Over Time**

For those tasks that were tested twice or more, correlations were calculated to discover the level of stability underlying the same task at different time points. The results are presented in Table 4.16.

Moderate correlations were found among measurements of ZF reading accuracy taken at three time points. The results indicate that, although there was a common processing of ZF orthographic decoding underlying ZF reading accuracy at three time points, only a moderate degree of stability in scores over a period of one year was observed.

**Table 4.16 Correlations between literacy measures in Year 1 and Year 2**

| | ZF reading accuracy_ Y1_po## | ZF reading accuracy_Y2 | CH recognition_Y2 |
|---|---|---|---|
| ZF reading accuracy_Y1_pr# | .49** | .44** | -- |
| ZF reading accuracy_Y1_po## | -- | .40** | -- |
| Character recognition_Y1 | -- | -- | .87** |

# ZF reading accuracy_Y1_pr: ZF reading accuracy before ZF course in Year 1

## ZF reading accuracy_Y1_po: ZF reading accuracy after ZF course in Year 1

Regarding character recognition, the high correlation between Year 1 and Year 2 results indicates that, while a year of literacy instruction did result in improved Chinese character recognition (see previous chapter), children's relative standing on this task remained very stable.

## 4.4 The Relationships among RAN Tasks

Table 4.17 presents the zero-order correlation (Pearson r) of all the subtasks in RAN in Year 1 and Year 2. Since no correlation was found between RAN and non-verbal intelligence, there was no reason to control for this background factor.

**Table 4.17 Correlation between subtasks of RAN in Year 1 and Year 2**

| | | Year 1 | | Year 2 | | | |
|---|---|---|---|---|---|---|---|
| | | Digit | Object | Digit | Object | ZF | Character |
| 1st year | Digit | -- | | | | | |
| | Object | .61** | -- | | | | |
| 2nd year | Digit | .70** | .52** | -- | | | |
| | Object | .51** | .67** | .72** | -- | | |
| | ZF | .55** | .42** | .71** | .67** | -- | |
| | Character | .64** | .53** | .79** | .71** | .82** | -- |

** Correlation is significant at the 0.01 level (2-tailed).

Despite a year's interval, correlations from moderate to very strong were found among these RAN tasks. This indicates that all RAN tasks tap a similar process. However, the highest correlation between ZF and CH subtasks compared to the lowest correlation between ZF and object subtasks indicates that orthography tasks require slightly different skills from the object subtasks.

## 4.5 Discussion

The findings suggest that there are differences in the manner of sound-script mapping and phonological decoding process between different orthographies, such as ZF and

CH. Therefore, it is important to discuss the differences in their acquisition to know whether and how it is beneficial for pupils to learn ZF prior to CH. In addition, the reasons for the various performances on RAN tasks will be discussed.

### 4.5.1 Development of Ability to Read ZF and CH

**ZF Literacy Acquisition**

As mentioned earlier, the traditional approach of sound structure in Mandarin was applied (see section 1.1.1.1), for it matches more closely the method of spelling with ZF (see fig. 1.1). Instruction in using ZF orthography is given to pupils at the beginning of schooling to teach them to spell words they know and to help them teach themselves novel words written in characters. It was surprising to find that the accuracy rate of ZF letter knowledge was high at school entrance (91%). In addition, it was found that most children became fairly accurate in ZF reading and spelling after only ten weeks of ZF instruction. In other words, pupils improved their recognition and reading of ZF after the intensive ZF course under the condition where their ZF letter knowledge was well established at preschool stage.

Also, the contrast between two types of errors made in ZF reading accuracy tasks across three time points is noteworthy (see Tables 4.3 and 4.6). The number of phono-lexical errors consistently decreased across three time points (1.17, .96 and .47) while the visual errors increased in Year 2 (.91, .47 and .92). Particularly the average rate is similar at the last two time points, i.e., post the ZF course and the beginning of grade two. The decrease in phono-lexical errors suggests that, as pupils gained more experience in ZF reading, the correct decoding of larger units of ZF written words, such as the two-syllabic ZF words of the ZF reading accuracy task, became easier. This result is in line with the hypothesis proposed by psycholinguistic grain size theory (Ziegler and Goswami, 2005). On the other hand, the increase in visual error rate indicates that the detailed identification of ZF words became less dominant when pupils became used to reading ZF words on the large-unit level. Another possible explanation is that it took intensive training to increase and/or maintain the accuracy in detailed identification of ZF words.

Lastly, according to the errors made in ZF letter naming, segment substitution, symbol confusion and unfamiliarity of sound structures represented by letters were the three major challenges for pupils in correctly applying sound-mapping knowledge. With far more strokes on average in characters than in ZF letters, it is not surprising that in a previous study by Wang, Hung, Chang and Chen (2008), characters were found to be acquired gradually across all six grades in primary school.

**CH Literacy Acquisition**

According to the results presented in this chapter, correctly decoding Chinese characters strongly emphasizes visual processing. Regarding the difficulty for pupils of decoding characters, the results on accuracy in character reading may be informative. In this task, the visual distracters adopted are illegal characters similar to the target ones but differing from them in missing or displacing one or two strokes. The relatively higher rate on the visual errors compared to the phonological-lexical errors in the task (see Table 4.6) indicates that children tended not to identify in a speed test whether all strokes of a character are included and correctly placed. However, this result does not necessarily imply that awareness of the structure of characters might develop from the large unit, such as character and/or radical level, to the stroke level, including the placement and number of strokes.

The results of the legality judgement task show that the implicit knowledge of radical forms of characters was acquired earlier than radical placement in Year 2. The foils in the form subtask are the single characters with similar outlook but with a few strokes missed or displaced (see Figure 2.5). The result therefore demonstrates that pupils had better awareness on the stroke level than the radical level, which is concerned with the right placement of certain radicals. Thus, it is suggested that awareness of characters' written structure develops from small to large units, similar to the direction of development in ZF word reading.

In the study by Wang, Perfetti and Liu (2005) of the legality judgement task, participants were recruited from among immigrant families living in Washington, DC. They received English education at school, but spoke Chinese at home, and attended a Chinese weekend school. Also, only simplified characters were taught. It is likely that their parents were highly educated and had high socio-economic status. In contrast, our sample received Chinese literacy in a mainstream school with a wide variation in family background and literacy exposure at home. The fact that there was no difference in Chinese character knowledge among children growing up in such diverse family and educational backgrounds shows that character legality judgement might not be influenced by social related conditions, if children are exposed to a sufficient level of Chinese characters. Also, how character knowledge is accumulated, whether in a traditional or a simplified form, seems to be universal and dependent only on its script features.

### 4.5.2 Variable Performance among Rapid Automatized Naming Tasks

In Year 1, the difference in speed between digit and object naming tasks was statistically significant , i.e., faster on digit RAN (see Table 4.11). This result was in line with previous studies (e.g., Liao et. al., 2008) and indicated that, as early as school entry, access to graphological information (digit task) was easier and therefore quicker than access to non-graphological information (object task).

In Year 2, ZF and CH naming tasks were added. In order to control the above confounding factor of different number of items in a line between tasks, the arrangement of items in the ZF and CH naming tasks replicated the object naming task. Similar to the results of Year 1, it was found that children performed faster on the graphological tasks (ZF and CH) than the non-graphological object task (see Table 4.13). The difference in processing level between the two kinds of rapid naming was reflected in the correlation analyses (see Table 4.17) where the lowest correlations were between object naming and three other RAN tasks.

This difference may be due to a limited set of digit stimuli which have high-frequency exposure in daily life as suggested by Wolf (1991); or lesser perceptual complexity for graphological stimuli (Liao, et. al., 2008). However, in the current study, the difference might also be attributed to other causes. For example, the arrangement and complexity of visual stimuli in the digit and object naming tasks were different from each other. In the study, both digit and object tasks comprised of fifty items, but the number of items in a row was different: five for digit and ten for object tasks (see appendix 2:12 and 2:13). Moreover, compared to the digit task, the symbol or layout of the stimuli in the object task is more complex. Therefore, further evidence of whether graphological RAN with higher automaticity level generally is a better predictor of reading performance than non-graphological RAN will be discussed in Chapter 5.

Furthermore, it is noteworthy that children performed better on CH rapid naming than ZF (see Table 4.13), despite the following factors: (a) longer exposure to and/or higher familiarity with ZF letters for Grade 2 pupils; (b) a relatively constrained set of symbols in ZF orthography (i.e. only 37 ZF letters); (c) fewer strokes in ZF stimuli. The results replicated what has been found in previous studies (e.g., Liao, et. al., 2008) and were attributed to the difference in perceptual complexity or the higher level of automaticity in processing between well-known characters and ZF symbols. Since the two tasks also differed as to whether lexical information was being assessed (i.e. letter vs. single character word), the efficiency in naming characters could also be attributed to excitatory lexical accessing compared to rapid naming of letters in ZF (Stainthorp et. al., 2010). This evidence of the difference between ZF and CH RAN performance suggests the role of RAN varies as a function of the orthography system (Liao et al., 2008), and will be explored further in the next chapter, which deals with predictors of reading.

## 4.6 Summary

This chapter has presented and discussed the development of literacy and of RAN in two orthography systems. In the next chapter, the predictors of literacy skills, including spoken language, PA, and RAN, will be analysed and discussed within the literacy education context in Taiwan.

# Chapter 5 Results and Discussion III:
# The Predictors of PA and Literacy Acquisition

This chapter covers the third topic of the study and addresses the following research questions:

3a. How are literacy skills in Grade 1 and 2 predicted by measures of PA, RAN and spoken language?

3b. How is PA in Grade 1 and 2 predicted by measures of spoken language, literacy skills and RAN?

The chapter will firstly present results of correlation and multiple regression analysis followed by discussions of how these results link to the above research topic.

## 5.1 Correlations of All Measures in the Study

In order to know the strength of association between all pairs of measures of the study, correlation analysis was conducted for individual tasks and PA factors. The results are presented in Table 5.1, 5.2, 5.3 and 5.4. PA factor scores, rather than scores of PA subtasks, were used here as the former have higher construct validity. Before the correlation analysis was conducted, raw scores on all variables were transformed to normalize their distribution. Blom’s proportion estimation formula, which converts raw scores into normalized z scores (i.e. z scores derived from percentile ranks under the assumption of a normal distribution), was used. After non-verbal intelligence was partialled out (Table 5.4 all and Table 5.1 & 5.2 above diagonal), most of the significant correlations were moderate in strength. Few correlations were either strong or very strong and most of those were found in speed tasks or tasks sharing the same orthography, either ZF or characters.

**Table 5.1 Correlations between tasks in Year 1 (below diagonal) and partial correlations controlling non-verbal intelligence (above diagonal)**

| Year 1 vs Year 1 | | Literacy | | | | | | PA factor | | | RAN | | spoken language | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ZF letter knowledge | Read accu._ZF_pr | CH recognition | ZF Spelling | Read accu._ZF_po | School exam | General PA | Syllable_tone PA | Implicit PA | Digit | Object | semantic fluency | PPVT | Picture naming | Aud memory |
| Literacy | ZF letter knowledge | 1 | .26* | .1 | .24 | .19 | .33* | .22 | -.05 | 0 | -.15 | -.21 | .19 | .18 | .23 | .29* |
| | Read accu._ZF_pr | .26* | 1 | .56*** | .37** | .51*** | .42*** | .3* | -.11 | .16 | -.49*** | -.29* | .14 | -.21 | .26* | .02 |
| | CH recognition | .23* | .61*** | 1 | .13 | .39** | .28* | -.04 | -.02 | .15 | -.35** | -.17 | -.03 | .11 | .21 | .09 |
| | ZF Spelling | .32** | .31** | .18 | 1 | .03 | .25* | .25* | .15 | .17 | -.11 | -.09 | .15 | .13 | .1 | .16 |
| | Read accu._ZF_po | .21 | .49*** | .39*** | .18 | 1 | .43*** | .28* | -.06 | .17 | -.34** | -.3* | .12 | -.07 | .13 | .17 |
| | School exam | .39** | .48*** | .50*** | .27* | .42*** | 1 | .42*** | -.1 | .17 | -.21 | -.27* | .16 | .09 | .17 | .28* |
| PA factor | General PA | .34** | .33** | .16 | .31** | .33** | .49*** | 1 | -.04 | .3* | -.21 | -.17 | .17 | -.05 | .16 | .11 |
| | Syllable_tone PA | -.03 | -.08 | -.08 | .12 | -.09 | -.14 | -.09 | 1 | -.51*** | .23 | .17 | .26* | .2 | -.05 | -.02 |
| | Implicit PA | .11 | .22* | .31** | .21* | .27* | .26* | .38** | -.46*** | 1 | -.18 | -.22 | -.05 | .12 | -.02 | -.02 |
| RAN | Digit | -.09 | -.51*** | -.43*** | -.16 | -.44*** | -.29** | -.29** | .25* | -.25* | 1 | .63*** | -.26* | .15 | 0 | -.09 |
| | Object | -.2 | -.33** | -.26* | -.11 | -.33** | -.27* | -.17 | .19 | -.23* | .61*** | 1 | -.29* | .07 | -.19 | -.17 |
| spoken language | Semantic fluency | .24* | .09 | -.01 | .2 | .19 | .15 | .22* | .16 | .07 | -.25* | -.25* | 1 | 0 | -.04 | -.02 |
| | PPVT | .27* | -.12 | .23* | .14 | .01 | .17 | .01 | .05 | .16 | .1 | -.02 | .08 | 1 | .07 | .26 |
| | Picture naming | .27** | .29** | .35*** | .17 | .19 | .27** | .35*** | -.01 | .14 | -.14 | -.27* | .04 | .16 | 1 | .23 |
| | Aud_memory | .40*** | .14 | .26* | .21* | .17 | .38*** | .30** | -.09 | .15 | -.14 | -.21* | .06 | .27* | .26* | 1 |

**Table 5.2 Correlations between tasks in Year 2 (below diagonal) and partial correlations controlling non-verbal intelligence (above diagonal)**

| Year 2 vs Year 2 | | Literacy | | | | | | | | | PA factor | | | RAN | | | | S. L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Radical_place_RT | Radical_place_accu. | Radical_form_RT | Radical_form_accu | Comprehension | CH recognition | Read accu._ZF | Read accu._CH | School exam | Small segment PA | Syllable implicit PA | Tone PA | Digit | Object | Zhuyin Fuhao | Character | Pseudo word memory_span |
| Literacy | Radical_place_RT | 1 | .03 | .77*** | .25* | -.14 | -.16 | -.34* | -.28* | -.14 | -.06 | .07 | -.18 | .25 | .16 | .27* | .34* | -.04 |
| | Radical_place_accu. | -.05 | 1 | .02 | .28* | .04 | -.23 | -.04 | .06 | -.03 | .03 | -.04 | .01 | .23 | .09 | .21 | .31* | .02 |
| | Radical_form_RT | .73*** | -.07 | 1 | .26* | -.1 | -.23 | -.37** | -.24 | -.17 | -.08 | .02 | -.10 | .34* | .24 | .34* | .49*** | -.06 |
| | Radical_form_accu. | .26* | .31** | .21* | 1 | -.08 | -.08 | -.14 | .01 | -.05 | 0 | -.01 | .17 | .11 | .16 | .18 | .33* | .03 |
| | Comprehension | -.12 | 0 | -.05 | .03 | 1 | .26* | .18 | .18 | .45*** | .33* | .12 | .10 | -.28* | -.31* | -.08 | -.24 | .39** |
| | CH recognition | -.19 | -.06 | -.21* | .08 | .34** | 1 | .17 | .48*** | .29* | -.05 | -.09 | -.08 | -.36** | -.06 | -.18 | -.36** | .12 |
| | Reard accuracy_ZF | -.26* | .07 | -.37** | .03 | .21* | .27** | 1 | .43*** | .33* | .26* | .09 | .03 | -.29* | -.23 | -.17 | -.27* | .05 |
| | Read accuracy _CH | -.30** | .1 | -.33** | .07 | .21* | .46** | .54** | 1 | .17 | -.06 | -.14 | .1 | -.27* | -.15 | -.16 | -.18 | .09 |
| | School exam | -.14 | -.07 | -.15 | .05 | .52*** | .40*** | .40*** | .30** | 1 | .23 | -.06 | .12 | -.32* | -.28* | -.21 | -.27* | .07 |
| PA factor | Small segment PA | -.02 | 0 | -.09 | .08 | .36*** | .08 | .34** | .12 | .30** | 1 | .38** | .30* | -.09 | -.10 | -.07 | -.13 | .10 |
| | Syllable_implicit PA | .04 | .08 | -.18 | .09 | .14 | -.01 | .25* | .06 | 0 | .35** | 1 | .01 | -.06 | -.13 | -.08 | -.03 | -.05 |
| | Tone PA | -.23* | .07 | -.15 | .15 | .14 | .06 | .01 | .14 | .07 | .31** | .05 | 1 | -.18 | -.05 | -.05 | -.09 | -.13 |
| RAN | Digit | .26* | .13 | .29** | .04 | -.24* | -.40** | -.32** | -.29** | -.36** | -.11 | -.03 | -.19 | 1 | .71*** | .71*** | .78*** | -.09 |
| | Object | .14 | .04 | .25* | .03 | -.21 | -.16 | -.27* | -.18 | -.30** | -.15 | -.17 | -.1 | .72*** | 1 | .63*** | .70*** | -.14 |
| | Zhuyin Fuhao | .19 | .17 | .29** | .07 | -.14 | -.25* | -.23* | -.19 | -.29** | -.2 | -.13 | -.13 | .71*** | .67*** | 1 | .81*** | 0 |
| | Character | .31** | .24* | .44*** | .2 | -.22* | -.37*** | -.33** | -.25* | -.33** | -.21 | -.07 | -.16 | .79*** | .71*** | .82*** | 1 | -.13 |
| S. L. | Pseudo word mem span | -.09 | .11 | -.16 | .03 | .31** | .19 | .1 | .06 | .07 | .18 | .12 | .01 | -.11 | -.19 | -.1 | -.18 | 1 |

## 5.3 Correlations between tasks in Year 1 and Year 2

| Y1 vs Y2 | | Literacy | | | | | | | | | PA factor | | | RAN | | | | S. L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Radical_place_RT | Radical_place_accu | Radical_form_RT | Radical_form_accu | Comprehension | CH recognition | Read accu._ZF | Read accu._CH | School exam | Small segment PA | Syllable implicit PA | Tone PA | Digit | Object | Zhuyin Fuhao | Character | Pseudo word memory_span |
| Literacy | ZF letter knowledge | -.09 | .04 | -.14 | .06 | .27* | .16 | .25* | .12 | .27* | .47** | .05 | .13 | -.14 | -.17 | -.19 | -.25* | .27* |
| | Read accu._ZF_pr | -.12 | -.08 | -.12 | .03 | .25* | .39** | .44*** | .38*** | .45*** | .42*** | .2 | .2 | -.37*** | -.26* | -.36*** | -.37*** | -.08 |
| | CH recognition | -.22* | .05 | -.19 | .14 | .30** | .86*** | .30** | .55*** | .41*** | .12 | -.08 | .17 | -.43*** | -.2 | -.35** | -.42*** | .13 |
| | Spelling | -.02 | -.07 | .1 | .01 | .23* | .15 | .16 | .11 | .24* | .36** | .2 | -.09 | -.08 | -.09 | -.25* | -.16 | .1 |
| | Read accu._ZF_po | -.02 | -.12 | -.19 | .02 | .27** | .37** | .40** | .22* | .52*** | .2 | .14 | .02 | -.47*** | -.40*** | -.41*** | -.44*** | .07 |
| | School exam | -.08 | .1 | -.04 | .17 | .47*** | .43*** | .48*** | .35*** | .61*** | .46*** | .07 | .18 | -.22* | -.12 | -.13 | -.17 | .16 |
| PA factor | General PA | .03 | 0 | 0 | .05 | .40*** | .11 | .30** | .21* | .34*** | .67*** | .25* | .2 | -.23* | -.21 | -.28** | -.26* | .18 |
| | Syllable_tone PA | .22* | 0 | .25* | .11 | -.03 | -.04 | -.07 | -.1 | -.1 | -.06 | -.15 | -.11 | .14 | .11 | .03 | .07 | .06 |
| | Implicit PA | -.13 | .05 | -.24* | 0 | .2 | .24* | .28** | .16 | .17 | .28** | .35*** | .12 | -.13 | -.16 | -.22* | -.21* | .12 |
| RAN | Digit | .17 | .22* | .18 | .02 | -.26* | -.39*** | -.25* | -.22* | -.31** | -.22* | -.24* | -.17 | .70*** | .51*** | .55*** | .64*** | -.07 |
| | Object | .16 | .12 | .15 | .06 | -.34** | -.27* | -.16 | -.16 | -.43*** | -.21* | -.14 | -.14 | .52*** | .67*** | .42*** | .53*** | -.17 |
| spoken language | Semantic fluency | -.06 | -.23* | -.15 | -.01 | .2 | .06 | .15 | .07 | .32** | .22* | .23* | -.06 | -.19 | -.29** | -.37*** | -.31** | .09 |
| | PPVT | -.02 | .08 | -.09 | .1 | .27* | .28** | .08 | .21* | .14 | .05 | .09 | .05 | -.02 | -.03 | -.06 | .03 | .36*** |
| | Picture naming | .01 | -.04 | .1 | .1 | .37*** | .26* | .02 | .22* | .30** | .28** | .17 | .23* | -.13 | -.15 | -.23* | -.16 | .17 |
| | Aud_memory | .16 | -.12 | .11 | .15 | .31** | .27* | .30** | .16 | .2 | .35*** | .23* | .05 | -.12 | -.14 | -.1 | -.15 | .26* |

## 5.4 Partial correlations controlling non-verbal intelligence between Year 1 and Year 2

| Y1 vs Y2 (partialled) | | Literacy | | | | | | | | | PA factor | | | RAN | | | | S. L. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Radical_place_RT | Radical_place_accu | Radical_form_RT | Radical_form_accu | Comprehension | CH recognition | Read accu._ZF | Read accu._CH | School exam | Small segment PA | Syllable implicit PA | Tone PA | Digit | Object | Zhuyin Fuhao | Character | Pseudo word memory_span |
| Literacy | ZF letter knowledge | -.09 | -.01 | -.07 | -.06 | .23 | .07 | .18 | -.04 | .23 | .38** | -.08 | -.02 | -.2 | -.15 | -.13 | -.23 | .19 |
| | Read accu._ZF_pr | -.16 | -.15 | -.19 | .02 | .13 | .35** | .40** | .35** | .44*** | .38** | .22 | .21 | -.40*** | -.32* | -.38** | -.41*** | -.17 |
| | CH recognition | -.22 | -.13 | -.24 | 0 | .23 | .81*** | .12 | .51*** | .33* | -.04 | -.16 | .01 | -.37** | -.12 | -.31* | -.37** | 0 |
| | Spelling | 0 | -.13 | .20 | -.08 | .11 | .07 | .13 | .04 | .20 | .28* | .19 | -.25 | -.02 | .01 | -.11 | -.06 | -.02 |
| | Read accu._ZF_po | -.04 | -.27* | -.17 | -.16 | .21 | .37** | .32* | .08 | .53*** | .11 | .01 | .01 | -.45*** | -.38** | -.35** | -.39** | .08 |
| | School exam | -.06 | .02 | -.02 | -.02 | .33* | .30* | .51*** | .23 | .62*** | .41*** | -.01 | .08 | -.21 | -.12 | -.05 | -.13 | .08 |
| PA factor | General PA | .05 | -.03 | .04 | -.1 | .36** | -.05 | .26* | .03 | .32* | .63*** | .25 | .13 | -.24 | -.24 | -.23 | -.21 | .19 |
| | Syllable_tone PA | .18 | .02 | .19 | .18 | 0 | .12 | 0 | .07 | .01 | -.11 | -.09 | -.21 | .14 | .08 | .04 | .07 | .05 |
| | Implicit PA | -.13 | -.06 | -.22 | -.20 | .16 | .04 | .12 | -.05 | .10 | .24 | .23 | .05 | -.06 | -.10 | -.13 | -.14 | .11 |
| RAN | Digit | .25 | .32* | .27* | .13 | -.20 | -.35** | -.22 | -.17 | -.28* | -.21 | -.25* | -.19 | .76*** | .61*** | .60*** | .67*** | -.10 |
| | Object | .19 | .18 | .11 | .15 | -.37** | -.21 | -.10 | -.08 | -.44*** | -.23 | -.11 | -.15 | .51*** | .68*** | .44*** | .54*** | -.18 |
| spoken language | Semantic fluency | -.09 | -.24 | -.14 | -.11 | .19 | .01 | .12 | .03 | .27* | .17 | .13 | -.12 | -.20 | -.25* | -.32* | -.27* | .04 |
| | PPVT | .14 | .06 | .13 | .11 | .19 | .11 | -.09 | .05 | -.01 | -.02 | -.13 | -.12 | .09 | .10 | .12 | .17 | .36** |
| | Picture naming | .03 | -.02 | .18 | .04 | .33* | .10 | -.03 | .11 | .30* | .18 | .21 | .09 | .01 | -.07 | -.09 | -.01 | .14 |
| | Aud_memory | .18 | -.25 | .29* | -.02 | .33* | .16 | .11 | -.01 | .13 | .17 | .07 | -.04 | -.15 | -.07 | 0 | -.07 | .19 |

## 5.2 Multiple Regression Analyses of Prediction of Literacy

Given the longitudinal design of the study, it was possible to examine causal relationships among skills by conducting multiple regression analyses. In addition, concurrent relationships were also analysed to discover whether any clusters of tasks or factors were closely linked.

Two-step hierarchical regression was conducted in a longitudinal analysis to discover: (a) the proportion of the outcome variance explained by a given predictor (step 1); (b) the unique variance explained by a given predictor by controlling all other predictors (step 2). The R squared change in each variable showing the individually predictive contribution was examined after each step.

**Predictors of ZF reading accuracy after ten-week course**

A follow-up study was included in Year 1 to trace the development of ZF reading and spelling during the first ten weeks of formal instruction (see Table 2.8). Multiple regression analyses were conducted and the results are summarised in Table 5.5. Given that RAN and spoken language measures were measured only a few weeks before the dependent variables, any predictive effect which they had was more likely to be concurrent than longitudinal.

**Table 5.5 Longitudinal prediction of literacy skills after ten-week ZF course from tasks at the beginning of Grade 1: Multiple Regression Analysis**

| **Dependent variables** | | **ZF reading acc._po** | | **ZF spelling** | | **ZF school exam** | |
|---|---|---|---|---|---|---|---|
| **Predictors** | | **Step 1** | **Step 2** | **Step 1** | **Step 2** | **Step 1** | **Step 2** |
| **Domain measured** | **Task** | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ |
| | df | 73 | | 71 | | 62 | |
| **Nonverbal IQ** | TONI nonverbal IQ | .03 | .00 | .03 | .00 | .09** | .00 |
| **Literacy measures** | ZF letter knowledge | .05 | .00 | .08* | .02 | .11** | .00 |
| | ZF reading accuracy before ZF course | .27*** | .05* | .12** | .04 | .21*** | .04* |
| | CH recognition | .17*** | .01 | .04 | .00 | .21*** | .04* |
| **PA** | Factor I | .08* | .01 | .08* | .00 | .17*** | .06** |
| | Factor II | .00 | .01 | .02 | .05* | .02 | .02 |
| | Factor III | .05 | .01 | .04 | .04 | .06* | .01 |
| **Rapid naming** | Digit | .14** | .00 | .03 | .00 | .07* | .02 |
| | Object | .09* | .01 | .01 | .01 | .09* | .02 |
| **Spoken language skills** | Semantic fluency | .02 | .00 | .04 | .00 | .01 | .00 |
| | Vocabulary | .00 | .01 | .03 | .00 | .06* | .02 |
| | Picture naming | .03 | .00 | .02 | .00 | .07* | .01 |
| | Auditory memory | .03 | .01 | .02 | .00 | .12** | .01 |
| **Overall $R^2$** | | .35** | | .28 | | .46*** | |
| **Adjusted $R^2$** | | .21** | | .12 | | .35*** | |

* p < .05; ** p < .01; *** p < .001

Step 1: proportion of outcome (ZF spelling) variance explained by a given predictor

Step 2: proportion of outcome variance explained by a given predictor, after controlling for all other predictors, from other domains and the same block (= unique variance explained by a given predictor)

As shown in Table 5.5, the general pattern of correlations was different among the three ZF literacy skills. Firstly, non-verbal intelligence had no unique predictive effect on three ZF literacy tasks after controlling for all other predictors. This showed that early progress in learning ZF does not relate to pupils' intelligence level.

The ZF reading accuracy focusing on ZF decoding skill at the end of ten weeks of training was predicted (step 1) by two ZF literacy measures, the general PA factor, and digit and object naming. However, only the autoregressor, ZF reading accuracy before the intensive ZF course (the same skill measured earlier), remains a unique predictor after additionally controlling for all other measures (step 2). Only 35% of variance is explained by all predictors, and as little as 21% when a more stringent, adjusted model is taken into account.

Regarding the ZF spelling skill, this was predicted (step 1) by ZF letter knowledge and ZF reading accuracy before the ZF course, and by the general PA factor. After additionally controlling for all other measures (step 2), only the syllable-tone PA factor – basically a large unit PA – made a significant unique contribution to predicting children's spelling after an auditory syllabic input. Only 28% of variance is explained by our predictors, and as little as 12% when a more stringent, adjusted model is taken into account. It is somewhat surprising that, instead of the small unit PA, it was the large unit PA that had a significant predictive effect on the spelling performance, given that the ZF orthography is semi-syllabic and has consistent sound-letter mapping in general. In order to clarify this result and to learn whether all syllable and tone PA tasks predict the ZF spelling skill, further regression analyses into all individual tasks comprising the PA battery were conducted. The analysis concerned only PA tasks; no other tasks were taken into consideration. Considering there are implicit and explicit designed tasks in the PA battery, except for the two-step analyses introduced earlier, an extra step was added to find the proportion of outcome variance that was explained by a given PA task after controlling for PA tasks from the other domain. The results are presented in Table 5.6.

**Table 5.6 Longitudinal prediction of ZF spelling skills after ten-week ZF course from all PA subtasks: Multiple Regression Analysis**

| Predictors | | Step 1 | Step 2 | Step 3 |
|---|---|---|---|---|
| **Domain** | **Tasks** | $r^2$ | $\Delta R^2$ | $\Delta R^2$ |
| | df | **80** | **75** | **71** |
| ImPA | Syllable | .00 | .01 | .00 |
| | Rime | .03 | .00 | .01 |
| | Onset | .05 | .01 | .01 |
| | Phoneme | .04 | .05* | .06* |
| | Tone | .01 | .00 | .00 |
| ExPA | Syllable | .09** | .07* | .06* |
| | Rime | .07* | .02 | .00 |
| | Onset | .02 | .00 | .01 |
| | Phoneme | .10** | .05* | .02 |
| | Tone | .07* | .03 | .02 |
| **Overall $R^2$** | | | | .26* |
| **Adjusted $R^2$** | | | | .16* |

* p < .05; ** p < .01; *** p < .001

Step 1: proportion of outcome (ZF spelling) variance explained by a given PA task

Step 2: proportion of outcome variance explained by a given PA task, after controlling for predictors from other domain.

Step 3: proportion of outcome variance explained by a given PA task, after controlling for all other predictors, from other domain and the same block (= unique variance explained by a given predictor)

The ZF spelling was predicted (step 1) by four explicit PA tasks, except for the onset level. However, after controlling for variables from other domains (step 2), implcit PA at the phoneme level, explicit PA at the syllable and phoneme levels predicted the ZF spelling. When additionally controlling for all other predictors (step 3), only implicit PA at the phoneme level and explicit PA at the syllable level made a unique contribution to ZF spelling after the ten-week ZF course. Given the very low reliability (0.22) and high guessing rate (0.86) of the implicit PA at the phoneme level (see Table 3.3), it might not be sufficiently consistent to be an effective predictor. Thus, explicit PA at the syllable level was the only effective PA task to predict ZF spelling.

Going back to the third dependent variable in Table 5.5, nearly half (46%) of individual differences in ZF school exam results were explained by all literacy measures, two PA factors, both naming tasks and three spoken language skills. However, only the ZF reading accuracy, character recognition and the general PA factor were unique predictors after additionally controlling for all other measures from a given predictor (step 2). Further multiple regression analysis with three steps was conducted to discover which PA task may effectively predict the ZF school exam results. The results of the analysis are presented in Table 5.7.

**Table 5.7 Longitudinal prediction of the school exam results after ten-week ZF course from all PA subtasks: Multiple Regression Analysis**

| Predictors | | **Step 1** | **Step 2** | **Step 3** |
|---|---|---|---|---|
| **Domain** | **Tasks** | **$r^2$** | **$\Delta R^2$** | **$\Delta R^2$** |
| | df | **84** | **79** | **75** |
| ImPA | Syllable | .01 | .02 | .02 |
| | Rime | $.06^{*}$ | .01 | .00 |
| | Onset | .04 | .00 | .00 |
| | Phoneme | .01 | .00 | .00 |
| | Tone | .00 | .00 | .00 |
| ExPA | Syllable | .02 | .02 | .01 |
| | Rime | $.08^{*}$ | .04 | .00 |
| | Onset | .04 | .02 | .00 |
| | Phoneme | $.22^{***}$ | $.14^{***}$ | $.08^{**}$ |
| | Tone | $.09^{**}$ | $.07^{*}$ | .02 |
| **Overall $R^2$** | | | | $.27^{**}$ |
| **Adjusted $R^2$** | | | | $.18^{**}$ |

* $p < .05$; ** $p < .01$; *** $p < .001$

Step 1: proportion of outcome (ZF spelling) variance explained by a given PA task

Step 2: proportion of outcome variance explained by a given PA task, after controlling for predictors from other domain.

Step 3: proportion of outcome variance explained by a given PA task, after controlling for all other predictors, from other domain and the same block (= unique variance explained by a given predictor)

The school ZF exam results were predicted (step 1) by implicit PA at the rime level and three explicit PA tasks, including rime, phoneme and tone levels. However, after controlling for variables from other domains (step 2), explicit PA at the phoneme level and explicit PA at the tone level were left. When additionally controlling for all other predictors (step 3), only explicit PA at the phoneme level made a unique contribution to school ZF exam results.

To conclude, the analyses suggest that different literacy tasks are associated with different PA skills. Tasks requiring auditory input decoding were longitudinally explained by explicit syllable PA. However, only explicit PA at the phoneme level facilitated the school achievements relying on written input. In addition, no PA factor was involved in predicting ZF reading accuracy after intense ZF instruction.

**Comparing longitudinal predictors of ZF and CH reading in Year 2**

Multiple regression analyses were conducted in two parts. Five literacy skills in Year 2 are the dependent variables to be predicted by the measures which were first conducted in Year 1 (see Table 5.8). How four measures of character legality judgement were predicted by other measures will then be presented in a separate table (see Table 5.9), since the tasks focused more on character knowledge acquisition and had almost no significant correlations with other literacy skills (see section 4.2). Two-step multiple regression analyses were conducted for each dependent variable.

## Table 5.8 Longitudinal prediction of five literacy skills in Year 2 from tasks in Year 1: Multiple Regression Analysis

| Domain measured | task | ZF reading accuracy | | CH reading accuracy | | CH recognition | | ZF & CH reading comprehension | | ZF & CH school exam | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| **Nonverbal IQ** | TONI nonverbal IQ | .08* | .02 | .18** | .07* | .09* | .00 | .10** | .00 | .06* | .00 |
| **Literacy measures** | ZF letter knowledge | .06* | .00 | .01 | .02 | .02 | .00 | .09* | .00 | .09** | .00 |
| | ZF reading accuracy_pr | .19*** | .04 | .13** | .03 | .15** | .02* | .04 | .02 | .19*** | .00 |
| | ZF reading accuracy_po | .12** | .00 | .02 | .04 | .17*** | .00 | .08* | .00 | .29*** | .06** |
| | Ch recognition | .04 | .03 | .31*** | .10** | .72*** | .29*** | .14** | .03 | .13** | .01 |
| | ZF spelling | .03 | .01 | .02 | .01 | .03 | .00 | .04 | .00 | .07* | .01 |
| | ZF school exam | .27*** | .12** | .12** | .01 | .18*** | .01 | .17*** | .00 | .35*** | .07** |
| **PA** | Factor I | .10** | .00 | .02 | .01 | .00 | .00 | .15** | .04 | .12** | .00 |
| | Factor II | .00 | .02 | .00 | .00 | .00 | .01 | .00 | .00 | .00 | .00 |
| | Factor III | .04 | .02 | .00 | .02 | .02 | .00 | .06* | .00 | .01 | .01 |
| **rapid naming** | Digit | .06* | .01 | .04 | .00 | .15** | .01 | .07* | .03 | .08* | .02 |
| | Object | .01 | .02 | .01 | .00 | .04 | .00 | .14** | .00 | .20*** | .05* |
| **Spoken language skills** | Semantic fluency | .02 | .00 | .01 | .00 | .00 | .00 | .04 | .00 | .09* | .02 |
| | Vocabulary | .00 | .01 | .06* | .01 | .07* | .00 | .10** | .00 | .01 | .00 |
| | Picture naming | .00 | .01 | .04 | .00 | .03 | .00 | .15** | .02 | .12** | .01 |
| | Auditory memory | .03 | .00 | .02 | .00 | .05 | .00 | .13** | .01 | .04 | .01 |
| **Overall $R^2$** | | .43** | | .48** | | .78*** | | .46** | | .60*** | |
| **Adjusted $R^2$** | | .27** | | .33** | | .72*** | | .30** | | .48*** | |

* $p < .05$; ** $p < .01$; *** $p < .001$

Step 1: proportion of outcome (ZF spelling) variance explained by a given task

Step 2: proportion of outcome variance explained by a given task, after controlling for all other predictors, from other domain and the same block (= unique variance explained by a given predictor)

Regarding these five literacy variables in Year 2, in general, the overall R square (ranging from 43% to 78%) of all predictors in Year 1 were higher than those of predicting ZF literacy skills after the intensive ZF course (ranging from 28% to 46% ; see table 5.5). Literacy skills in Year 1 are the main predictors of the same block of dependent variables. All PA factors, the digit naming task and spoken language measures had no unique predictive effect on any dependent variable when the reading materials became Chinese characters shown in a standard font size and assisted by ZF characters. In other words, as ZF letters became a complementary system of Chinese orthography after the intensive ZF course, the specific impact of PA factors, the digit naming task and spoken language measures on literacy decreased. Nevertheless, literacy skills in Year 2 using ZF or CH orthography systems to measure were predicted by different combinations of predictors and these results did present the multi-dimensional aspect of literacy acquisition.

Firstly, different patterns of predictors were found for ZF and CH reading accuracy. ZF reading accuracy in Year 2 was predicted by three ZF literacy measures in Year 1, the general PA factor and digit naming. However, after controlling all other predictors, only the ZF school exam had a unique predictive effect (12%) on ZF reading accuracy. The result implies that after a year of practice the level of ZF reading accuracy was not predicted best by previous ZF decoding skill or speed (i.e., ZF reading accuracy in Year 1) , but by an integrated literacy achievement, the ZF school-wise exam. On the other hand, CH reading accuracy was found to be predicted by three literacy measures and the receptive vocabulary. However, unlike ZF reading accuracy, both nonverbal IQ (7%) and CH recognition (10%) in Year 1 made a unique contribution after all other predictors were controlled. It seems that, after nine months of CH literacy education, CH reading accuracy still relied greatly on general cognitive ability, such as non-verbal IQ. Additionally, the acquisition of Chinese orthography relied much more on previous learning or experience; it is not as simple as ZF letters, which are composed by far fewer strokes and a limited number of scripts.

Unlike CH reading accuracy, the CH recognition task focuses on the number of characters known by pupils. Participants were asked to name a list of characters. Regarding CH recognition in Year 2, it was predicted by four literacy measures, digit naming and receptive vocabulary. However, children's character recognition in Year 1 was by far the most powerful predictor (29%) of character recognition skills in Year 2. ZF reading accuracy at school entrance also made a unique contribution to character recognition. This result implies that, despite the different orthography systems, both of ZF decoding skills and characters recognition before formal education begins may already predict the number of characters recognised a year later.

In Year 2, ZF and CH reading comprehension was predicted by the greatest number of measures, including four literacy measures, two PA factors, two naming tasks and three spoken language tasks. However, no specific measure had a unique predictive effect on reading comprehension over and above other measures.

Lastly, like reading comprehension, school exam results in Year 2 were also predicted by eleven predictors, but with slightly different components: six literacy measures, one PA factor, two naming tasks and two spoken language tasks. However, only ZF reading accuracy after the ZF course (6%), school exam results in Year 1 (7%), and object RAN (5%) made a unique contribution. This pattern is similar to that observed in predicting school exam results in Year 1 (see Table 5.8). Object naming is the only non-literacy task that showed a unique predictive effect on literacy performance in Year 2. The common process between CH reading and object naming might be triggering the reader's lexical representation in order to decode the symbol or script. The other possibility is that both tasks are instances of 'paired associate learning' where arbitrary connections between a visual symbol and its name need to be made and activated (Li et. al., 2008).

**Table 5.9 Longitudinal prediction of CH legality judgement in Year 2 from tasks in Year 1: Multiple Regression Analysis**

| Domain measured | task | R_position_accuracy | | R_form_accuracy | | R_position _RT | | R_form _RT | |
|---|---|---|---|---|---|---|---|---|---|
| | | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| | df | 55 | | 55 | | 55 | | 55 | |
| Nonverbal IQ | TONI nonverbal IQ | .03 | .04 | .00 | .00 | .03 | .02 | .06* | .03 |
| Literacy measures | ZF letter knowledge | .00 | .01 | .00 | .00 | .02 | .02 | .02 | .03 |
| | ZF reading accuracy_pr | .01 | .00 | .00 | .00 | .04 | .00 | .06* | .01 |
| | ZF reading accuracy_po | .04 | .04 | .02 | .02 | .01 | .01 | .04 | .00 |
| | Ch recognition | .00 | .00 | .01 | .00 | .08* | .03 | .09* | .02 |
| | ZF spelling | .01 | .01 | .00 | .01 | .00 | .00 | .02 | .06* |
| | ZF school exam | .01 | .04 | .00 | .02 | .02 | .00 | .02 | .00 |
| PA | Factor I | .00 | .00 | .01 | .00 | .00 | .01 | .00 | .01 |
| | Factor II | .00 | .01 | .03 | .02 | .04 | .01 | .04 | .00 |
| | Factor III | .00 | .00 | .03 | .00 | .03 | .00 | .07* | .02 |
| rapid naming | Digit | .06* | .00 | .00 | .01 | .07* | .00 | .07* | .00 |
| | Object | .03 | .00 | .02 | .01 | .04 | .00 | .02 | .00 |
| Spoken language skills | Semantic fluency | .05 | .05 | .01 | .01 | .01 | .00 | .02 | .01 |
| | Vocabulary | .02 | .00 | .01 | .01 | .00 | .01 | .00 | .00 |
| | Picture naming | .00 | .00 | .00 | .01 | .00 | .00 | .01 | .03 |
| | Auditory memory | .03 | .07* | .00 | .00 | .02 | .04 | .04 | .05* |
| Overall $R^2$ | | .29 | | .13 | | .23 | | .40* | |
| Adjusted $R^2$ | | .09 | | -.13 | | .00 | | .22* | |

* $p < .05$; ** $p < .01$; *** $p < .001$

In general, there was little longitudinal prediction of character knowledge from the measures in Year 1. Only the reaction time of radical form judgement had a significant R square. Different patterns of predictors were found for accuracy and for reaction time on CH legality tasks. The accuracy of character legality judgement had almost no longitudinally significant predictors except digit RAN and auditory memory for radical position judgement (see section 2.3.4 'Radical judgement task' for details of its introduction). The results imply that accuracy of character knowledge was not very much associated with other literacy skills in early school years. However, it is surprising to find a unique contribution from auditory memory on radical position judgement. The result might be attributed to the syntactic and/or rule processing shared between the auditory memory task (see section 2.3.2) and radical position judgement (see section 1.1.3.2) (Hu, 2010).

Concerning the reaction time in making a judgement of radical position and/or form, character recognition and digit RAN in Year 1 both had a significant but not unique predictive effect. General IQ, ZF reading accuracy before the intensive ZF course, and PA factor III also explained the individual difference on the reaction time of radical form judgement. However, it is surprising to find that both ZF spelling and auditory memory made a unique contribution to the reaction time of radical form judgement. Since ZF spelling is the only writing task in the study, the above result might show the close association between ZF writing skill and the fast response to minor differences in characters' appearance. Regarding the link between the reaction time of radical form judgement and auditory memory, the possible explanation is that both of them require an efficient general working memory. This kind of link might only be observed once pupils have a certain level of awareness of how radical forms should look. Therefore, no relationship was found between the reaction time of radical position judgement and auditory memory.

**Comparing concurrent predictors of ZF and CH reading in Year 2**

As mentioned earlier, regression analyses were applied to examine how five literacy measures were predicted by other concurrent skills in Year 2. Character legality tasks were presented separately and categorised as independent variables to see if they made any contribution to the main five literacy measures. It will be predicted by a list of independent variables, including the five literacy measures, as well. The R squared change in each variable showing the individual predictive contribution was examined after each step. As in the previous multiple regression analysis, both the simple (step 1) and the unique (step 2) predictive effect are presented in Tables 5.10 and 5.11.

**Table 5.10 Concurrent prediction of literacy skills in Year 2 from individual tasks in Year 2: Multiple Regression Analysis**

| Domain measured | task | ZF reading accuracy | | CH reading accuracy | | CH recognition | | ZF & CH reading comprehension | | ZF & CH school exam | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| | df | 69 | | 68 | | 69 | | 69 | | 69 | |
| Nonverbal IQ | TONI nonverbal IQ | .07* | .03 | .16*** | .15*** | .08* | .08** | .12** | .09** | .05* | .05* |
| Literacy measures | CH legality_p_Accuracy | .00 | .00 | .01 | .01 | .02 | .00 | .00 | .00 | .01 | .00 |
| | CH legality_p_RT | .08* | .00 | .10** | .01 | .03 | .00 | .02 | .03 | .03 | .00 |
| | CH legality_f_Accuracy | .00 | .00 | .00 | .00 | .00 | .01 | .00 | .00 | .00 | .00 |
| | CH legality_f_RT | .16*** | .02 | .18** | .00 | .07* | .00 | .01 | .02 | .04 | .00 |
| PA | Factor I | .12** | .07** | .02 | .00 | .01 | .00 | .14** | .06* | .08** | .07* |
| | Factor II | .06* | .00 | .00 | .01 | .00 | .01 | .02 | .00 | .00 | .03 |
| | Factor III | .00 | .05* | .02 | .00 | .00 | .02 | .01 | .01 | .00 | .02 |
| rapid naming | Digit | .08** | .02 | .06* | .03 | .12** | .05* | .04 | .02 | .10** | .03 |
| | Object | .06* | .00 | .02 | .00 | .01 | .06* | .04 | .01 | .07* | .01 |
| | ZF letters | .05* | .01 | .03 | .00 | .05* | .01 | .01 | .02 | .07* | .00 |
| | Character | .11** | .00 | .06* | .00 | .14*** | .04* | .04 | .00 | .09** | .00 |
| Spoken language skills | pseudo-word memory span | .02 | .00 | .01 | .00 | .05* | .02 | .10** | .03 | .01 | .00 |
| Overall $R^2$ | | .35 | | .32*** | | .38** | | .34** | | .26* | |
| Adjusted $R^2$ | | .23 | | .19*** | | .26** | | .22** | | .12* | |

* p < .05; ** p < .01; *** p < .001

Firstly, non-verbal intelligence made a consistent and unique contribution ranging from 5% to 15% on all CH literacy tasks. The result might indicate that characters are not as easily acquired as ZF letters, and pupils relied greatly on their general cognitive skills to learn them.

Next, only the reaction time of character legality judgement had a simple predictive effect on both ZF and CH reading accuracy tasks, which also focused on speed of response. Moreover, the efficiency of character form legality judgement also made a contribution to variance of concurrent CH recognition. The result indirectly revealed the importance of reading fluency on learning new characters.

In addition, the patterns of predictors differed between the two orthographies. PA factors, particularly the small segmental PA factor, consistently explained uniquely 6% or 7% of the variances on those literacy performances that involved ZF letters, but made no significant contribution to CH-only tasks. The CH recognition task which might require naming skill was predicted uniquely by three naming tasks (digit, object and CH). Similarly, a few measures involving CH had a predictive effect on CH reading accuracy. However, only non-verbal intelligence made a significant and unique contribution (15%) to CH reading accuracy and indicated a high cognitive loading in this task.

It is noteworthy that, in Year 2, digit and CH RAN had a significant predictive effect on most of the literacy measures except ZF and CH reading comprehension, which had been longitudinally predicted by both digit and object RAN in Year 1. This change implies that different processes of RAN were measured in Year 1 and Year 2. In contrast to Year 1, RAN in Year 2 might not involve any process focusing on lexical processing and language competences for reading comprehension.

The only spoken language task administered at this phase, pseudo-word memory span, significantly predicted concurrent CH recognition and reading comprehension. The result showed the involvement of phonological processing in naming and reading characters with ZF letters alongside.

**Table 5.11 Concurrent prediction of CH legality judgement in Year 2 from individual tasks in Year 2: Multiple Regression Analysis**

| Skills measured | task | CH legality_p_Accuracy | | CH legality_f_Accuracy | | CH legality_p_RT | | CH legality_f_RT | |
|---|---|---|---|---|---|---|---|---|---|
| | | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 | Step 1 | Step 2 |
| Year 2 | *df* | *67* | | *69* | | *67* | | *69* | |
| Nonverbal IQ | nonverbal intelligence | .00 | .00 | .01 | .00 | .00 | .01 | .03 | .00 |
| Literacy measures | ZF reading accuracy | .00 | .00 | .00 | .00 | .08* | .02 | .16*** | .02 |
| | CH reading accuracy | .01 | .02 | .00 | .00 | .10** | .02 | .12** | .01 |
| | CH recognition | .02 | .01 | .00 | .01 | .03 | .00 | .07* | .00 |
| | ZF & CH reading comprehension | .00 | .00 | .00 | .00 | .02 | .00 | .01 | .01 |
| | ZF & CH school exam | .01 | .00 | .00 | .00 | .03 | .00 | .04 | .00 |
| PA | Factor I | .00 | .00 | .01 | .00 | .00 | .02 | .02 | .01 |
| | Factor II | .00 | .00 | .01 | .00 | .00 | .00 | .03 | .02 |
| | Factor III | .00 | .00 | .01 | .02 | .05* | .05* | .03 | .02 |
| rapid naming | Digit | .03 | .00 | .02 | .00 | .09** | .00 | .13** | .01 |
| | Object | .00 | .02 | .01 | .01 | .03 | .01 | .11** | .00 |
| | ZF letters | .03 | .00 | .02 | .01 | .06* | .00 | .14** | .00 |
| | Character | .06* | .04 | .07* | .10** | .12** | .03 | .27*** | .08** |
| Spoken language skills | pseudo-word memory span | .01 | .03 | .00 | .01 | .01 | .00 | .03 | .01 |
| Overall $R^2$ | | .17 | | .17 | | .26 | | .40** | |
| Adjusted $R^2$ | | .00 | | -.01 | | .10 | | .27** | |

* p < .05; ** p < .01; *** p < .001

Concerning the acquisition of character knowledge in Year 2, as with the results of longitudinal analyses (see Table 5.9), only the reaction time of radical form judgement had a significant R square. However, character RAN consistently had a significant predictive effect on all four measures, namely reaction time and accuracy aspects. Moreover, it specifically made unique contributions on both form legality measures (10% on accuracy and 8% on reaction time). In other words, the result presents the common process of what was measured in both the character RAN (an output task) and the CH legality judgement (an input task). Therefore, the common process here is very likely to be accessing character orthography representation.

As shown in Table 5.11, most of the measures which involved speed of response, such as reading accuracy and RAN tasks, had simple predictive effects on reaction time in both legality judgement tasks; all the tasks emphasise heavily the efficiency or fluency of reading. It is surprising to find that the PA factor III (the tone PA factor) had a predictive effect, both a simple and a unique contribution, on how quickly pupils made a radical position judgement. The result indicates that, even at the very early stage of character knowledge acquisition, the suprasegmental awareness is involved in becoming familiar with the script structure of a character.

To conclude, at the first two years of schooling, ZF or CH literacy education and/or experience is critical in setting a good foundation for pupils to become familiar with the legal form of character radicals. In other words, character knowledge acquisition for pupils in the early school years starts from seeing how radicals are made from combinations of strokes, then how characters are made from combinations of radicals.

**Differences in Patterns of Predictors for CH and ZF Literacy Acquisition**

One of the aims of the study was to discover if there were different patterns of predictors for ZF and CH literacy acquisition. Since many literacy tasks used in the study involved ZF, one way to examine the differences between ZF and CH orthography might be to compare the pattern of longitudinal predictors of ZF school exam performance in Year 1 and ZF plus CH school exam performance in Year 2. It would also be sensible to compare the pattern of longitudinal and concurrent predictors for both ZF and CH reading accuracy in Year 2.

With almost the same group of predictors, the school exams in Years 1 and 2 both had more than one simple and/or unique predictor in all domains, namely literacy, PA, RAN and spoken language skills (see Table 5.5 & 5.8). In order to be more focused on unique predictors, only the pattern of those predictors with unique contributions will be compared here. Firstly, three predictors made a unique contribution to prediction of ZF exam results in a few weeks later in Year 1: ZF reading accuracy before the intensive course (4%), CH recognition (4%), and the general PA factor (6%). However, a totally different set of three predictors made a unique contribution to the prediction of ZF plus CH exam results in a few weeks later in Year 2: ZF reading accuracy after the intensive course (6%), the ZF exam in Year 1 (7%), and object RAN (5%). The results indicate a close link between PA and ZF reading which was not present or critical once CH orthography was involved.

The pattern of longitudinal predictors, both simple and unique, was very different in ZF and CH reading accuracy in Year 2 (see Table 5.8). No measure in the PA and RAN domains was involved in predicting CH reading accuracy. In contrast, only the spoken language domain was not involved in predicting ZF reading accuracy. When the unique predictors were examined, only the ZF school exam made a unique contribution (12%) to ZF reading accuracy, while non-verbal IQ and CH recognition both made a unique contribution (7% and 10%, respectively) to CH reading accuracy. Additionally, if the patterns of concurrent predictors for ZF and CH reading accuracy in Year 2 are compared, the pattern of simple predictors is very similar, except for RAN tasks; that is, more RAN subtasks had a significant simple, but not unique, predictive effect on ZF reading accuracy (see Table 5.10). Further checking of those predictors that made a unique contribution again found a diverse pattern: only non-verbal IQ was linked to CH reading accuracy while PA factors I and III (with 7% and 5%, respectively) were linked to ZF reading accuracy. The above results demonstrate the difference in processing between ZF and CH reading accuracy. For pupils at Grade two, ZF reading accuracy was closely linked to concurrent PA skills and earlier (year 1) ZF school exam, whereas CH reading accuracy relied heavily on general cognition competence and earlier (year 1) CH recognition. Conclusively, the difference in processing between ZF and CH reading accuracy might be largely attributed to the characteristics of the two orthographies: ZF being more dependent on PA and RAN; and CH on characters learned before school entry and non-verbal IQ.

In order to integrate the results mentioned above so that the different patterns of predictors for CH or ZF literacy acquisition stand out, a box and arrow model showing PA, RAN and oral language skills as predictors of major reading skills is presented in Figure 5.1. In accordance with the Simple View of Reading, CH and ZF reading comprehension is included to show another pattern of predictors in contrast to either ZF or CH single word reading. Every correlation between predictor and outcome is indicated in the figure.

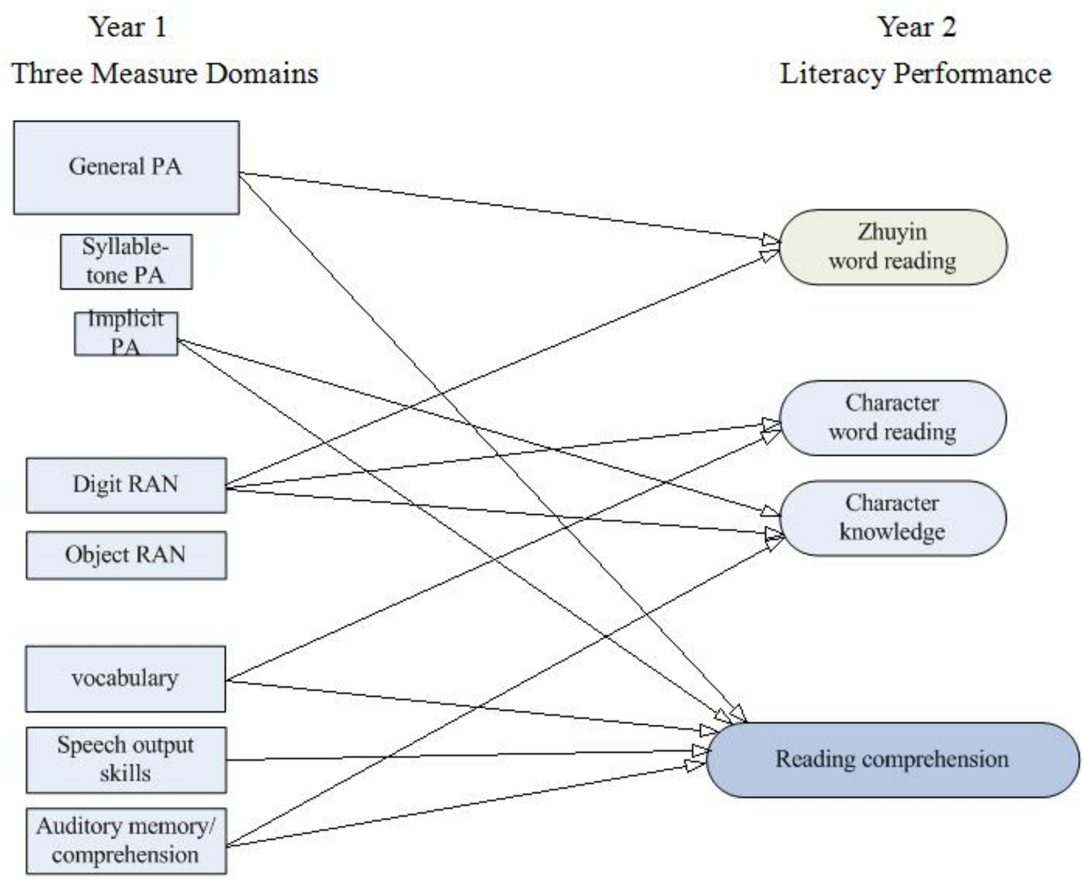


**Figure 5.1 Predictive relationship between the three measures of PA, RAN and oral language skills and literacy**

The potential roles of PA, RAN and oral language skills in predicting literacy acquisition are very different, according to how these three measures account for the variance of literacy performance shown in Figure 5.1. In short, preceding PA skills did not relate to CH word reading or CH knowledge, but were directly associated with ZF word reading and ZF plus CH reading comprehension. Graphological RAN linked to ZF word reading, CH word reading and CH knowledge but did not relate to reading comprehension. Oral language skills were all associated with reading comprehension which emphasized lexical understanding. In addition, oral language skills also accounted for the variance of CH literacy and reading comprehension but not that of ZF word reading.

## 5.3 Multiple Regression Analysis of Prediction of Phonological Awareness

The PA battery was administered twice at the beginning of Grades 1 and 2. By multiple regression analyses, concurrent and longitudinal predictors of PA were examined systematically (see Tables 5.12 and 5.13). Both the simple (step 1) and the unique (step 2) predictive effect were presented. No concurrent regression analysis of PA in Year 2 was conducted since the only significant correlation was found between PA and reading comprehension (see Table 5.1, 5.2, 5.3 and 5.4) and this has been shown in section 5.2.

**Table 5.12 Concurrent prediction of PA skills from tasks in Year 1: Multiple Regression Analysis**

| **Dependent variables** | | **PA Factor I** | | **PA Factor II** | | **PA Factor III** | |
|---|---|---|---|---|---|---|---|
| **Predictors** | | **Step 1** | **Step 2** | **Step 1** | **Step 2** | **Step 1** | **Step 2** |
| **Domain measured** | **Task** | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ |
| | Df | 65 | | 65 | | 65 | |
| **Nonverbal IQ** | TONI nonverbal IQ | .07* | .02 | .00 | .01 | .05 | .01 |
| **Literacy measures** | ZF letter knowledge | .08* | .01 | .01 | .01 | .00 | .01 |
| | ZF reading accuracy before ZF course | .09** | .02 | .01 | .00 | .05* | .01 |
| | CH recognition | .02 | .03 | .01 | .00 | .08* | .00 |
| **Rapid naming** | Digit | .07* | .03 | .06* | .04 | .07* | .01 |
| | Object | .04 | .01 | .03 | .00 | .04 | .01 |
| **Spoken language skills** | Semantic fluency | .04 | .01 | .06* | .12** | .00 | .01 |
| | Vocabulary | .00 | .00 | .01 | .02 | .03 | .02 |
| | Picture naming | .09** | .03 | .01 | .00 | .01 | .00 |
| | Auditory memory | .07* | .02 | .00 | .00 | .01 | .00 |
| **Overall $R^2$** | | .27* | | .19 | | .17 | |
| **Adjusted $R^2$** | | .15* | | .07 | | .04 | |

Different patterns of predictors were found among the three PA factors. Only PA factor I (the general PA factor) had a significant R square and was significantly predicted by variables across different domains, such as non-verbal IQ, literacy, RAN and spoken language skills; but none of them had a unique predictive effect. Nevertheless, the evidence that both picture naming (an output task) and auditory memory (an input task) had significant predictive effects on the general PA factor in Year 1 shows that PA skills did reflect the integration of the speech processing system. Moreover, another spoken language skill, semantic fluency, made a significant and unique contribution to PA factor II (the syllabic-tone PA factor). Since semantic fluency relies heavily on efficiency in retrieving lexical representation, the result might provide evidence of the importance of syllabic and tone PA in decoding syllabic-morphological Chinese orthography representing tonal languages.

Concerning PA factor III, which involved only implicit PA skills, concurrent ZF reading accuracy, character recognition and digit RAN all had significant predictive effects. The results suggest that the processing of epilinguistic knowledge may be common to all these variables. In addition, it is noteworthy that digit RAN had a consistent predictive effect on all three concurrent PA factors.

Next, the results on the longitudinal predictive effect of all measures in Year 1 on three PA factors in Year 2 are presented in Table 5.13.

**Table 5.13 Longitudinal prediction of PA skills in Year 2 from individual tasks in Year 1: Multiple Regression Analysis**

| **Dependent variables** | | **PA Factor I** | | **PA Factor II** | | **PA Factor III** | |
|---|---|---|---|---|---|---|---|
| **Predictors** | | **Step 1** | **Step 2** | **Step 1** | **Step 2** | **Step 1** | **Step 2** |
| **Domain measured** | **Task** | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ | $r^2$ | $\Delta R^2$ |
| | Df | 67 | | 67 | | 67 | |
| **Nonverbal IQ** | TONI nonverbal IQ | .08* | .00 | .14** | .09** | .10* | .05 |
| **Literacy measures** | ZF letter knowledge | .21*** | .03 | .00 | .03 | .00 | .00 |
| | ZF reading accuracy before ZF course | .17*** | .04* | .09* | .04* | .07* | .03 |
| | ZF reading accuracy after ZF course | .03 | .02 | .00 | .01 | .01 | .02 |
| | CH recognition | .00 | .02 | .00 | .11** | .03 | .00 |
| | ZF spelling | .11** | .00 | .04 | .00 | .02 | .07* |
| | ZF school exam | .18*** | .00 | .02 | .00 | .05 | .01 |
| **PA** | Factor I | .41*** | .12*** | .10** | .00 | .05 | .01 |
| | Factor II | .01 | .00 | .01 | .01 | .06* | .01 |
| | Factor III | .06* | .00 | .10* | .06* | .03 | .00 |
| **Rapid naming** | Digit | .04 | .00 | .07* | .07** | .06* | .02 |
| | Object | .06* | .01 | .02 | .03 | .02 | .00 |
| **Spoken language skills** | Semantic fluency | .04 | .00 | .02 | .00 | .01 | .01 |
| | Vocabulary | .01 | .00 | .01 | .00 | .00 | .00 |
| | Picture naming | .05 | .00 | .08* | .07** | .03 | .00 |
| | Auditory memory | .05 | .00 | .03 | .02 | .00 | .00 |
| **Overall $R^2$** | | .59*** | | .51** | | .32 | |
| **Adjusted $R^2$** | | .46*** | | .36** | | .10 | |

* p < .05; ** p < .01; *** p < .001

Step 1: proportion of outcome (ZF spelling) variance explained by a given task

Step 2: proportion of outcome variance explained by a given task, after controlling for all other predictors, from other domain and the same block (= unique variance explained by a given predictor)

PA factors in Year 2 were significantly predicted by diverse patterns of measures in Year 1. Firstly PA factor I (small unit PA factor) was predicted by nonverbal IQ, four ZF literacy tasks, two PA factors and object naming. After controlling for other variables, both ZF reading accuracy before the intensive course and the general PA factor in Year 1 still made a unique contribution to predicting PA factor I in Year 2. Up to 59% of its variance is explained by all measures in Year 1, and as much as 46% when a more stringent, adjusted model is taken into account. The results indicate clearly that the ZF orthography experience influences and/or facilitates the small unit PA factor a year later. Since PA factor I in Years 1 and 2 represents general PA skills and small unit PA, respectively (see section 3.1.2: factor analysis), the high (up to 12%) unique predictive effect of PA factor I in Year 1 on the small unit PA factor in Year 2 shows that better small unit PA is predicted, or, more strongly, derived from a better foundation of general PA skills.

Next, PA factor II, representing mostly syllable awareness, was predicted by many variables. Up to 51% of its variance is explained by all measures in Year 1, but only 36 % when a more stringent, adjusted model is taken into account. After controlling for all other variables, the study found significant and unique contributions of Year 1 measures in all domains, such as ZF reading accuracy (before the intensive ZF course), character recognition, PA factor III, digit naming and picture naming. Half of the predictors are the tasks responded in syllabic utterances, such as CH recognition, digit RAN and picture naming. PA factor II, although called syllable PA factor, actually explained only 42% variance by implicit PA at the onset level (see Table 3.16). This might therefore explain why this factor was also predicted by Year 1 ZF reading accuracy measured before the ZF course and by Year 1 PA factor III (including implicit PA at the phoneme and rime levels). Lastly, PA factor III (the tone PA factor) was predicted by nonverbal IQ, ZF reading accuracy before the intensive course, PA factor II and digit naming in Year 1. However, after controlling for all other variables, only the ZF spelling task made a unique contribution to PA factor III. The result is not surprising since in the spelling task marking the tones of a syllable was required. Therefore, it is plausible to attribute the development of tone PA to the orthography experience during the first school year.

It is interesting to track down how the three PA factors in Year 1 (General PA, Syllable-tone PA and Implicit PA) are linked to the other three PA factors in Year 2 (Small segment PA, Syllabic-implicit PA and Tone PA). The results here also provide the evidence for the interpretations made about the multiple PA constructs in Chapter 3 (see section 3.1.2: factor analysis). For example, PA factor I in Year 1 (general PA factor) made a high (up to 41%) contribution to PA factor I in Year 2 (small unit PA factor). This result suggests there is a close relationship between previous general PA and later small unit PA. The evidence supports the possibility that general PA skills facilitate the development of small unit PA in the first school year.

In addition, PA factor III (implicit PA factor) in Year 1 made a unique contribution to PA factor II in Year 2 (mainly syllabic PA, but also implicit PA on rime and phoneme levels), which had a negative correlation with concurrent PA factor I. These results imply that the presence of implicit PA skills at school entrance, particularly on the rime and phoneme levels, are not sufficient to support the development of small unit PA skills a year later. This may indicate that these children were lagging behind in their development of explicit PA and it is this which is critical for later literacy development. Therefore, it is important that both implicit and explicit PA skills are tested to ensure that children have broken through to an explicit stage of PA development and are not stuck at an earlier implicit PA phase.

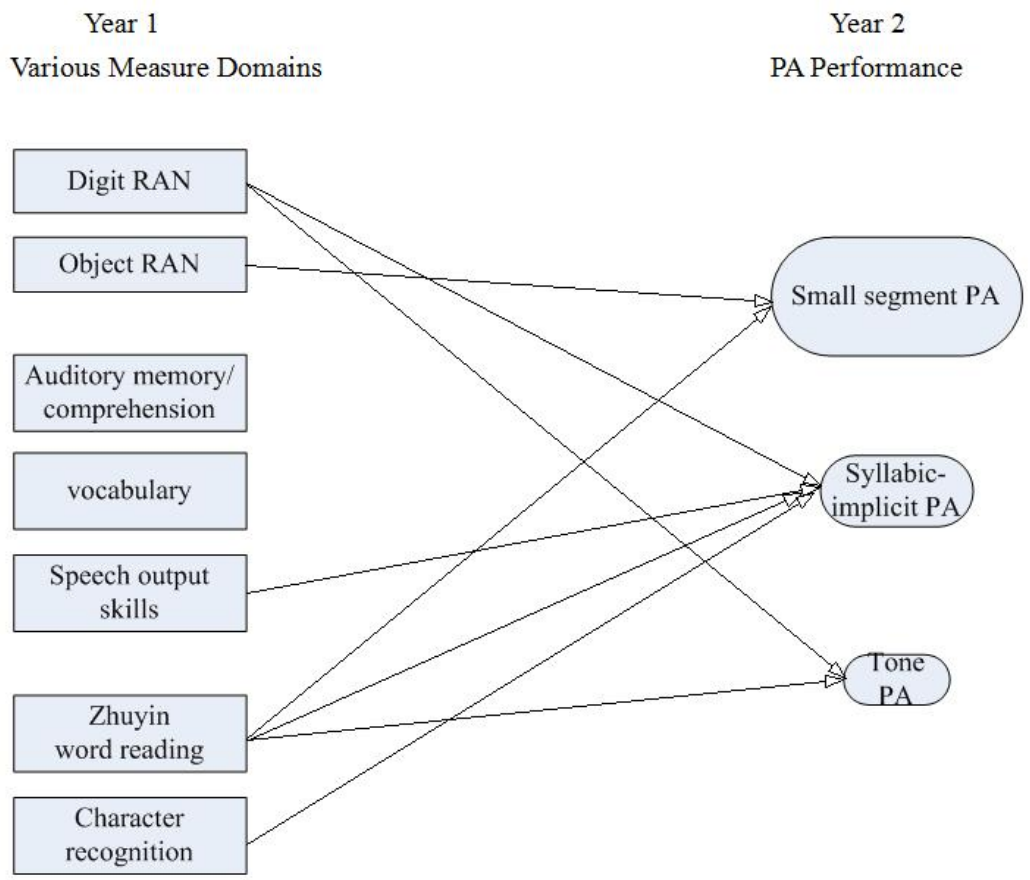


**Figure 5.2 Predictive relationship between the three measures of RAN, oral language skills and literacy and PA**

The results of PA in Year 2 in association with preceding RAN, oral language skills and CH or ZF literacy acquisition are summarized in Figure 5.2. The link between preceding RAN and PA might be attributed to the level of automaticity. Graphological RAN was found to have a large predictive effect on PA at large-segment (syllable), implicit or supra-segment (tone) levels; and non-graphological RAN was associated with finer-grained PA, such as phoneme, rime or onset levels, which develop principally after school entrance.

Regarding the link between PA in Year 2 and spoken language skills at school entrance, only the speech output measure (i.e. picture naming) accounted for the syllabic PA factor which is negatively correlated with small segment PA. As small segment PA mostly developed after formal education (see section 3.1.2), the result suggests that in Mandarin-speaking children speech output skills acquired before formal education are more associated with the less fine-grained phonological representations (i.e. those applied in larger segment PA). However, it is noteworthy that there was a ceiling effect in the picture-naming task. Therefore, it was possible that the predictive effect of speech output skills in relation to syllabic PA factors was under-estimated.

Lastly, both ZF and CH competence had a simple and/or unique predictive effect on all three PA factors in Year 2, longitudinally and concurrently (see Tables 5.12 & 5.13). More specifically, ZF reading accuracy before the intensive ZF course made a unique contribution (4%) to the small unit PA factor in Year 2 while CH recognition made a unique contribution (11%) to the syllabic and implicit PA factor in Year 2. It suggests that, despite lacking consistent small grain-size correspondence, the characteristic of the characters' sound structure, i.e. the syllabic level, still had its own impact on later PA development. However, given that the two PA factors in Year 2 correlated negatively (see section 3.1.2), this effect might suggest the decay of small unit PA once ZF no longer appears in textbooks.

## 5.4 Discussion

In this chapter, literacy and PA have been treated as dependent variables of other measures to learn how they develop during the early years of schooling and to discover their significant predictors from either a longitudinal or a concurrent perspective. In the following section, the theoretical and/or practical implications of the above results will be discussed. The contribution of the four domains, namely PA, RAN, spoken language, literacy to the prediction of various literacy or PA skills will be examined, and a comparison made with results from previous studies of alphabetic written languages and Chinese orthography.

### 5.4.1 Predicting Literacy Acquisition

It might be very specific to Chinese orthography that character knowledge acquisition comprises different stages, such as knowing what the radical should look like, and then the script structure, which might be linked to how characters are pronounced and meaning of words. Therefore, there is no doubt that its acquisition will take longer than learning to decode and may extend over the six years in primary schools (Wu & Huang, 2004). Further investigations of the orthography-phonology correspondence (introduced in section 1.1.3.2) would expand our understanding of what, when and how particular character knowledge would be acquired in general and could also be applied to CH instruction. Exploring the role of ZF instruction preceding CH instruction would also inform our understanding of the efficacy of current arrangement of literacy curriculum in Taiwan.

**Sequence of ZF and CH instruction**

Based on Figure 5.1, ZF seems to be a good transitional orthography for children to decode its spelling and learn the pronunciation of novel characters since it associates or emphasizes the general PA skills acquired from speech experience much more than character acquisition. A similar argument was made by Ziegler and Goswami (2005); a relatively consistent orthography with small grain-size correspondence lessens the number of correspondence at various linguistic levels that beginning readers have to learn.

Furthermore, regarding either ZF only or ZF plus CH literacy tasks in Year 2, the patterns of predictors are very similar in terms of how many domains are involved. The predictors of literacy performance indicate that pupils in Year 2 might rely heavily on ZF reading skills to complete a literacy task. In this sense, acquiring ZF is beneficial for pupils beginning to read and understand written Chinese. However, an alternative view is that focusing on ZF scripts with a consistent correspondence between graphemes and phonemes, could be detrimental to pupils' development of character knowledge (Chen & Yuen, 1991). Therefore, a further question to ask is when and how to instruct pupils to change from depending on ZF scripts to focusing more on characters.

**PA as as a predictor of literacy**

Previous studies have shown that syllabic PA at the pre-school stage has a small but unique predictive effect on CH recognition at a later stage (e.g. McBride-Chang et. al., 2011), but contradictory results which showed no predictive effect of onset-rime PA on later CH recognition have also been found (e.g. Huang & Hanley, 1997). This contradiction might be attributed to the different demands made by the PA tasks, i.e. explicit or implicit PA tasks.

The question of whether any PA skill may predict CH recognition a year later was systematically examined in the present study by the design of a comprehensive PA assessment. Only PA factor III in both Year 1 (i.e. implicit PA skills) and Year 2 (i.e. tone PA) had significant contribution to reaction time of two different character legality tasks, i.e., the form and position of radicals. (see table 5.9 & 5.11). The results show a small degree of PA involvement in acquiring character knowledge, but not in learning new characters. However, this impact of PA at various linguistic levels might increase as pupils learn more phonetic-semantic compounds. It was not possible within the present study to determine what levels of PA are important for later CH acquisition or which will be maintained in the longer term in Mandarin-speaking children. As other studies have focused on how older children develop their GPC knowledge (Li, 2009), it would be worthwhile to follow the trajectory of the association between PA skills and CH acquisition in the later grades.

In line with previous studies of Mandarin-speaking children (e.g. Tzeng et al., 2003; Hsieh & Tzeng, 2004), digit RAN had extensive predictive effects on CH literacy tasks, although most of them were not unique predictors. It is noteworthy that, apart from digit RAN, both object and CH RAN made concurrent and unique contributions to CH recognition in Year 2 as well. The results demonstrate that both lexical (i.e. object) access and orthographic (i.e. digit and CH) access were involved in the CH recognition task and provide evidence for the distinct morpho-syllabic feature of Chinese orthography. Further evidence resulted from the analyses of spoken language predictors.

In summary, PA as a longitudinal or concurrent predictor showed that, while small unit PA was closely linked to ZF-related tasks, the larger unit PA was involved in the auditory input task, e.g. spelling a ZF syllable by listen to it; and the tone PA had a concurrent and unique predictive effect on radical position judgement. However, it was RAN rather than PA skills which accounted for more variances on character-related measures.

**RAN as a predictor of literacy**

The role of RAN in predicting reading fluency has been investigated in other studies (Babayiğit & Stainthorp, 2011; Cheung et. al., 2004; Georgiou et. al., 2006; Ho et. al., 2004; Liao, 2008; Tzeng, 2004), in particular whether RAN (or any of its subtasks) is equally important for both reading accuracy and comprehension. The following discussion will focus more on the longitudinal predictive effect of RAN tasks (see Tables 5.5, 5.8 & 5.10).

Firstly, in Year 1, as shown in Table 5.5, both digit and object RAN at school entrance were significant predictors of performance on two ZF tasks undertaken after the intensive ZF course, i.e. ZF reading accuracy and the school exam, both of which rely on visual input. However, RAN did not predict performance in the auditory input ZF task (i.e. spelling a ZF syllable by listen to it). The results may be attributed to the visual processing which underlies both RAN and ZF reading tasks, as previous studies suggested (e.g. Stainthorp et al., 2010). In addition, the results might also indicate that a degree of ZF reading automaticity and lexical accessing was tapped by each of the two tasks.

Regarding the literacy tasks in Year 2, digit RAN in Year 1 significantly predicted most literacy performance apart from the character reading accuracy task. The result is difficult to explain primarily in terms of visual processing; it may indicate that children did not develop sufficient orthographic representations required to read characters in an effortless and automatic manner. The idea that RAN might index skills beyond visual processing has also been proposed by recent RAN studies (e.g. Stainthorp et al., 2010).

In contrast, object RAN in Year 2 significantly predicted two ZF-plus-character tasks, i.e. reading comprehension and the school exam, which relied more on lexical accessing than on speed of processing. Moreover, individual difference in object RAN uniquely accounted for five per cent of the variance in school exam performance in Year 2. The results highlighted that the lexical access process tapped in object RAN in school entrance may predict the comprehension-related literacy skills a year later. In other words, object RAN was a stable measure of lexical accessing skills over time and may prove to be a useful index of word-finding speed.
Lastly, regarding the link between RAN and character orthographic knowledge, it was found that digit RAN in Year 1 significantly predicted performance on all aspects of character legality judgement apart from radical form accuracy (see Table 5.9). A possible explanation is that orthographic representation tapped by digit RAN shows no association with judgement of radical form accuracy for the legality judgement of radical forms requires finer orthographic representation.

In summary, the link between digit RAN and reading is the level of automaticity required which is dependent on mature visual processing and/or orthographic representation. In contrast, the association between object RAN and reading reflects a common feature of lexical access. Thus, at the stage of early literacy acquisition, graphological RAN is longitudinally linked with most of the ZF or CH reading skills; and non-graphological RAN is concurrently associated with ZF plus CH reading fluency.

**Spoken language skills as a predictor of literacy**

Vocabulary, auditory memory and pseudo-word memory span were the only three language predictors of CH-only tasks (see Tables 5.8, 5.9 & 5.10). Vocabulary in Year

1 had a longitudinal but simple predictive effect on CH reading accuracy and CH recognition. Auditory memory and comprehension made a longitudinal and unique contribution to legality judgement, in accuracy (of the radical position subtask) and reaction time (of the radical form subtask). Pseudo-word memory span had a concurrent and simple predictive effect on CH recognition. These results indicate not only the close links between CH script and lexical representation, but also the key role of working auditory memory load in learning new characters, particularly their phonological features.

According to previous studies, the role of spoken language skills in literacy acquisition has mostly focused on: (a) the common lexical accessing shared with reading comprehension; and (b) abundant lexical representations, which might support efficiency in decoding written forms on single word recognition (Catts et al., 2006; Nation & Snowling, 2004; Ricketts et al., 2007). In the present study, ZF school exam performance after the intensive teaching course was significantly predicted by three spoken language skills, namely vocabulary, picture naming and auditory memory/comprehension. However, no such link was observed in ZF word reading and spelling tasks. The results may indicate a lack of lexical accessing in decoding and spelling a semi-alphabetic orthography (ZF) since lexical accessing was the only difference between ZF school exam and other ZF literacy tasks.

On the other hand, most of the literacy skills in Year 2 apart from ZF reading accuracy were significantly predicted by one or more spoken language skills, although the predicting effect is not unique (see Table 5.8). The result suggests that the lexical features within Chinese characters emphasize vocabulary span on recognizing characters. This finding was also partially consistent with the prediction from the dual-route framework highlighting the interaction between phonological and semantic pathways to word recognition (Nation & Snowling, 2004; Ricketts, Nation, & Bishop, 2007). Additionally, various combinations of all four spoken language skills accounted for 9 to 15 per cent of variance in reading comprehension and literacy academic achievement. The results support the *Simple View of Reading*, indicating that oral language competence would contribute major variances in reading comprehension (Catts et al., 2006; Gough et al., 1996; Stuart et al., 2008).

Lastly, the only spoken language skill accounting for the variance of character orthographic knowledge in Year 2 (both radical position accuracy and radical form reaction time) is auditory memory/comprehension. This finding indicates that oral comprehension skills may have an important role in the development of orthography knowledge, particularly in understanding literacy instruction as well as accessing related lexical representations. Further research is needed to clarify the interaction between oral comprehension and Chinese orthographic knowledge.

### 5.4.2 Predicting PA Development of the First School Year

Previous studies investigating PA development after formal education starts have mostly focused on the reciprocal link between PA and orthography experience, in particular the significant improvement in phonemic awareness among alphabetic-language-speaking children (e.g. Duncan & Bolik, 1999). Similar results were also found in Mandarin-speaking children and attributed to ZF or pinyin instruction (e.g. Chan et al., 2005; Sue et al., 2008). According to Figure 5.2, ZF word reading predicted all PA factors in Year 2, but CH word reading predicted only syllable-implicit PA factors in Year 2. If these results are taken together with the results shown in Figure 5.1, the reciprocal relationships between PA and literacy acquisition seem to be a function of orthographic systems, and different aspects of their association are revealed according to the features of orthographic systems.

Secondly, PA skills were concurrently and longitudinally predicted by RAN at school entrance. According to the core-phonological deficit theory (Wagner & Torgesen, 1987), both RAN and PA involve underlying phonological processing. However, itt is questionable which level of phonological processing is shared between the two measures. In the present study, only syllabic and tonal PA factors were predicted by digit RAN at school entrance (see Table 5.13). Since no small segment PA factor was associated with digit RAN, it might imply that only limited phonological processing was tapped by the RAN measure. In other words, the findings from this study do not support the theory of a core-phonological processing skill between RAN and PA.

Lastly, the lack of an association between vocabulary and three PA factors at Grade 2 suggests that the Lexical Restructuring Model (Walley et al., 2003) does not explain PA development after school entrance when vocabulary alone cannot account for the refinement of phonological representations.

## 5.5 Conclusion

The present study found that reading accuracy of different orthographies did require different prerequisite skills. Small unit PA is more strongly linked with ZF reading acquisition than CH reading. In addition, orthography had a substantial impact on PA development during the first school year. The intertwined relationships among spoken language, PA and written languages implied that the role of PA development in Mandarin-speaking children after beginning school should not be neglected. Difficulty in any one of them would have an impact on the others and therefore lead to a poorer outcome in literacy achievement. This issue will be explored more in the next chapter.

# Chapter 6: Results and Discussion IV

# Literacy, PA, RAN and Spoken Language in Typically and Atypically Developing Children

Previous studies of preschool children in Taiwan have identified that around 6.1% of them may have speech and/or language difficulties (e.g. Cheng et. al., 2009). Similarly, in this study, a small group of children were also found to have speech difficulties when they started school. In addition, another small group of children had reading comprehension or output difficulties after a year of schooling. This chapter was specifically inspired by these observations and aims to investigate the last two of the five research topics:

4. Differences in Literacy, PA, RAN and Spoken Language between children with typically and atypically developing speech output skills

    4a. Do children with atypical speech or reading development at the 1st grade continue to perform less well on PA and/or literacy a year later?

    4b. Does that depend on the writing system they use?

5. Differences in Literacy, PA, RAN and Spoken Language between children with typically and atypically developing reading skills.

    5a. Can atypical literacy performance at the 2nd grade be traced back to a poor performance on spoken language skills, PA, RAN and/or literacy at school entrance?

    5b. Do those differences between children with typically and atypically developing reading skills depend on the writing system of the tasks?

This chapter presents two preliminary studies to address these research questions.

## 6.1 Study 1: Comparison between Children With and Without Speech Difficulty

As mentioned in the literature review in Chapter 1, previous studies have shown that poorer spoken language skills and/or PA at the preschool stage increases the risk of reading difficulties in English-speaking children (e.g. Peterson et. al, 2009). Similarly, Mandarin-speaking children with a phonological disorder have been found to perform less well on PA and ZF spelling tasks (Yen, 2005).

In the present study, questionnaire responses in Year 1 (see Appendix 2:2), revealed that 15.5% of the parents had been or were still concerned about their child's speech and/or language difficulty/delay. The speech output performance of the cohort as measured via the picture-naming task was carefully examined in both Years 1 and 2. Seven pupils were found to have persisting speech difficulties. Their speech accuracy performance on the picture-naming task was substantially delayed in the first year (-2 standard deviation from the mean of this cohort). In order to investigate if their speech difficulty was associated with any difficulty or difference in their literacy skills, the speech output, PA, and literacy, profile of this group of children was specifically examined at the second year.

When tested in the second year, each child had more or less improved his/her speech output skills. The Wilcoxon Signed Ranks Test was used to examine the differences in their overall accuracy in picture naming between Year 1 and Year 2. It was found that the difference was statistically significant ($p < 0.05$). Their phonological deviation pattern and their accuracy in picture-naming tasks in Year 1 and Year 2 are listed in Table 6.1.

**Table 6.1 Phonological deviation patterns of children with speech difficulties**

| No. | Child's ID (Gender) | Year 1 | | Year 2 | |
|---|---|---|---|---|---|
| | | Accuracy (%)* | Phonological deviation patterns | Accuracy (%)* | Phonological deviation patterns |
| 1 | HB (M) | 23 | Backing, stopping, lateralization, affrication, deaffrication, onset deletion | 53 | Backing, deaffrication |
| 2 | CY (F) | 47 | Final consonant deletion, affrication, deaffrication | 97 | Deaffrication |
| 3 | JX (F) | 60 | Deaffrication, onset deletion | 87 | Deaffrication |
| 4 | WQ (F) | 60 | Backing | 80 | Backing |
| 5 | CYJ (F) | 60 | Stopping, backing | 100 | |
| 6 | LT (M) | 63 | Backing, stopping, deaffrication | 77 | Backing, deaffrication |
| 7 | LY (M) | 67 | Deaffrication | 77 | Deaffrication |

* The accuracy of picture naming

Three of them had improved a lot and were within 1 standard deviation range in Year 2 according to the distribution of the performance of this cohort at the first year. Two of them had received speech therapy in their Grade 1 period: one (CY) for two half-hour sessions and the other (CYJ) for ten. The third (JX) had almost resolved her speech delay after a year without any speech and language intervention.

The remaining four had persisting pronunciation errors and were not free from speech difficulty at Grade 2. Further analysis of their phonological processes showed that backing and deaffrication were the two most frequent symptoms. The other phonological processes, such as stopping, lateralization, affrication, onset deletion, and final consonant deletion, appear to have been resolved by Year 2. The last two processes in particular are often targeted through the routine teaching of onset and coda awareness during the first year of school.

### 6.1.1 Methodology

The seven children with significant speech output errors at the start of school were categorised as the speech difficulty (SD) group. Three of them had resolved their difficulties by year 2. The remaining eighty-seven pupils in the cohort who had no problem with their speech output comprised the typically developing (TD) group.

### 6.1.2 Results

**Phonological awareness**

Tables 6.2 and 6.3 show the variety of PA profiles within the SD group (their accuracy on each implicit and explicit PA task) in both years, compared to the mean performance of the SD and TD groups.

**Table 6.2 Percent of accuracy (%) in implicit PA of the speech difficulty group**

| | Year 1 | | | | | Year 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Child | Syl. | Pho. | Onset | Rime | Tone | Syl. | Pho. | Onset | Rime | Tone |
| HB | 80 | 30 | 40 | 60 | 50 | 100 | 50 | 40 | 20 | 40 |
| CY | 100 | 30 | 53 | 30 | 30 | 100 | 60 | 73 | 60 | 70 |
| JX | 80 | 30 | 40 | 60 | 0 | 80 | 40 | 60 | 80 | 70 |
| WQ | 100 | 20 | 67 | 50 | 50 | 100 | 40 | 80 | 50 | 70 |
| CYJ | 80 | 50 | 60 | 80 | 70 | 90 | 20 | 47 | 60 | 70 |
| LT | 80 | 80 | 47 | 70 | 50 | 100 | 40 | 67 | 90 | 80 |
| LY | 60 | 50 | 40 | 50 | 30 | 100 | 20 | 67 | 50 | 80 |
| SD Group Mean | 83 | 41 | 50 | 57 | 40 | 96 | 39 | 62 | 59 | 69 |
| TD Group Mean | 83 | 45 | 59 | 65 | 46 | 91 | 48 | 78 | 76 | 74 |

Note: Syl.: syllable; Pho.: phoneme

**Table 6.3 Percent of accuracy (%) in explicit PA of the speech difficulty group**

| | Year 1 | | | | | Year 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Child | Syl. | Pho. | Onset | Rime | Tone | Syl. | Pho. | Onset | Rime | Tone |
| HB | 20 | 0 | 0 | 10 | 0 | 90 | 40 | 63 | 45 | 85 |
| JX | 60 | -- | 0 | 20 | 0 | 95 | 10 | 53 | 45 | 90 |
| WQ | 75 | 10 | 53 | 20 | 40 | 85 | 50 | 80 | 60 | 75 |
| CY | 90 | 00 | 30 | 60 | 70 | 85 | 40 | 13 | 90 | 10 |
| CYJ | 85 | 20 | 00 | 55 | 70 | 90 | 50 | 80 | 30 | 100 |
| LT | 75 | 20 | 00 | 85 | 55 | 95 | 60 | 20 | 100 | 85 |
| LY | 65 | 20 | 30 | 60 | 65 | 85 | 60 | 37 | 70 | 80 |
| SD Group Mean | 67 | 12 | 18 | 44 | 43 | 89 | 40 | 51 | 53 | 86 |
| TD Group Mean | 79 | 30 | 49 | 58 | 58 | 89 | 46 | 67 | 78 | 86 |

Note: Syl.: syllable; Pho.: phoneme

The SD group performed less well than the TD speech group on most of the PA tasks, except implicit PA at the syllable level in both years, and explicit PA at the syllable tone levels in Year 2. In other words, the SD group performed as well as their peer group on the large unit PA and suprasegmental PA but not on the small unit PA tasks. A Mann-Whitney Test was adopted to examine if these differences were significant in addition to differences between the two groups in their performance on other literacy, RAN and spoken measures. Table 6.4 presents only the significant effects. The full table is presented in Appendix 6:1.

**Table 6.4 Performance with significant differences between speech difficulty and typical developing groups**

| | | Speech difficulty (N=7) | | Typical group (N=85) | | Cohen's D | U | p value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | | |
| Non verbal intelligence | | 93 | 7.18 | 103.04 | 11.04 | -0.93 | 113 | 0.02 |
| **Literacy (Max)** | | | | | | | | |
| Y1 | ZF Letter Knowledge (37) | 30.57 | 3.6 | 34.46 | 2.91 | -1.32 | 101.5 | 0 |
| | Character recognition (T score) | 40 | 6.73 | 52.83 | 18 | -0.74 | 133 | 0.02 |
| | School exam (100) | 82.14 | 7.2 | 93.75 | 5.8 | -1.98 | 64.5 | 0 |
| | ZF Spelling (20) | 7 | 3.83 | 9.87 | 3.48 | -0.82 | 159 | 0.04 |
| | Read Accuracy_ZF _po* (24) | 9.14 | 3.39 | 12.22 | 3.31 | -0.93 | 150 | 0.03 |
| Y2 | Character recognition (T score) | 44.86 | 5.34 | 56.32 | 13.89 | -0.85 | 132 | 0.02 |
| | School exam (100) | 90 | 5.2 | 95.39 | 5.15 | -1.05 | 103 | 0 |
| | Read_comprehension (T score) | 52.43 | 9.78 | 61.15 | 5.24 | -1.55 | 86.5 | 0 |
| **Phonological awareness (Max)** | | | | | | | | |
| Y1 | Explicit PA_Phoneme (20) | 2.33 | 1.97 | 5.9 | 4.2 | -0.87 | 119.5 | 0.03 |
| | Explicit PA_Onset (30) | 5.43 | 7.07 | 14.74 | 9.85 | -0.97 | 126 | 0.01 |
| Y2 | Implicit PA_Onset_ (15) | 9.29 | 2.14 | 11.64 | 2.63 | -0.91 | 142.5 | 0.02 |
| | Implicit PA_Rime (10) | 5.86 | 2.27 | 7.74 | 1.6 | -1.14 | 152 | 0.03 |
| | Explicit PA_Rime (20) | 10.57 | 5.35 | 15.68 | 5.22 | -0.98 | 147 | 0.03 |
| **Spoken Language Skills (Max)** | | | | | | | | |
| Y1 | Auditory_memory | 7.33 | 1.63 | 9.98 | 2.57 | -1.05 | 94.5 | 0.01 |

*Read accuracy_ZF_po: Reading accuracy after ZF course

There was no difference between the SD and TD groups on any RAN measures. Although there was a difference in IQ - the SD group had lower IQ than the TD group - none of the children with SD performed less than 1 standard deviation below the population average. The SD group also performed worse than the TD group on auditory memory.

On PA, as stated above, the SD group performed worse than the TD group on the small unit PA tasks. Unlike the TD cohort who improved significantly on both implicit PA at the rime and onset levels from Year 1 to Year 2 (Figure 3.1), there was no significant improvement on these skills in the SD group (rime Z = -.14, p > .05; onset Z = -1.93, p > .05). Yen (2008) suggests that such a pattern might indicate an inability to take advantage of learning through orthographic experience. Further, the SD group performed less well on a few ZF literacy tasks, including ZF plus CH reading comprehension; and was lower achievers in the school exams in both years. However, there were no differences between the SD and TD performances on CH reading accuracy or CH legality judgement. The only CH task which showed a difference in both years was character recognition.

In summary, the SD group performed less well than the TD group on: nonverbal IQ, speech processing, oral comprehension and letter-sound mapping skills, all of which impact on their literacy acquisition after starting school.

### 6.1.3 Discussion

Previous studies have argued that due to the nature of Chinese orthography, implicit PA at syllable and tone levels are two important predictors of character acquisition, while implicit PA at onset and rime levels make no contribution. This effect is apparent before formal education or any instruction in a phonetic system (Sue et. al, 2008). In the present study, although the SD and TD groups showed significant differences on CH recognition (see Table 6.4), there was no difference between them on either implicit syllable PA or implicit tone PA. Therefore, it seems that the SD groups performance on implicit syllable PA or implicit tone PA did not disadvantage their learning of CH recognition. On the other hand, the evidence that many small unit PA skills showed significant differences between the two paired groups seems more critical, particular as ZF learning is majorly emphasised at the preschool stage in Taiwan. That is, children are expected to learn ZF and are not encouraged to recognise characters before schooling. The children with speech difficulties might be hindered by having to learn ZF prior to learning characters since they are not good at the small unit PA tasks crucial for ZF learning.

## 6.2 Study 2: Comparisons between Atypical and Average Readers

### 6.2.1 Methodology

In contrast to the previous section, Study II is a retrospective study. In order to identify the atypical group within the main cohort, a performance of $10^{th}$ percentile and below on the literacy tasks was set. Children whose performance was between the $45^{th}$ and $55^{th}$ percentiles on the same tasks acted as control group (i.e. the average performance group). Three literacy measures in Year 2, namely ZF reading accuracy, CH reading accuracy and ZF plus CH reading comprehension, were chosen as the target tasks. Table 6.5 presents information on the numbers and genders of these three chosen pairs.

**Table 6.5 The number of boys and girls performing below the 10 %ile on these literacy tasks (atypical) and between the 45 and 55 %iles (typical)**

| | | Boys | Girls | Total |
|---|---|---|---|---|
| ZF reading accuracy | Atypical | 7 | 9 | 16 |
| | Typical | 12 | 13 | 25 |
| CH reading accuracy | Atypical | 4 | 8 | 12 |
| | Typical | 14 | 11 | 25 |
| ZF plus CH reading | Atypical | 9 | 3 | 12 |
| Comprehension | Typical | 17 | 20 | 37 |

A Mann-Whitney Test was then conducted to compare the average raw scores of each atypical-typical pair of groups in all domains of the study, namely literacy, PA, RAN and spoken language skills, at Grade 1 (longitudinal difference) and Grade 2 (concurrent difference). Given that the number of differences between boys and girls in the atypical group on reading comprehension is high, further analysis was conducted to check the gender effect. It was found that ZF plus CH reading comprehension is the only literacy task in this study to have a gender effect where girls performed better than boys ($Z = 1.99$, $p < .05$). In addition, girls consistently performed better than boys at the following PA tasks: Year 1— implicit PA at the onset level ($Z = 1.99$, $p < .05$), implicit PA at the tone level ($Z = 2.10$, $p < .05$), explicit PA at the onset level (Z = 3.37, p < .01); Year 2—explicit PA at the phoneme level (Z = 1.97, p < .05). This finding needs to be borne in mind when we considering the results on reading comprehension.

### 6.2.2 Results

**A comparison between poor and average readers in ZF reading accuracy in Year 2**

Firstly, comparisons between the poor and average groups in ZF reading accuracy in Year 2 were analysed. Table 6.6 presents only the significant effects. The full table of the descriptive statistics is presented in Appendix 6:2.

**Table 6.6 Performance with significant differences between the poor and average ZF reading accuracy groups**

| | | Poor group (N=16) | | Average group (N=25) | | Cohen's D | U | p Value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | | |
| **Literacy (Max)** | | | | | | | | |
| Y1 | ZF_Letter Knowledge (37) | 32.13 | 3.9 | 34.92 | 1.93 | 0.99 | 103.5 | 0.01 |
| | School exam (100) | 88.4 | 8.36 | 93.16 | 5.16 | 0.73 | 110 | 0.02 |
| | ZF Spelling (20) | 7.88 | 3.24 | 10.36 | 4.43 | 0.63 | 109.5 | 0.02 |
| | Read accuracy_ZF_pr* (24) | 6.67 | 2.92 | 9.28 | 3.18 | 0.86 | 108.5 | 0.03 |
| | Read accuracy_ZF_po** (24) | 9.63 | 2.22 | 12.16 | 3.22 | 0.89 | 107 | 0.01 |
| Y2 | Read accuracy_CH_ (24) | 10.69 | 2.82 | 13.2 | 2.16 | 0.28 | 97.5 | 0.01 |
| **Phonological awareness (Max)** | | | | | | | | |
| Y1 | Implicit PA_Phoneme_ (10) | 5 | 1.26 | 4 | 1.55 | -0.7 | 113.5 | 0.02 |
| | Implicit PA_Tone_ (10) | 3.19 | 2.34 | 5.32 | 2.39 | 0.91 | 104 | 0.01 |
| | Explicit PA_Rime_ (20) | 7.75 | 6.86 | 12.64 | 6.24 | 0.76 | 117 | 0.03 |
| | Explicit PA_Tone_ (20) | 6.56 | 6.42 | 13.8 | 3.73 | 1.48 | 69.5 | 0 |
| Y2 | Implicit PA_Rime_ (10) | 6.75 | 1.39 | 8.12 | 1.64 | 0.9 | 106.5 | 0.01 |
| | Explicit PA_Rime_ (20) | 11.25 | 6.22 | 16.4 | 4.59 | 0.99 | 98 | 0.01 |

*Read accuracy_ZF_pr: Reading accuracy before ZF course; **Read accuracy_ZF_po: Reading accuracy after ZF course

Given that groups are divided into typical and atypical based on their literacy scores, the differences between literacy scores is not surprising. The interesting finding would be where there are differences on non-literacy tasks. All significant differences were found to be in either literacy or the PA domain. Moreover, children with average or poor ZF reading accuracy in Year 2 did not differ significantly on their RAN and spoken language skills in Year 1 and 2.

Apart from the two ZF reading accuracy tasks in Year 1, only ZF letter knowledge, ZF school exam and its spelling task showed significant differences between the two groups. The results indirectly imply that the poorer performance of children on ZF reading accuracy might be closely connected to poorer ZF sound-mapping skills, which might appear as insufficient ZF knowledge, less well ZF academic performance and/or an inability to spell out correctly what they had heard. This result was in line with previous studies in alphabetic scripts (e.g., Muter et. al., 2004) and may relate to less sensitive phonological awareness skills.

Indeed, there were significant differences between the two groups on their PA performance. Children who performed less well on ZF reading accuracy also had lower accuracy rates on phoneme, tone and rime PA tasks in Year 1, and rime PA tasks only in Year 2. This poorer performance was found in both implicit and explicit PA tasks and suggests that the atypical group has a core difficulty with input and output speech processing skills (Stackhouse & Wells, 1997).

This core difficulty is not necessarily apparent early on. For example, the atypical group on ZF reading accuracy performed less well than the typical group on implicit PA at the rime level in Year 2 but not in Year 1. This is not a usual pattern since both implicit PA and explicit PA at rime level improved significantly in Year 2 in the typically developing children. A Wilcoxon test was conducted on these data. It was found that both groups improved in implicit PA at the rime level longitudinally according to mean accuracy. However, for the atypical group, the improvement of implicit PA at the rime level is not significant ($Z = 1.06$, $p > .05$); but the typical group did improve significantly (Z = 2.60, $p < .01$). This result implies that the atypical group in ZF reading accuracy did not profit from the ZF orthography experience as much as their peer group during the first school year. In other words, no reciprocal relationship was found between implicit rime PA and ZF orthography in the atypical ZF reading group. Since ZF is a semi-syllabic orthography lacking consistent sound-letter mapping on the rime (or syllable ending), the poor performance on implicit rime PA over time for the atypical ZF reading group suggests: (a) the increase in the difficulty level of mastering an orthography with less consistent correspondence; (b) the reciprocity of ZF orthography and PA may be confusing rather than helpful in identifying similar linguistic units.

**A comparison between average and poor readers in CH reading accuracy**

Since character reading is the ultimate skill to be acquired for Mandarin-speaking children, it is sensible to examine what skills would be closely linked to CH reading accuracy at Grade 2. Table 6.7 shows those tasks (highlighted in grey) which show a major gap in performance between the average and the poor readers in CH reading accuracy. The full table of descriptive statistics is presented in Appendix 6:3.

**Table 6.7 Performance with significant differences between the poor and average CH reading accuracy groups**

| | | Poor group (N=12) | | Average group (N=25) | | Cohen's D | U | p Value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | | |
| **Literacy (Max)** | | | | | | | | |
| Y1 | Character recognition_T score | 31 | 14.76 | 51.83 | 13.86 | 51.83 | 35.5 | 0 |
| | School exam_ (100) | 86.5 | 10.12 | 93.12 | 5.82 | 93.12 | 81 | 0.02 |
| | Read accuracy_ZF__pr* (24) | 5.91 | 2.81 | 9.16 | 3.17 | 9.16 | 59.5 | 0.01 |
| | Read accuracy_ZF__po** (24) | 10.25 | 3.19 | 12.44 | 2.9 | 12.44 | 76 | 0.02 |
| Y2 | Character recognition_T score | 40.42 | 6.67 | 54.44 | 10.06 | 54.44 | 28 | 0 |
| | Read accuracy_ZF (24) | 9.08 | 3.06 | 12.76 | 2.91 | 12.76 | 55 | 0 |
| **Phonological awareness (Max)** | | | | | | | | |
| Y1 | Implicit PA_Tone (10) | 3.5 | 2.47 | 5.42 | 2.45 | 5.42 | 82.5 | 0.04 |
| **Rapid Automatised Naming (Sec)** | | | | | | | | |
| Y1 | Digit | 47.17 | 14.02 | 36.82 | 10.77 | 36.82 | 70.5 | 0.01 |
| Y2 | Digit | 38.95 | 10.66 | 30.46 | 8.13 | 3.46 | 68.5 | 0.02 |
| | Character | 39.82 | 6.34 | 32.36 | 6.77 | 32.36 | 58 | 0.01 |

*Read accuracy_ZF_pr: Reading accuracy before ZF course; **Read accuracy_ZF_po: Reading accuracy after ZF course

In general, the pattern of performance on tasks is different from previous results on ZF reading accuracy. Firstly, rapid naming tasks become more important in this comparison. Children who performed less well in CH reading accuracy also performed worse in digit RAN in both years and on CH RAN in Year 2. They also performed less well on the ZF school exam in Year 1 and on character-based tasks, such as character recognition. Their performance on the implicit tone PA task in Year 1 was also less good but no spoken language tasks triggered any differences. This result seems to indicate that CH reading accuracy is connected more closely to visual-verbal pairing (reflected in RAN measure) than to the speech processing system (reflected in PA measure).

Moreover, according to previous results where both implicit and explicit tone PA improved substantially after a year of schooling, implicit tone PA at school entrance is the only PA task linked to in later poor CH reading accuracy. In other words, it is the level of implicit tone PA acquired by daily exposure to Mandarin and/or Chinese script that is connected to later CH reading accuracy. On the basis of this result and its implications, it seems to be sensible to propose the importance of tone PA in character reading accuracy.

**A comparison between children with average and poor reading comprehension**

The last comparison of literacy skills in Year 2 is on ZF plus CH reading comprehension. Table 6.8 presents the measures on which there was a difference between children with average and poor reading comprehension. The full table of descriptive statistics is presented in Appendix 6:4.

**Table 6.8 Performance with significant differences between the poor and average reading comprehension groups**

| | | Poor group (N=12) | | Average group (N=37) | | Cohen's D | U | p value |
|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | | |
| | Non verbal intelligence | 92.08 | 6.2 | 105.19 | 9.65 | 1.48 | 51 | 0 |
| **Literacy (Max)** | | | | | | | | |
| Y1 | ZF_Letter Knowledge(37) | 32.25 | 4 | 34.64 | 2.93 | 0.75 | 134 | 0.047 |
| | CH recognition (T score) | 38.55 | 4.23 | 53.5 | 13.49 | 1.26 | 49 | 0 |
| Y2 | CH recognition (T score) | 43.75 | 9.07 | 57.38 | 12.23 | 1.19 | 76 | 0 |
| | School exam (100) | 91.42 | 5.09 | 96.38 | 2.86 | 1.43 | 87.5 | 0 |
| **Phonological awareness (Max)** | | | | | | | | |
| Y1 | Implicit PA_Onset (15) | 7.25 | 3.08 | 9.71 | 2.38 | 0.97 | 100.5 | 0.01 |
| | Explicit PA_Phoneme(20) | 2.91 | 2.74 | 6.38 | 4.02 | 0.93 | 98 | 0.01 |
| | Explicit PA_Onset (30) | 8.25 | 10 | 14.86 | 10.25 | 0.66 | 126 | 0.03 |
| Y2 | Explicit PA_Syllable (20) | 17.17 | 1.53 | 18.11 | 1.54 | 0.62 | 134.5 | 0.04 |
| | Explicit PA_Rime (20) | 10.33 | 5.88 | 16.08 | 4.99 | 1.11 | 86 | 0 |
| **Rapid Automatised Naming (Sec)** | | | | | | | | |
| Y1 | Object | 71.75 | 23.5 | 56.46 | 14.24 | -0.91 | 129.5 | 0.04 |
| **Spoken Language skills (Max)** | | | | | | | | |
| Y1 | Vocabulary (T-score) | 105.17 | 7.69 | 113.78 | 7.79 | 1.12 | 86 | 0 |
| | Picture Naming (30) | 24.08 | 7.15 | 28.51 | 1.71 | 1.19 | 106 | 0.01 |

Firstly, nonverbal intelligence discriminated between those with average and poor comprehension. Moreover, those with poor comprehension performed significantly less well across the four domains measured. Both ZF and CH skills in Years 1 and 2 showed a difference between the two groups. The results suggest that poor comprehenders had difficulty understanding what they had read regardless of which script they were reading. In addition, both large and small unit PA skills, particular onset PA in Year 1, showed differences between the two groups. This result reflects a mixture of the impact from two different orthographies. The evidence that the atypical and average groups differed on object RAN, vocabulary and picture naming in Year 1 indicates that the task (reading comprehension) involves lexical representations and access. To conclude, the above results show the importance of the above skills for developing ZF plus CH reading comprehension. In other words, without mastering these skills to some degree, children might perform less well than their peer group in reading comprehension.

### 6.2.3 Discussion

The results show that in the poor readers, performance in the domains which contribute to reading accuracy (PA and RAN in particular) vary depending on which script is being read. Furthermore, the profile of performances within the four domains of PA, RAN, spoken language and literacy measures which contribute to reading comprehension is different from that related to reading accuracy in either CH or ZF. Thus when investigating literacy development in children learning more than one script it is necessary not only to separate out reading accuracy and comprehension, but also to examine separately performance on the different scripts involved. Although the results based on the present analysis are limited in scope, they may indicate what skills are important for acquiring average reading accuracy or reading comprehension. Moreover, the pattern of results for the poor readers might reveal the at risk profile indicative of future literacy difficulties including dyslexia.

It has been proposed that a RAN deficit, particular in digit RAN, might be present in Mandarin-speaking children with developmental dyslexia, and that this is more closely related to their character recognition ability than their reading comprehension (e.g. Hsieh & Tzeng, 2004). This idea is supported to some degree by the results of the present study. Children in the poor and the average group for CH reading accuracy showed significant differences in digit RAN in both year 1 and 2, and CH RAN in year 2 (see Table 6.7). However in year 1, implicit tone PA performance was also different in the atypical and average groups in CH reading accuracy. Thus RAN and PA may be separate markers for identifying difficulties on learning CH and ZF orthographies respectively. In other words, there is a relationship between performance on literacy tasks and the writing system used.

To conclude, a high percentage of the script with both phonological and lexical units, such as phonetic-semantic compounds, would be a feasible way to make the writing system easily adopted among various languages (or dialects). Consequently, the sound-script mappings of the kind of characters would become complicated as the original pronunciation of a character might not be the same in a particular language background. The complicate mappings would make sub-syllabic PA skills less critical in its development but more linked to RAN performance which requires a syllabic speech output. In contrast, ZF orthographic system highlights more on regular sound-script mapping and would therefore related more on sub-syllabic PA skills. The divert patterns of demand between ZF and CH might therefore impact more on high risk readers whose PA or RAN skills is less complete.

## 6.3 Conclusions

Although the two studies presented in the chapter are small in scale, they are the first studies of how children with speech and/or reading difficulties tackle the two different scripts, ZF and CH. It is not possible to compare the SD and poor reader groups directly as some of the participants belong to both groups (such as 101JX and 110HB). However, some interesting results were found. For example, it was the children in the poor ZF reading and SD groups that failed to progress with implicit rime and/or onset PA tasks which supports previous studies that children with speech difficulties may also have difficulties with PA. This finding raises questions about the benefit for the SD group of learning ZF as a support for CH acquisition as required in the national curriculum. However, it also contributes to our understanding of how young children at risk of developing literacy difficulties might be identified early in year 1 of school.

# Chapter 7
# General Discussion and Conclusion

This study focuses on the critical transitional period when Mandarin-speaking children learn to read two diverse orthographies during their first school year. The study systematically examined the development of PA between the first and the second school year, including implicit and explicit PA on various linguistic levels. The impact of both spoken language and written languages was carefully reviewed and taken into account. A group of literacy skills, including reading accuracy and comprehension, and RAN were also measured. Finally, emergent poor readers and a group of children with speech difficulties were specifically examined. In this last chapter, general discussion of what has been investigated in the study and its relationship to previous studies will be presented. An indication of the perceived strengths and possible contributions of the study will then be presented, as well as suggestions for improvements. Possible applications of the results and future work based on the outcome will conclude this chapter and thesis.

## 7.1 General Discussion

### 7.1.1 Literacy Development in Two Orthographic Systems

In Taiwan, learning ZF at the beginning of the first grade before learning characters is required in the national curriculum. The ZF phonics instruction during the first three months of Grade 1 seeks to set a good foundation for later character acquisition. However, the theoretical or practical evidence for the above compulsory arrangement has lacked systematic examination and discussion, failing to mention alternatives that might be useful for children who have special needs. Previous studies focusing on literacy acquisition of Mandarin-speaking children assumed that written language competence in Chinese characters very much depended on the foundation of spoken language skills (e.g. Ho 2005). However, what we have not known in detail is the psycholinguistic impact of learning a transitional orthography (i.e., ZF) before the formal orthography (characters), particularly when these two orthographies, though visually similar, are totally different in their sound-script mapping. This present study may be the first systematic attempt to investigate the trajectory of literacy acquisition in Mandarin-speaking children and the impact of instruction in both ZF and CH.

The first important issue to discuss is whether learning ZF has any negative effect on subsequent learning of CH, as mentioned in previous studies (e.g., Chen & Yuen, 1991). In the present study, it was found that ZF spelling made a unique contribution to the reaction time in making a judgement of characters' radical format in year 2. This suggests that there is a close association between ZF writing skill and the fast response to minor differences in the appearance of characters. The result may be attributed to the similarities in the characteristics of scripts in ZF and CH, such as the fact that both of them are composed of strokes, as suggested by previous studies (e.g. Ou, 2011).

Moreover, it was found that, despite the different orthography systems, both ZF reading accuracy and number of characters recognised before formal education may already predict the number of characters recognised a year later. This finding suggests that literacy teaching in the first year of school does not alter the pattern of differences among children that already existed before school starts. The result echoes the results in previous studies demonstrating that CH acquisition in primary school seems mainly to be achieved by rote learning (e.g., Wu & Huang, 2004). Another possible explanation is that current literacy instruction is ineffective in compensating for differences between children that are already present before they start school.

Thus, it seems that learning ZF does not adversely affect the learning of characters. Rather, it enhances the child's familiarity with the script of characters. However, learning ZF does not have a positive effect for school entrants on recognising more characters. In order to know what skills are critical for CH acquisition, it might be necessary to examine further the linguistic features and cognitive processes involved when reading the orthography.

Lastly, different profiles of performances within the four domains of PA, RAN, spoken language and literacy measures contributed differently to reading comprehension and reading accuracy (see table 6.6, 6.7 and 6.8). This suggests that there are two independent dimensions, i.e., word recognition and language comprehension, to becoming a skilled reader, which is in keeping with *the Simple View of Reading* put forward by Gough et al. (1996). Further, both ZF reading accuracy and CH word recognition predicted reading comprehension longitudinally (see Table 5.8) during the early school years suggesting that better word reading would lead to better reading comprehension at a later stage.

### 7.1.2 Relationships between PA Development and Literacy Acquisition

Using a new PA battery composed of PA tasks at various linguistic levels, the study investigated how PA develops in Mandarin-speaking children after literacy instruction starts, and whether PA is a good predictor of literacy acquisition a year later. The question of whether children with speech difficulty would be disadvantaged in literacy acquisition, due to possible atypical development of their PA skills, was also addressed.

A comprehensive PA battery was specifically developed to tap the different linguistic levels underlying both implicit PA and explicit PA. This PA battery is based on a common unit design where children listen to a pair of words and are asked to produce the shared unit, and which has been used to test English-speaking pupils who had been taught phoneme-grapheme mapping (Duncan & Bolik, 1999). The cognitive demand of the design was claimed to fit better for those children who had received reading instruction and may understand the task well (Ziegler & Goswami, 2005). In this study, our evidence showed that the cohort had good ZF letter knowledge (see section 4.1.1). Therefore, adopting the common unit design in the PA battery for assessing Mandarin-speaking children at school entrance would not make the tasks too difficult for them. In addition, the comprehensive PA battery in this study is an advance on previous Mandarin PA batteries since it adopts pseudo-word stimuli and therefore no lexical processing is involved in responding to PA tasks (Chan, 2005; Huang & Hanley, 1997; Ko & Lee, 1996; Sue et al., 2008; Xu, 2004; Yen, 2005). Also, it takes account of specific linguistic properties of the Chinese language family, such as tone variation and the differences between Mandarin and Taiwanese in onset phonemes.

As addressed in the discussion section of Chapter three, PA performance at school entrance and its development in the first school year were in line with previous studies where ZF or pinyin instruction was found to have major impact on the improvement of onset and tone PA, in both implicit and explicit PA tasks (Sue, et. al., 2008; Xu, et. al., 2004). However, whereas children in Mainland China demonstrated limited implicit PA on onset, rime and tone levels (range 32-35 %) at the beginning of schooling (Xu, et. al., 2004), in the present study, the accuracy rates of the cohort were 59%, 65% and 47% on the onset, rime and tone levels respectively. The difference might be attributed to the popularity of informal ZF letter-sound mapping instruction in preschools in Taiwan (Hung, 2008).

Another important issue is the development of phonemic PA in Mandarin-speaking children. Previous studies showed better phonemic PA performance in later school years, either in an implicit oddity task conducted at Grade 4 or an explicit deletion task conducted at Grade 5 (Chan et. al., 2005; Xu, et. al., 2004). The results suggested the long lasting influence of ZF or pinyin instruction on phonemic PA development. In the present study, implicit phonemic PA remained similar between year 1 (45%) and 2 (47%); but the accuracy rate of explicit phonemic PA improved significantly from

29% to 45% between year 1 and 2. As explicit phonemic PA seems to have improved as orthography experience increases, it is possible that accuracy rate of explicit phonemic PA in Mandarin-speaking children in their later school years will grow faster than that of implicit phonemic PA. However, this improvement might not simply reflect the development of phonemic PA skill but also the effect of orthography experience. This hypothesis would warrant further examination in a follow-up study to know whether it is necessary to have ZF words alongside CH till Grade 4. Particularly, in this study, it was found that CH acquisition might not benefit from small unit PA. Therefore, it becomes questionable whether PA skills facilitated by ZF orthography experience might occupy more cognitive resources than the PA skills closely related to character acquisition, such as Implicit PA on the rime and phoneme levels (see section 5.1.1).

To date, it has been difficult to establish if PA is a precursor of later literacy acquisition in Mandarin-speaking children. Previous studies have focused mainly on correlation analysis between PA and CH recognition and found significant concurrent correlations (e.g., Huang, 1997). Recently, one study in Hong Kong examined the effect of explicit syllabic PA on predicting character recognition and found a very limited unique contribution (1%) (Tong et. al., 2011). The systematic examination of PA factors as predictors of literacy acquisition in the present study makes an important contribution to this issue. For example, it was found that PA as a predictor reflects the grain-size levels of phonological representation accessed in different orthographies. In general, small unit PA was closely linked to ZF-related tasks; larger unit PA was involved in the auditory input task, e.g. ZF spelling; and tone PA had a concurrent and unique predictive effect on character knowledge, such as radical position judgement. Therefore, in the Taiwanese context, where children are required to learn ZF before CH, small unit PA skills, such as phoneme, rime and onset PA, are critical for literacy achievement. However, tone PA may be the main precursor of future character knowledge when learning CH over a longer time period.

The present study also explored the relationships between PA and spoken language skills. In particular whether children with speech difficulty experience atypical PA development may influence and/or relate to their literacy acquisition in turn. This concern has been investigated in several studies of English speaking children due to the close link between PA and literacy acquisition in alphabetic languages (Dodd & Gillon, 2001; Hesketh, 2004; Stackhouse & Wells, 1997). For example, children with a history of speech output difficulty are also at risk of reading difficulty at a later stage (e.g., Peterson, et. al., 2009). However, in Taiwan, only one master's thesis has focused on the issue (Yen, 2008). In that study, children with persisting speech difficulty at Grade one (age between 6-7) performed less well on explicit syllable and onset PA tasks, and were also poorer than the control group on ZF dictation, spelling, and reading aloud of ZF letters, words and tones.

The present study supports these findings but extends them by examining the diverse patterns between the two orthographic systems. First of all, the speech output skills of the cohort predicted both ZF reading accuracy at Grade 1 and CH reading accuracy at Grade 2. This result shows the close link between speech output skills and ZF and CH reading accuracy. However, children with speech difficulty performed less well on some small unit PA skills and ZF literacy tasks, including character recognition and ZF plus CH reading comprehension. These children also demonstrated lower achievement in the school exams in both years, but showed no differences in their performance on CH reading accuracy or CH legality judgement. Therefore, it is quite likely that Mandarin-speaking children with speech difficulty will have poorer small segment PA skills which are closely linked to future ZF literacy performance and the amount of recognised characters. Their disadvantage on CH acquisition may not relate to CH decoding but with the complicated mapping of sound-script among characters.

### 7.1.3 Relationships between RAN and Literacy Acquisition

The second theme of the study is an investigation of the links between RAN and literacy acquisition. From a psycholinguistic perspective, RAN involves converting visual written input to serial speech output. This process relies on preceding reading experience and/or practice (Clarke, Hulme & Snowling, 2005). In contrast to the core phonological processing theory (Wagner & Torgesen, 1987), the double-deficit hypothesis (Wolf & Bowers, 1999) distinguishes between phonological awareness and RAN when discussing links with reading. This hypothesis suggests that RAN has a unique role in highlighting specific aspects of reading difficulty, such as central processing deficit. The evidence from the present study is more in keeping with the double deficit hypothesis since the links between either PA or RAN and reading are different. The link between PA and reading was different for semi-syllabary (ZF) and morpho-syllabic (CH) orthography systems. However, the association between RAN and reading accuracy was not different for the two orthography systems. Both ZF and CH word reading accuracy were significantly predicted by digit RAN. Graphological RAN and ZF and CH word reading accuracy was found to reach a similar level of automaticity which might depend a lot on visual processing or orthographic representation.

Furthermore, the evidence from this study implies that the orthographic difference between ZF and CH is impossible to be detected by RAN tasks. This might be because both ZF and CH are constituted by fewer or more strokes even though they are based on diverse script-sound mapping rules. As also suggested by Moll, Fussenegger, Willburger and Landerl (2009), it seems that RAN is not a measure of orthographic processing, although different level of orthographic representations is required to naming various graphological stimuli speedily.

Regarding the relationship between non-graphological RAN and concurrent reading performance, in the present study, children performed faster on the graphological RAN tasks (ZF and CH) than the non-graphological object RAN tasks. This finding replicates previous studies of Mandarin-speaking children (e.g. Liao et al., 2008). Moreover, graphological RAN with higher automaticity level represents a better predictor of later reading performance than non-graphological RAN, as mentioned by Wolf (1991). However, this does not mean that non-graphological RAN was not associated with reading. In this study, object RAN significantly predicted concurrent reading tasks related to lexical access. The concurrent link between non-graphological RAN and reading might only be found during the early stage of literacy acquisition when reading accuracy and/or fluency is under-developed.. Nevertheless, the link between non-graphological RAN and concurrent literacy in both ZF and CH did highlight the importance of object RAN at the early stage of literacy acquisition.

Another aspect of the link between RAN and reading has been observed in studies of Chinese readers where digit RAN accounted for the variance of character-reading accuracy and fluency. The concurrent association between digit RAN and reading accuracy increased when Chinese reading skills improved, while the opposite had been observed in English studies (e.g. Liao et al., 2008). This pattern was not replicated in the present study, which looked at a younger cohort than previous studies. The concurrent associations between digit RAN and character recognition (Year 1 $r^2 = .20^{**}$; Year 2 $r^2 = .12^{**}$) or ZF reading accuracy (Year 1 $r^2 = .14^{**}$; Year 2 $r^2 = .08^{**}$) decreased from Year 1 to Year 2. Thus, although the variability of the relationship between digit RAN and reading accuracy across languages might be slight during the early school years, it might increase as literacy skill improves. In other words, digit

RAN is a good predictor of reading skills across languages, as suggested by previous studies (Georgiou, Parrila & Kirby, 2006; Ho, Chan, Tsang & Lee, 2002; Tzeng, 2004). However, it is the early school years when digit RAN is the strongest concurrent predictor of reading accuracy, especially in bilingual children.

To conclude, instead of proposing that the role of RAN varies as a function of the orthography system (Liao et al., 2008), the present study of early school children places more emphasis on the cross-linguistic stability of graphological RAN as a predictor of reading performance, whether concurrently or longitudinally. However, the role of non-graphological RAN in predicting lexical-related literacy skills should not be ignored. Moreover, at this stage, RAN represents kind of processing different from both phonological processing and orthographic processing, according to the evidence found in this study.

### 7.1.4 Relationships between Spoken Language Skills and Literacy Acquisition

The third theme of the study is to explore the role of spoken language skills in early reading acquisition in Mandarin-speaking children. Previous studies have suggested that the link between spoken language skills and literacy might focus on (a) the association between oral comprehension and reading comprehension; or (b) word recognition (e.g. Nation & Snowling, 2004; Ricketts et al., 2007). In the present study, vocabulary and auditory memory were associated longitudinally with CH reading accuracy, CH recognition and CH knowledge. However, the variance of ZF word reading or spelling could not be explained by spoken language skills. This pattern suggests that the link between spoken language skills and word recognition varies as a function of the orthography system. It is worth noting that in both the ZF and CH word-reading tasks, only words familiar to school entrants were included. Thus, the diverse relationships between CH and ZF word-reading and spoken language skills should be attributed not to phonological skills or non-phonological language skills but to the orthographic characteristics. In contrast to ZF, lexical radicals in Chinese characters might be the main source of the association between CH and spoken language skills which require lexical accessing as well. Most Chinese characters are inconsistent in orthographic-phonological mapping and are very much like so-called exceptional words in studies of readers of English (e.g. Ricketts et al., 2007) where recognition of exceptional words was closely related to vocabulary span.

Regarding the link between spoken language skills and reading comprehension, the evidence from this study supports the view that this link is linguistically universal (e.g. McBride-Chang et al., 2010). In the present study, all spoken language skills, except semantic fluency, were significantly associated with reading comprehension. This suggests that oral language competence is a main contributor to reading comprehension and is consistent with the *Simple View of Reading*, (Catts et al., 2006; Gough et al., 1996; Stuart et al., 2008). Since earlier (year 1) semantic fluency did not relate to later reading comprehension, it is very possible that, in the early school years, reading comprehension does not necessarily reflect reading fluency.

To summarize the roles of PA, RAN and spoken language skills in early reading development in the context of two orthographic systems, a simple but evidence-based box and arrow figure is presented in Figure 7.1. The results presented in the figure are based on the one-year longitudinal analyses and discussion presented in both Chapter 5 and this chapter, particularly the relationship between the performance of the two orthographic systems on both word reading and reading comprehension (see section

7.1.1). The squares represent the independent variables, and the circles the various literacy skills, categorized into word recognition and reading comprehension according to the two-dimensional *Simple View of Reading*. Each arrow with a white arrowhead shows a longitudinal predicting effect which exists across different cognitive domains. Each arrow with a black arrowhead shows a longitudinally predicting effect which exists within the literacy domain.

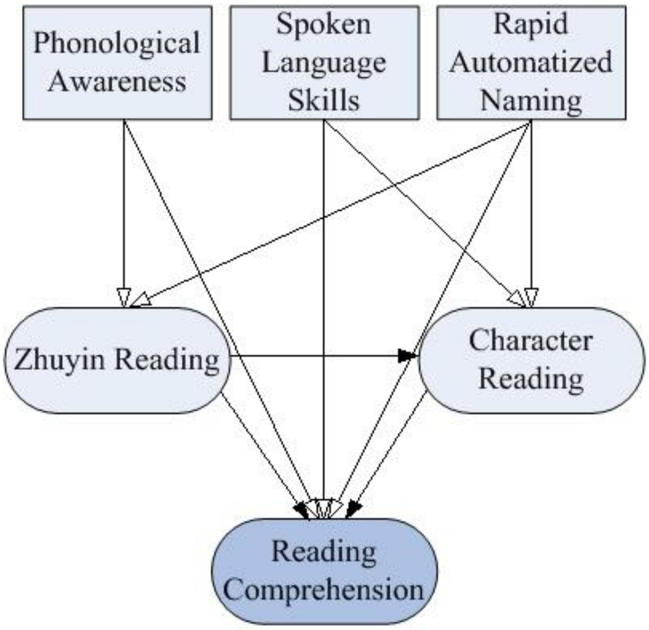


**Figure 7.1 A model of early reading development in Mandarin-speaking children**

In summary, Figure 7.1 presents how PA, oral language skills and RAN each relate to ZF and/or CH reading as well as to reading comprehension in the early school years. Within the literacy domain, ZF predicts CH performance, but not vice versa. However, both ZF and CH reading showed direct association with reading comprehension. This model suggests that:

a) The development of PA and oral language skills prior to formal education is an important foundation for literacy acquisition in both ZF and CH reading.

b) Programmes that enhance spoken language skills prior to formal education should be considered as a means of developing a firm foundation for later development of later CH reading and comprehension.

c) PA skills are directly related to ZF reading performance but not to CH reading performance where there is only an indirect relationship via firstly learning ZF. Therefore, programmes that support the development of PA skills prior to formal education may enhance ZF reading which in turn contributes to the development of CH reading. However, children who have difficulty or delay in developing PA, may benefit from bypassing learning ZF as a prerequisite to learning CF and instead learn CH directly and earlier.

d) As RAN contributes to both ZF and CH reading as well as to reading comprehension, it can be used as an index of readiness for acquiring literacy. The corollary of this is that a poor RAN performance may indicate children who are at-risk for reading difficulties regardless of which orthography system they adopt.

This model provides a good starting point for further investigations focusing on trajectory development between cognitive processing skills, oral language skills and literacy skills in later school years. Additionally, the indirect effect from PA, oral language skills and RAN toward ZF/CH reading skills at the word level as well as reading comprehension warrants further examination. Such a study may lead to a stronger rationale for a prevention programme which focuses on PA and oral language skills at the preschool stage in order to enhance children’s efficiency or performance on reading comprehension at a later stage.

Now that the three main themes of the study have been discussed, the next sections will present the contributions of the study, suggestions for improvement in methodology, general practical implications, and the direction of further studies.

## 7.2 What this Study Contributes

A main feature of this study is an investigation of the relationships between literacy acquisition and critical cognitive factors, such as PA and RAN, and spoken language skills in Mandarin-speaking children who are taught ZF before CH. In this section, what this study contributes will be summarised and elaborated.

### The Phonological Awareness Battery

The Phonological Awareness Test Battery developed specifically for this study is the first of its kind for Mandarin speaking children. It is based on the sound structure of Mandarin, the psycholinguistic model of Stackhouse and Wells (1997), and the conclusions of a previous study of PA development in preschool Mandarin-speaking children by Sue et. al. (2008). The inclusion of pseudo-word stimuli on five linguistic levels and both implicit and explicit task designs means it is the most comprehensive PA test battery used to date in a study of Mandarin-speaking children. It provides a framework that can be adapted for children from syllabic and tonal language backgrounds, particularly East Asian languages. A revised version with better reliability for the use of both researchers and practitioners could be developed . This could focus on tasks which tap grain-sized PA suited to the language in question.

### The Development of Suprasegmental PA

By the systematic investigation of PA development in Mandarin-speaking children via factor analysis, a critical aspect of the development of tone PA emerged for the first time. That is, tone PA in Mandarin shares a common factor with large unit PA

(PA_syllable) before the ZF training course; but dissociates from PA-syllable and follows its own path after one year of ZF and CH instruction. The finding reveals the prosodic nature of suprasegmental PA before schooling and how it is changed by the experience of a phonetic orthography, i.e., ZF.

**The Pros and Cons of Learning ZF before CH**

Even though the learning of ZF is compulsory in the national curriculum in Taiwan, no study has questioned the pros and cons of learning ZF for long-term CH acquisition as the present study has done. The experience of learning ZF before characters connects metalinguistic PA skills to ZF orthography, whose sound-letter mapping is mostly regular. This experience might strengthen pupils' first impression that written scripts are used only to represent their phonological characteristics. Consequently, they are familiar with accessing the lexical information via phonological processing on small unit linguistic levels, which is very much emphasised in decoding ZF words. However, character orthography involves a totally different process of sound-script mapping where phonological information is neither the only clue nor a regular guide to its pronunciation. Moreover, lexical information expressed in characters on the radical level is usual. Children have to be encouraged to strengthen the link between sound, script and morpheme to improve their reading fluency before they can read without the support of ZF words. For the next step, the trade-off interaction of psycholinguistic processes between learning these two orthographies at a later stage and how it develops is required to establish empirically at what stage the ZF support can be discontinued.

## 7.3 Recommendations for Further Studies

Generalising the findings from this study is limited by a number of factors that could be addressed in subsequent studies. The first practical limitation was the number of participants. A larger cohort would be beneficial for multiple regression analysis. It was not feasible to include more participants in the present study because of the limited time and manpower available to collect comprehensive baseline data within the first three months of the study.

Another improvement would be to include pseudo-word span as a subtask of PA and measure it in both year 1 and 2 of the study, as it is a task that can be used to examine whether the design of the implicit PA tasks risks overloading children's working memory capacity. The present results suggest that the items of this pseudo-word span task should range from one to five syllable strings for preschool or early school children. The test-retest reliability of the pseudo-word span task could also be recorded when it is first conducted.

If it were possible, it is also suggested to include repeatedly measuring PA one or two weeks after the end of the ZF intensive course so that we may see the direct impact of the ZF course on PA development and also examine how PA develops after the CH orthographic system is introduced.

Lastly, there are a few improvements that could be made if the PA battery developed in the study is to be published in the future and used more widely. Regarding the design itself, it is good to include a variety of linguistic levels in the PA subtasks. However, since PA is a developmental skill, it is suggested that only those linguistic levels should be included which are specific to the language spoken as well as appropriate to a particular age range of participants. In the case of Mandarin-speaking children at school entrance, implicit PA might be excluded as it might not be acquired naturally in a Mandarin environment and might be greatly influenced by ZF instruction. A thorough solution would be to establish local developmental norms so that it is clear which linguistic levels of PA should be included for which age group of children, according to which language they speak. This will shorten the tedious testing procedure by leaving out those subtasks on a few linguistic levels which are not relevant for certain participants. An extra advantage of cutting down the subtasks for a particular group is to include more trial items for each relevant level rather than mixing teaching items and testing items together, as was done in the study.

## 7.4 Practical Implications

There are several practical implications based on the outcomes of the study for researchers, clinicians, teachers and education policy makers.

### Cross-linguistic Application

The study provides substantial evidence of how written languages affect PA development after schooling at various linguistic levels and how different orthographies might shape distinct patterns of literacy acquisition. This evidence may be applied to other syllabic or tonal languages as well as other occasions where syllabic writing systems are dominant. Moreover, in addition to Taiwan, other areas using characters as their official written form, such as Mainland China and Hong Kong, may be persuaded by the outcomes of the study to pay more attention to the link between spoken and written language, as well as to their policy on literacy instruction. Further studies of populations/cohorts whose mother tongue is different from their written script would be helpful in forming a more comprehensive psycholinguistic theory to explain the essential and varied processes of literacy acquisition.

### Assessment and Intervention for Children with Speech Difficulties

The PA battery developed for this study could be used by speech and language clinicians to profile the PA development of children with speech difficulties. For example, for preschool children, the battery could be used to examine which linguistic levels of phonological awareness a child has already acquired and what targets to set in line with their PA capability. Further, knowing if a child has developed implicit and/or explicit PA skills, allows a clinician to know what kind of stimulus or response would be appropriate in therapy. Lastly, those measures which detect the gap experienced by children with speech disorders and their peer group may be carefully monitored from their preschool age and considered for involvement in therapy targets.

**Collecting the Profiles of High-Risk Readers**

By adopting the four domains of measures used in this study, namely spoken language skills, PA, RAN and literacy skills, the various patterns of children's strengths and weaknesses in literacy acquisition were identified in their early school years. These measures, detected children who were high-risk poor readers, could be used by teachers and clinicians to identify early children at risk of later literacy difficulties and to monitor their progress and response to any intervention.

**Literacy Instruction**

There are three main implications for ZF and CH instruction in literacy acquisition. First, it is necessary to include ZF instruction in the last year of preschool to facilitate children's ZF letter knowledge. Second, Chinese characters, particularly those with simple strokes and a rich embedded lexical message, may be introduced informally to stimulate children's character knowledge and enable them to accumulate recognised characters at an early stage. Third, it may be worthwhile for children who have difficulty in learning ZF because of their weaker PA to acquire CH directly, as characters demand less small-unit PA skill than ZF. Therefore, although learning ZF before CH is currently obligatory for the sake of long-term CH acquisition, it is suggested that some flexibility is desirable particularly for those children with a speech difficulty or dyslexia who may fin d it easier to learn characters directly without being required to read ZF first. Experiencing some success in learning characters rather than failing to grasp the small unit PA principles involved in ZF may also help to maintain their interest in learning to read.

## 7.5 Future Directions

The present study found that the number of characters recognised at Grade 2 could be predicted by the ZF reading accuracy and character recognition skill of the children before they began their formal education. This early experience is therefore worthy of further investigation. In particular what factors influence the number of recognised characters in Mandarin-speaking preschool children and how this early character recognition can be acquired.

Another direction for further study was mentioned previously in Chapter 6. Based on the preliminary results of differences between atypical and average groups, further studies might include matched groups comparisons on reading-age and speech output-age, as well as on chronological age, as a means of examining further the skills necessary for reading accuracy and comprehension, and which are more vulnerable in children with speech difficulty or poor literacy skills. These findings would also contribute to the development of evidence-based early screening and intervention. In addition, including more qualitative error analysis than was possible in the present study could investigate whether phonemic PA is critical for ZF and/or CH acquisition. For example by examining the errors made on explicit phonemic PA tasks, or by collecting data on the further development of phonemic PA in the same cohort. Such a follow-up study would expand our knowledge about the nature of phonemic PA and how it is shaped by orthography experience.

Lastly, the PA battery itself could be developed further and published, once its psychometric properties, such as objectivity, reliability and validity, have been checked and local norms for Mandarin-speaking children have been set. It is also feasible to develop a screening measurement of high risk readers based on those tasks in the battery that are sensitive enough to distinguish poor readers from average readers.

## 7.6 Conclusion

Even though PA has been widely investigated in relation to its critical role in literacy acquisition in either the Chinese language family or alphabetic languages, little attention has been paid to the trajectory of its development before and after schooling and how PA in Mandarin-speaking children relates to specific orthography experience, family languages and literacy instruction.

This study has investigated PA development over the critical transitional period when Mandarin-speaking children are learning to read two diverse orthographies during their first school year, by designing a comprehensive PA battery and conducting it repeatedly at the beginning of Grades 1 and 2. Concurrent spoken language skills were assessed as well to clarify further whether PA is a primary linguistic skill or is more likely to be a cognitive and metalinguistic skill. Another cognitive factor linked to literacy acquisition and developmental dyslexia in Chinese, RAN, was also included and assessed twice in this one-year longitudinal study.

Careful examination of how spoken language skills, PA and RAN predict performance on various tests of literacy in ZF and CH, including reading accuracy, letter knowledge and reading comprehension, demonstrate concurrently and longitudinally that diverse patterns of critical preceding skills are linked with each orthographic system. The present study, to the best of our understanding, is the first to examine the pros and cons of learning a semi-syllabic orthography, ZF, before Chinese characters. Furthermore, the preliminary finding in this study of the disadvantage of learning ZF before characters for children with speech difficulties provides an evidence-based argument on how to facilitate their long-term character acquisition. In addition, a profile of target skills to be monitored by teachers and/or clinicians for high-risk readers was presented in the study which can enable early formal assessment and monitoring to take place and intervention to be planned.

To conclude, this study provides an inclusive perspective on how Mandarin-speaking children in Taiwan develop their early written language skills on the foundation of spoken language experience and related to two cognitive factors, namely PA and RAN. The present study provides solid psycholinguistic evidence of the reciprocal relationship between cognitive skills and languages, including spoken and written languages, and its outcomes lead to many interesting topics for further study, such as character acquisition at the preschool stage, critical cognitive deficit of developmental dyslexia in Chinese children, and the nature of phonemic PA in Mandarin-speaking children and how it is shaped by orthography experience.

The findings can also help practitioners to identify children at risk for literacy difficulties early, and provides evidence for policy makers to discuss the best teaching methods for developing literacy skills in young Mandarin speaking children.

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# APPENDICES

## Appendix 2:1a[3] Departmental Ethics Approval on 2009

### ETHICS REVIEWER'S COMMENTS FORM

This form is for use when ethically reviewing a research ethics application form.

| | |
|---|---|
| **1. Name of Ethics Reviewer:** | Dr Richard Body<br>Dr Patricia Cowell<br>Dr Stuart Cunningham |
| **2. Research Project Title:** | Literacy development of Mandarin-speaking children |
| **3. Principal Investigator (or Supervisor):** | Lili Yeh |
| **4. Academic Department / School:** | Human Communication Sciences |

**5. I confirm that I do not have a conflict of interest with the project application**

**6. I confirm that, in my judgment, the application should:**

| **Be approved:** | **Be approved with *suggested* amendments in '7' below:** | and/or | **Be approved providing *requirements* specified in '8' below are met:** | **<u>NOT</u> be approved for the reason(s) given in '9' below:** |
|---|---|---|---|---|
| ✓ | | | | |

| |
|---|
| **7. Approved with the following suggested, optional amendments (i.e. it is left to the discretion of the applicant whether or not to accept the amendments and, if accepted, the ethics reviewers do not need to see the amendments):** |
| |
| **8a. Approved providing the following, compulsory requirements are met (the ethics <u>reviewers do not need to see the required changes</u>):** |
| |
| **8b. Approved providing the following, compulsory requirements are met (the ethics <u>reviewers need to see the required changes</u>):** |
| |
| |
| **9. Not approved for the following reason(s):** |
| |
| **10. Date of Ethics Review:** 5 August 2009 |

[3] The number before the colon will always refer to the chapter of the thesis.

# Appendix 2:1b Departmental Ethics Approval on 2010

The University Of Sheffield.

**Department of Human Communication Sciences**
31 Claremont Crescent
Sheffield S10 2TA UK

**Head of Department**
**Professor Joy Stackhouse**, PhD., F.R.C.S.L.T., C.Psychol., A.F.B.Ps.S

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17th September 2010

Dear Lily

Title: A Study of Literacy Development of Mandarin-Speaking Children

Thank you for your submission to the HCS Research Ethics Committee. The committee has reviewed your submission and supporting documents and grants you approval to commence the research.

We hope your project proceeds smoothly

Yours sincerely

Prof R Varley
Chair of HCS Ethics Committee

**Appendix 2:2 Family History Questionnaire**

## Child's family information and development

Notification: All the information in the questionnaire will be used only for academic purpose and will be carefully kept confidential. Please hand it to your child's teacher after you fill it in. Thank you very much.

1. Child's name: ________________________________________.
2. Date of Birth: (year/month/day) __________/__________/__________.
3. Parent's nationality:

   -- Father: □ Taiwan, R.O.C. □ Others (please notify it) ______________.

   -- Mother: □ Taiwan, R.O.C. □ Others (please notify it) ______________.

4. Parent's education:

   -- Father: □ elementary □ secondary school □ college □ university □ above university

   -- Mother: □ elementary □ secondary school □ college □ university □ above university

5. Family's general income per month (1 GBP = 48 NT):
   - □ Below NT 50,000
   - □ NT 50,000—NT 100,000
   - □ NT 100,000—NT 200,000
   - □ Above NT 200,000
6. What languages and their propotion are spoken to your child ? (Tick all that apply and notify its percentage of use, e.g., Min [30%] and Mandarin [70%])
   - □ Min dialogue, percentage:_______________.
   - □ Mandarin, percentage:_______________.
   - □ Hakka, percentage:_______________.
   - □ Others; (please notify what it is and its percentage) _______________ .
7. Have you ever been concerned about your child's speech and/or language development?
   - □ No
   - □ Yes

   If yes, please explain:________________________________________.
8. Has your child received any speech and language therapy?
   - □ No
   - □ Yes; (please notify the reason and how long it took.) ___________

**Appendix 2:3 Picture Naming Task**

## Appendix 2:4 Pseudo-word Memory Span Task

### a. In ZF words

| Level | Item1 |
|---|---|
| 3 syllables | ㄙㄥˊ__ㄅㄜ__ㄏㄛˋ |
| | ㄖㄚ__ㄊㄝˋ__ㄋㄛˇ |
| 4 syllables | ㄎㄨㄛˊ__ㄏㄩˋ__ㄕㄝ__ㄧㄜˇ |
| | ㄎㄧㄚ__ㄇㄜˇ__ㄖㄨㄝ__ㄗㄛˊ |
| 5 syllables | ㄖㄧˊ__ㄗㄩ__ㄅㄩㄚˋ__ㄉㄡˊ__ㄘㄧˋ |
| | ㄏㄧ__ㄈㄨㄚˇ__ㄅㄝ__ㄋㄤˇ__ㄙㄨㄛˊ |
| 6 syllables | ㄎㄧˇ__ㄉㄝ__ㄘㄩˋ__ㄗㄛ__ ㄙㄨㄥˊ__ㄆㄜˋ |
| | ㄌㄝˊ__ㄘㄧㄣ__ ㄅㄜˋ__ㄈㄩ __ㄙㄛˇ__ㄗㄚˋ |
| 7 syllables | ㄆㄩ__ㄏㄛˇ__ㄊㄟˋ__ ㄌㄜˊ__ㄈㄧㄚˋ__ㄘㄡˊ__ㄐㄧㄜ |
| | ㄙㄣˇ__ㄓㄝˊ__ㄎㄛ __ㄈㄠˋ__ㄌㄨㄚ __ㄇㄧㄨ__ㄘㄧˇ |
| 8 syllables | ㄊㄝˇ__ㄘㄛˊ__ㄋㄡ__ㄎㄟˋ__ㄅㄩˇ__ㄍㄧ__ ㄆㄢˇ__ㄌㄥ |
| | ㄆㄡˋ__ㄙㄜˇ__ㄈㄩ__ ㄕㄝˇ__ㄎㄧㄚˋ__ㄋㄨㄛ__ㄘㄨˇ__ㄖㄢ |
| 9 syllables | ㄈㄛˋ__ㄒㄧㄛˊ__ㄔㄝˇ__ㄋㄧㄛˋ__ㄖㄨ__ㄍㄧˊ__ㄆㄨㄚˊ__ㄏㄛˋ__ㄓㄣˊ |
| | ㄎㄩㄚ__ㄊㄜˊ__ㄋㄛˇ__ㄘㄤˋ__ㄙㄝˋ__ㄋㄧㄜˇ__ㄆㄝ__ㄈㄞˊ__ㄊㄧㄣˇ |

### b. In IPA translation

| Level | Item1 |
|---|---|
| 3 syllables | sʌŋ˧˥__ pə __ xo˥˩ |
| | ɻ̻a˥__tʰɛ˥˩__ no˨˩˦ |
| 4 syllables | kʰuo˧˥__ xy˥˩__ʃɛ˥__ iə˨˩˦ |
| | kʰia˥__ mə˨˩˦__ɻ̻uɛ˥__tso˧˥ |
| 5 syllables | ɻ̻a˧˥__tsy˥__pya˥˩__ tou˧˥__tsʰi˥˩ |
| | xi˥__fua˨˩˦__pɛ˥__na˨˩˦__suo˧˥ |
| 6 syllables | kʰi˨˩˦__tɛ˥__tsʰy˥˩__tso˥__soŋ˧˥__pʰə˥˩ |
| | lɛ˧˥__tsʰin˥__pə˥˩__f y˥ __so˨˩˦__tsa˥˩ |
| 7 syllables | pʰy˥__xo˨˩˦__tʰ ei ˥˩__lə˧˥__fia˥˩__tsʰou˧˥__tɕiə˥ |
| | sən˨˩˦__tʃɛ˧˥__kʰo˥ __fau˥˩__lua˥ __miu˥__tsʰi ˨˩˦ |
| 8 syllables | pʰɛ˨˩˦__tsʰo˧˥__nou˥__kʰei ˥˩__py˨˩˦__ki˥__pʰan˨˩˦__lʌŋ˥ |
| | pʰou˥˩__ sə ˨˩˦__fy˥__ ʃɛ˨˩˦__kʰia˥˩__nuo˥__tsʰu˨˩˦__ɹan˥ |
| 9 syllables | fo˥˩__ɕio˧˥__tʃʰɛ˨˩˦__nio˥˩__ɻ̻u˥__ki˧˥__pʰua˧˥__xo˥˩__tʃən˧˥ |
| | kʰya˥__tʰə˧˥__no˨˩˦__tsʰaŋ˥˩__sɛ˥˩__ni ə˨˩˦__pʰɛ˥__fa˧˥__tin˨˩˦ |

## Appendix 2:5a Implicit PA Tasks (Correct responses are highlighted in grey.)

### 2:5a (1). ImPA_Syllable

| No | Target | Option1 | Option2 | Option3 |
|---|---|---|---|---|
| 1 | ɹ̩a˧˥fo˥˩ | kʰɛ˧˥xy˥˩ | sʌŋ˧˥tə˥˩ | tʃɛ˧˥**fo˥˩** |
| 2 | tʃei˥˩fi˧˥ | pʰə˥˩ ʃy˧˥ | no˥˩**fi˧˥** | tsʰy˥˩tʰa˧˥ |
| 3 | kʰia˥tʃʰo˨˩˦ | **kʰia˥**tʰɛ˨˩˦ | tsʰyɛ˥mə˨˩˦ | tuə˥ky˨˩˦ |
| 4 | tʰɛ˧˥mə˥ | ky˧˥fo˥ | **tʰɛ˧˥**xi˥ | ʃo˧˥ɹ̩a˥ |
| 5 | tɛ˥sən˨˩˦ | ɹ̩u˥tʰʌŋ˨˩˦ | tsy˥naŋ˨˩˦ | ni˥**sən˨˩˦** |
| 6 | xo˨˩˦tsi˥ | nɛ˨˩˦**tsi˥** | tʃʰɛ˨˩˦pə˥ | tsʰy˨˩˦fə˥ |
| 7 | no˨˩˦ fə˥˩ | kʰi˨˩˦sɛ˥˩ | **no˨˩˦**tsa˥˩ | tsʰu˨˩˦my˥˩ |
| 8 | tɕya˥ɹ̩ə˥ | **tɕya˥**xi˥ | ɹ̩uɛ˥ʃɛ˥ | mio˥pʰy˥ |
| 9 | ki˧˥tʰɛ˥˩ | tso˧˥pə˥˩ | ɹ̩a˧˥tʃʰo˥˩ | **ki˧˥**tsa˥˩ |
| 10 | tʃʰy˥˩iə˨˩˦ | **tʃʰy˥˩**aɛ˨˩˦ | xo˥˩ao˨˩˦ | fɛ˥˩oɛ˨˩˦ |

Tone 1, 2, 3 and 4 are marked as the following symbols respectively: ˥, ˧˥, ˨˩˦ and ˥˩.

### 2:5a (2). ImPA_Onset

| No. | Target | Option1 | Option2 | Option3 |
|---|---|---|---|---|
| 1 | ɹ̩a˧˥ | lə˧˥ | kʰɛ˧˥ | **ɹ̩i˧˥** |
| 2 | xɛ˨˩˦ | pʰə˨˩˦ | **xo˨˩˦** | tsi˨˩˦ |
| 3 | tʰei˥ | nou˥ | lua˥ | **tʰio˥** |
| 4 | pʰou˥˩ | **pʰyi˥˩** | fia˥˩ | sei˥˩ |
| 5 | no˨˩˦ | pə˨˩˦ | **nɛ˨˩˦** | ka˨˩˦ |
| 6 | kʰei˥˩ | ɕyə˥˩ | **kʰia˥˩** | pou˥˩ |
| 7 | tɕiə˥ | ɹ̩uɛ˥ | nuo˥ | **tɕya˥** |
| 8 | mia˥ | **myə˥** | xuɛ˥ | lua˥ |
| 9 | ɕya˧˥ | tsuə˧˥ | **ɕiɛo˧˥** | kʰui˧˥ |
| 10 | tsɛ˧˥ | to˧˥ | ki˧˥ | **tso˧˥** |
| 11 | fai˧˥ | **fyə˧˥** | tsʰo˧˥ | xiɛ˧˥ |
| 12 | tsʰu˨˩˦ | **tsʰi˨˩˦** | tʰo˨˩˦ | tʃʰɛ˨˩˦ |
| 13 | tʃyə˥ | tei˥ | **tʃoi˥** | tsua˥ |
| 14 | ʃo˧˥ | **ʃɛ˧˥** | fə˧˥ | sa˧˥ |
| 15 | tʃʰy˥˩ | tsa˥˩ | tʰɛ˥˩ | **tʃʰo˥˩** |

**2:5a (3). ImPA_Phoneme**

| No. | Target | Option1 | Option2 | Option3 |
|---|---|---|---|---|
| P1-1 | pya˧˥ | kʰuo˧˥ | tʰə˧˥ | tyɛ˧˥ |
| P1-2 | luɛ˥˩ | ɹ̥ua˥˩ | pə˥˩ | nio˥˩ |
| P1-3 | miu˥ | pʰɛ˥ | tʃʰuo˥ | tsʰiə˥ |
| P1-4 | tsʰyo˨˩˦ | fua˨˩˦ | pʰə˨˩˦ | lyɛ˨˩˦ |
| P1-5 | niə˨˩˦ | tʰo˨˩˦ | fiɛ˨˩˦ | ɹ̥ua˨˩˦ |
| P1-6 | tsuə˧˥ | ɹ̥a˧˥ | pʰua˧˥ | kʰiɛ˧˥ |
| P2-1 | soŋ˧˥ | tʃən˧˥ | kʌŋ˧˥ | tɛ˧˥ |
| P2-2 | tʰin˨˩˦ | sə˨˩˦ | pʰan˨˩˦ | pʌŋ˨˩˦ |
| P2-3 | tsʰaŋ˥˩ | tʰʌŋ˥˩ | ɹ̥ɛn˥˩ | tʃʰy˥˩ |
| P2-4 | ɹ̥an˥ | pɛ˥ | lʌŋ˥ | tsʰin˥ |

**2:5a (4). ImPA_Rime**

| No | Target | Option1 | Option2 | Option3 |
|---|---|---|---|---|
| 1 | ɹ̥a˥ | pɛ˥ | tə˥ | na˥ |
| 2 | pə˥˩ | tə˥˩ | tsʰi˥˩ | pʰy˥˩ |
| 3 | tʰei˥˩ | pou˥˩ | ʃei˥˩ | fau˥˩ |
| 4 | py˨˩˦ | si˨˩˦ | tə˨˩˦ | tsʰy˨˩˦ |
| 5 | nɛ˨˩˦ | tʃʰo˨˩˦ | fə˨˩˦ | tʰɛ˨˩˦ |
| 6 | fi˧˥ | lɛ˧˥ | ɹ̥i˧˥ | tsʰo˧˥ |
| 7 | kʰo˥ | tso˥ | fy˥ | tɛ˥ |
| 8 | tsʰy˥˩ | py˥˩ | lɛ˥˩ | xo˥˩ |
| 9 | tʃʰo˨˩˦ | nɛ˨˩˦ | xi˨˩˦ | so˨˩˦ |
| 10 | kai˧˥ | tou˧˥ | fai˧˥ | suo˧˥ |

### 2:5a (5). ImPA_Tone

| No. | Target | Option 1 | Option 2 | Option 3 |
|---|---|---|---|---|
| 1 | ɹ̠a˧˥ | **tɛ˧˥** | sə˨˩˦ | ki˥ |
| 2 | xɛ˨˩˦ | tsʰə˧˥ | fi˥˧ | **kʰo˨˩˦** |
| 3 | tʰei˥ | **kʰya˥** | muə˧˥ | tsua˥˧ |
| 4 | pou˥˧ | tʃʰua˥ | fiə˨˩˦ | **tyɛ˥˧** |
| 5 | no˨˩˦ | mə˥ | tsɛ˥˧ | **ɹ̠i˨˩˦** |
| 6 | fai˧˥ | **ʃuə˧˥** | noə˥ | lyɛ˨˩˦ |
| 7 | kʰei˥˧ | tsʰiə˥ | **pya˥˧** | pʰua˧˥ |
| 8 | tsə˥ | **tʰɛ˥** | lo˧˥ | pʰy˨˩˦ |
| 9 | ki˨˩˦ | tə˥ | **pʰɛ˨˩˦** | tʃo˥˧ |
| 10 | tʃʰy˥˧ | tsʰu˧˥ | **tə˥˧** | kʰɛ˨˩˦ |

### 2:5b Explicit PA Tasks (Answers are highlighted in grey.)

#### 2:5b (1) ExPA_Syllable

| No | Stimuli 1 | Stimuli 2 |
|---|---|---|
| 1 | ɹ̠a˧˥**fo˥˧** | tʃɛ˧˥**fo˥˧** |
| 2 | tʃei˥˧**fi˧˥** | no˥˧**fi˧˥** |
| 3 | **kʰia˥**tʃʰo˨˩˦ | **kʰia˥**tʰɛ˨˩˦ |
| 4 | **tʰɛ˧˥**mə˥ | **tʰɛ˧˥**xi˥ |
| 5 | tɛ˥**sən˨˩˦** | ni˥**sən˨˩˦** |
| 6 | xo˨˩˦**tsi˥** | nɛ˨˩˦**tsi˥** |
| 7 | **no˨˩˦** fə˥˧ | **no˨˩˦**tsa˥˧ |
| 8 | **tɕya˥**ɹ̠ə˥ | **tɕya˥**xi˥ |
| 9 | **ki˧˥**tʰɛ˥˧ | **ki˧˥**tsa˥˧ |
| 10 | **tʃʰy˥˧**iə˨˩˦ | **tʃʰy˥˧**aɛ˨˩˦ |

### 2:5b (2) ExPA_Onset

| No. | Stimuli 1 | Stimuli 2 |
|---|---|---|
| 1 | ɻa˧˥ | ɻi˧˥ |
| 2 | xɛ˨˩˦ | xo˨˩˦ |
| 3 | tʰei˥ | tʰio˥ |
| 4 | pʰou˥˩ | pʰyi˥˩ |
| 5 | no˨˩˦ | nɛ˨˩˦ |
| 6 | kʰei˥˩ | kʰia˥˩ |
| 7 | tɕiə˥ | tɕya˥ |
| 8 | mia˥ | myə˥ |
| 9 | ɕya˧˥ | ɕiɛo˧˥ |
| 10 | tsɛ˧˥ | tso˧˥ |
| 11 | fai˧˥ | fyə˧˥ |
| 12 | tsʰu˨˩˦ | tsʰi˨˩˦ |
| 13 | tʃyə˥ | tʃoi˥ |
| 14 | ʃo˧˥ | ʃɛ˧˥ |
| 15 | tʃʰy˥˩ | tʃʰo˥˩ |

### 2:5b (3)ExPA_Phoneme

| No. | Stimuli 1 | Stimuli 2 |
|---|---|---|
| P1-1 | pya˧˥ | tyɛ˧˥ |
| P1-2 | luɛ˥˩ | ɻua˥˩ |
| P1-3 | miu˥ | tsʰiə˥ |
| P1-4 | tsʰyo˨˩˦ | lyɛ˨˩˦ |
| P1-5 | niə˨˩˦ | fiɛ˨˩˦ |
| P1-6 | tsuə˧˥ | pʰua˧˥ |
| P2-1 | soŋ˧˥ | kʌŋ˧˥ |
| P2-2 | tʰin˨˩˦ | pʰan˨˩˦ |
| P2-3 | tsʰaŋ˥˩ | tʰʌŋ˥˩ |
| P2-4 | ɻan˥ | tsʰin˥ |

## 2:5b (4) ExPA_Rime

| No | Stimuli 1 | Stimuli 2 |
|---|---|---|
| 1 | ɹ̻a˥ | na˥ |
| 2 | pə˥˩ | tə˥˩ |
| 3 | tʰei˥˩ | ʃei˥˩ |
| 4 | py˨˩˦ | tsʰy˨˩˦ |
| 5 | nɛ˨˩˦ | tʰɛ˨˩˦ |
| 6 | fi˧˥ | ɹ̻i˧˥ |
| 7 | kʰo˥ | tso˥ |
| 8 | tsʰy˥˩ | py˥˩ |
| 9 | tʃʰo˨˩˦ | so˨˩˦ |
| 10 | kai˧˥ | fai˧˥ |

## 2:5b (5) ExPA_Tone

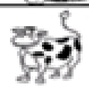
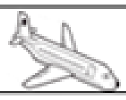
| No. | Stimuli 1 | Stimuli 2 |
|---|---|---|
| 1 | ɹ̻a˧˥ | tɛ˧˥ |
| 2 | xɛ˨˩˦ | kʰ˨˩˦ |
| 3 | tʰei˥ | kʰya˥ |
| 4 | pou˥˩ | tyɛ˥˩ |
| 5 | no˨˩˦ | ɹ̻i˨˩˦ |
| 6 | fai˧˥ | ʃuə˧˥ |
| 7 | kʰei˥˩ | pya˥˩ |
| 8 | tsə˥ | tʰɛ˥ |
| 9 | ki˨˩˦ | pʰɛ˨˩˦ |
| 10 | tʃʰy˥˩ | tə˥˩ |

**Appendix 2:6 Letter Knowledge**

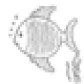
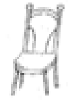
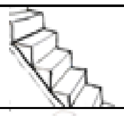
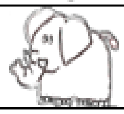
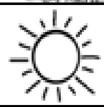
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| ㄅ | ㄧ | ㄑ | ㄓ | ㄗ | ㄌ | ㄞ | ㄝ | ㄇ | ㄍ |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| ㄒ | ㄚ | ㄠ | ㄡ | ㄨ | ㄤ | ㄆ | ㄎ | ㄔ | ㄘ |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| ㄟ | ㄢ | ㄜ | ㄦ | ㄈ | ㄏ | ㄖ | ㄊ | ㄋ | ㄩ |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | | | |
| ㄥ | ㄉ | ㄐ | ㄕ | ㄙ | ㄣ | ㄛ | | | |

**Appendix 2:7 ZF Read Accuracy Task (correct answers are marked by a circle)**

**2:7a Task A**

| No. | Drawing | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. |  | ㄒㄧㄠˇ ㄍㄡˇ ○ | ㄚㄧㄠˇ ㄑㄡˇ | ㄒㄧㄠˇ ㄖㄣˊ |
| 2. |  | ㄧㄢˇ ㄕㄥ | ㄧㄢˇ ㄐㄧㄥ ○ | ㄧㄞˇ ㄐㄧㄙ |
| 3. |  | ㄓㄡㄜ ㄗ˙ | ㄓㄨㄛ ㄗ˙ ○ | ㄅㄧˊ ㄗ˙ |
| 4. |  | ㄍㄨㄛˊ ㄗˋ | ㄍㄨㄜˊ ㄏㄧˊ | ㄍㄨㄛˊ ㄑㄧˊ ○ |
| 5. |  | ㄅㄦˋ ㄙㄧㄡˊ | ㄅㄤˋ ㄓㄣ | ㄅㄤˋ ㄑㄧㄡˊ ○ |
| 6. |  | ㄑㄧˋ ㄔㄜ ○ | ㄒㄧㄚˋ ㄔㄜ | ㄏㄧˋ ㄔㄛ |
| 7. |  | ㄖㄨˇ ㄋㄧㄡˊ ○ | ㄖㄡˇ ㄎㄧㄨˊ | ㄍㄨㄚ ㄋㄧㄡˊ |
| 8. |  | ㄧㄊˋ ㄗ˙ | ㄧㄝˋ ㄗ˙ ○ | ㄅㄧˊ ㄗ˙ |
| 9. |  | ㄚㄧㄐˇ ㄎㄧㄠˇ | ㄋㄧㄠˇ ㄋㄧㄠˇ | ㄒㄧㄠˇ ㄋㄧㄠˇ ○ |
| 10. |  | ㄅㄟˋ ㄐㄧ | ㄈㄟ ㄐㄧ ○ | ㄩㄟ ㄗㄧ |
| 11. |  | ㄩˊ ㄔㄨㄢˊ | ㄈˇ ㄥㄢˇ | ㄩˇ ㄙㄢˇ ○ |
| 12. |  | ㄐㄧㄢˇ ㄉㄠ ○ | ㄐㄧㄢˇ ㄔㄚˊ | ㄩㄧㄢˇ ㄉㄠ |

**2:7a Task B**

| | | | | |
|---|---|---|---|---|
| 1. |  | ㄣㄟ ㄒ˙ | ㄋㄟ ㄕㄤ | ㄋㄟ ㄗ˙ ○ |
| 2. |  | ㄕㄡˇ ㄇㄣˊ | ㄕㄨˇ ㄣㄧㄠˇ | ㄕㄡˇ ㄋㄧㄠˇ |
| 3. |  | ㄐㄧㄣ ㄩˊ ○ | ㄕㄥˋ ㄩˊ | ㄐㄧㄣ ㄇˊ ○ |
| 4. |  | ㄇㄠˊ ㄧ | ㄇㄠ ㄇㄧ ○ | ㄈㄠ ㄈㄧ |
| 5. |  | ㄒㄧㄤ ㄐㄧㄠ ○ | ㄒㄧㄦ ㄗㄧㄠ | ㄒㄧㄤˋ ㄐㄧㄠ |
| 6. |  | ㄧˋ ㄑㄧˇ | ㄧˇ ㄗ˙ ○ | ㄏˇ ㄗ˙ |
| 7. |  | ㄨㄟˇ ㄋㄚ | ㄗㄨㄟˇ ㄋㄚ ○ | ㄗㄨㄏˇ ㄣㄚ |
| 8. |  | ㄌㄡˊ ㄊㄧ ○ | ㄉㄡˊ ㄘㄧ | ㄌㄡˊ ㄊㄞˊ |
| 9. |  | ㄌㄧㄢˋ ㄟㄨㄚˋ | ㄉㄧㄢˋ ㄏㄡˋ | ㄉㄧㄢˋ ㄏㄨㄚˋ ○ |
| 10. |  | ㄉㄒˋ ㄚㄧㄤˋ | ㄉㄚˋ ㄒㄧㄤˋ ○ | ㄉㄚˋ ㄒㄧㄚˊ |
| 11. |  | ㄘㄞˋ ㄧㄦˊ | ㄉㄚˋ ㄧㄤˊ | ㄊㄞˋ ㄧㄤˊ ○ |
| 12. |  | ㄕㄨ ㄗ˙ ○ | ㄕㄨˋ ㄓ | ㄏㄨ ㄗ˙ |

**Appendix 2:8 CH Read Accuracy Task (correct answers marked by a circle)**

**2:8a Task A**

| No. | Drawing | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. |  | 棉被 ○ | 棉被 | 棉花 |
| 2. |  | 小熊 | 小熊 ○ | 小貓 |
| 3. |  | 下雨 | 雨傘 | 下雨 ○ |
| 4. |  | 風車 | 風箏 | 風箏 ○ |
| 5. |  | 衣服 | 衣架 | 衣服 ○ |
| 6. |  | 花朵 ○ | 花光 | 花朵 |
| 7. |  | 鉛筆 ○ | 鉛筆 | 毛筆 |
| 8. |  | 園丁 | 公園 ○ | 公園 |
| 9. |  | 開門 | 開門 ○ | 門檻 |
| 10. |  | 小魚 ○ | 魚池 | 小魚 |
| 11. |  | 門牙 | 刷牙 ○ | 刷牙 |
| 12. |  | 飯桌 | 吃飯 | 吃飯 ○ |

## 2:8b Task B

| No. | Drawing | 1 | 2 | 3 |
|---|---|---|---|---|
| 1 |  | [illegible]手 | 手掌 | 握手 ○ |
| 2 |  | 青蛙 ○ | 青菜 | 青[illegible] |
| 3 |  | 書本 | 書包 ○ | 書[illegible] |
| 4 |  | [illegible]步 | 跑步 ○ | 散步 |
| 5 |  | 兔毛 | 兔子 ○ | 免了 |
| 6 |  | 除草 | [illegible]地 | 草地 ○ |
| 7 |  | 抄菜 | 洗菜 | 炒菜 ○ |
| 8 |  | 房子 ○ | 房予 | 房間 |
| 9 |  | 卡片 ○ | 相片 | [illegible]片 |
| 10 |  | 林口 | 森林 | 森林 ○ |
| 11 |  | 唱歌 ○ | [illegible]歌 | 寫歌 |
| 12 |  | 百雲 | 白雲 ○ | 白天 |

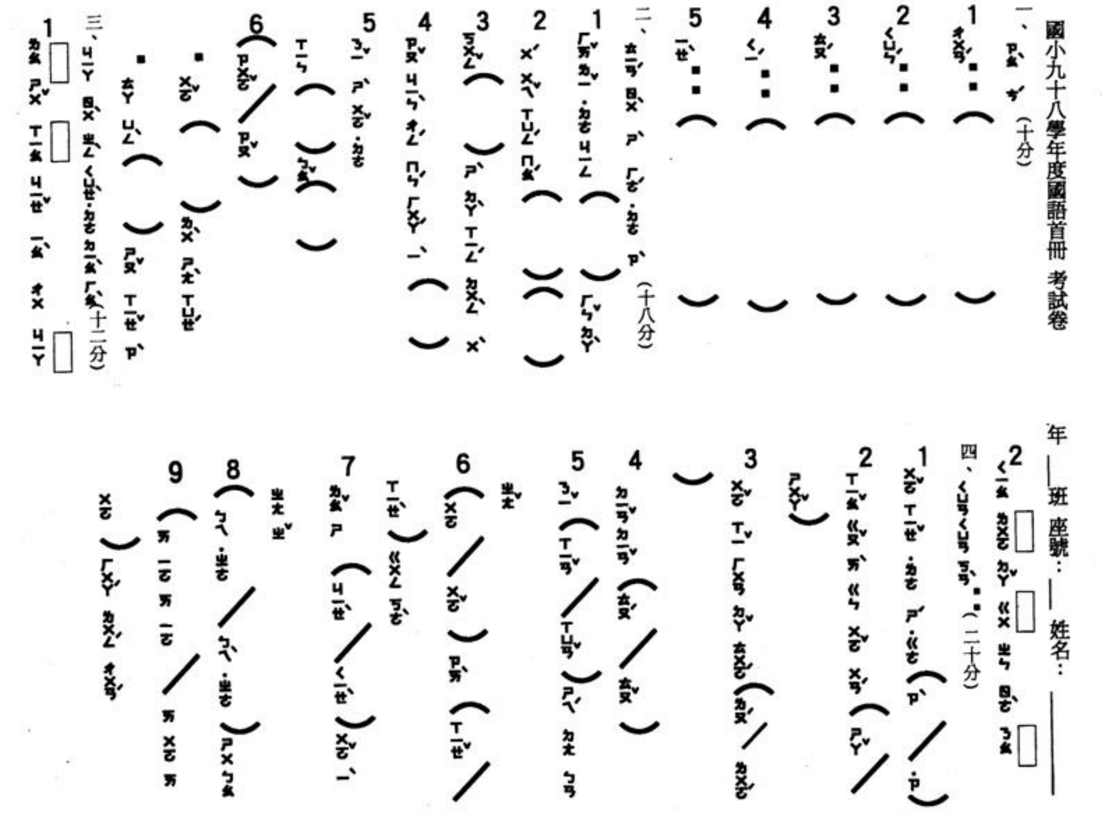
**Appendix 2:9 ZF Spelling Task**

| No | ZYFH | IPA |
|---|---|---|
| 1 | ㄐㄩㄢ | tɕyɛn˥ |
| 2 | ㄒㄩㄥˊ | ɕyoŋ˧˥ |
| 3 | ㄑㄧㄥˊ | tɕʰiŋ˧˥ |
| 4 | ㄉㄧㄢˋ | tiɛn˥˩ |
| 5 | ㄌㄧㄤˋ | liaŋ˥˩ |
| 6 | ㄍㄨㄞ | kuai˥ |
| 7 | ㄎㄨㄥˇ | kʰoŋ˨˩˦ |
| 8 | ㄓㄨㄛ | tʃuo˥ |
| 9 | ㄊㄧㄠˋ | tʰiao˥˩ |
| 10 | ㄗㄨㄟˇ | tsuei˨˩˦ |

| No | ZYFH | IPA |
|---|---|---|
| 11 | ㄋㄩㄢ | nyɛn˥ |
| 12 | ㄙㄩㄥˊ | syoŋ˧˥ |
| 13 | ㄈㄧㄥˊ | fiŋ ˧˥ |
| 14 | ㄍㄧㄢˋ | kiɛn˥˩ |
| 15 | ㄆㄧㄤˋ | pʰiaŋ˥˩ |
| 16 | ㄅㄨㄞ | puai˥ |
| 17 | ㄕㄨㄥˇ | ʃoŋ˨˩˦ |
| 18 | ㄖㄨㄛ | ɹ̥uo˥ |
| 19 | ㄎㄧㄠˋ | kʰiao˥˩ |
| 20 | ㄉㄨㄟˇ | tuei˨˩˦ |

**Appendix 2:10 School-wide Literacy Exam Sheet**

**2:9a Year 1 (2 pages)**


國小九十八學年度國語首冊 考試卷

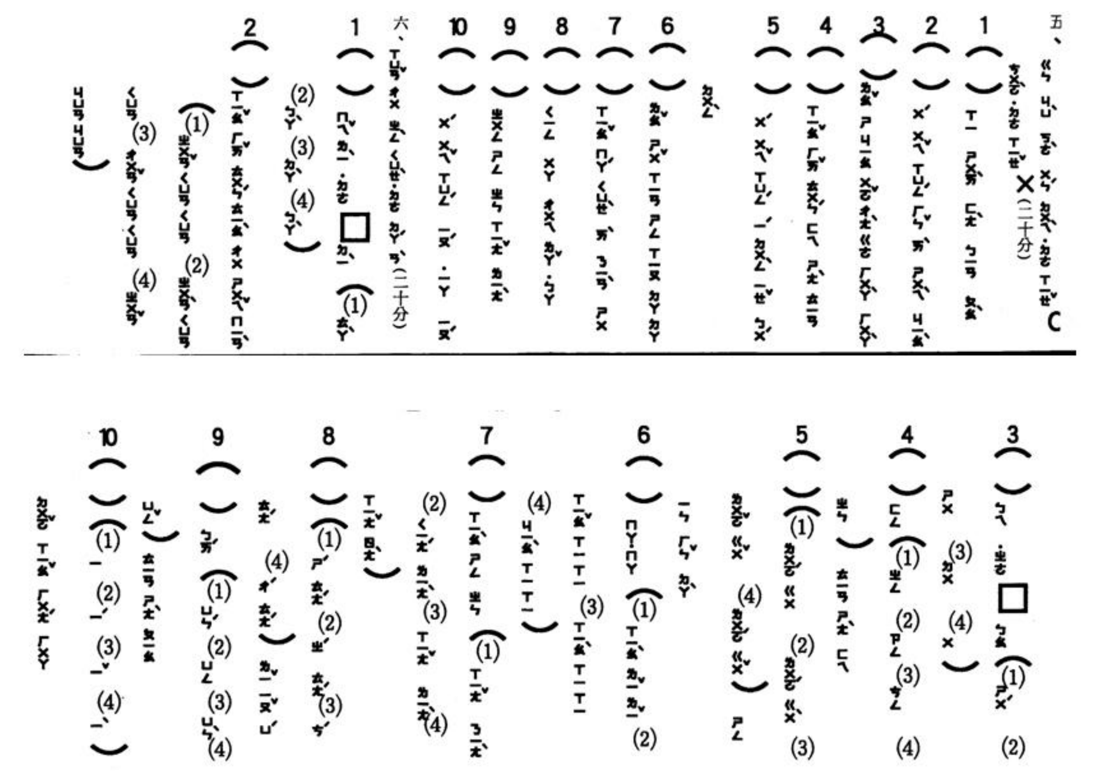
一、(十分)

二、(十八分)

三、(十二分)

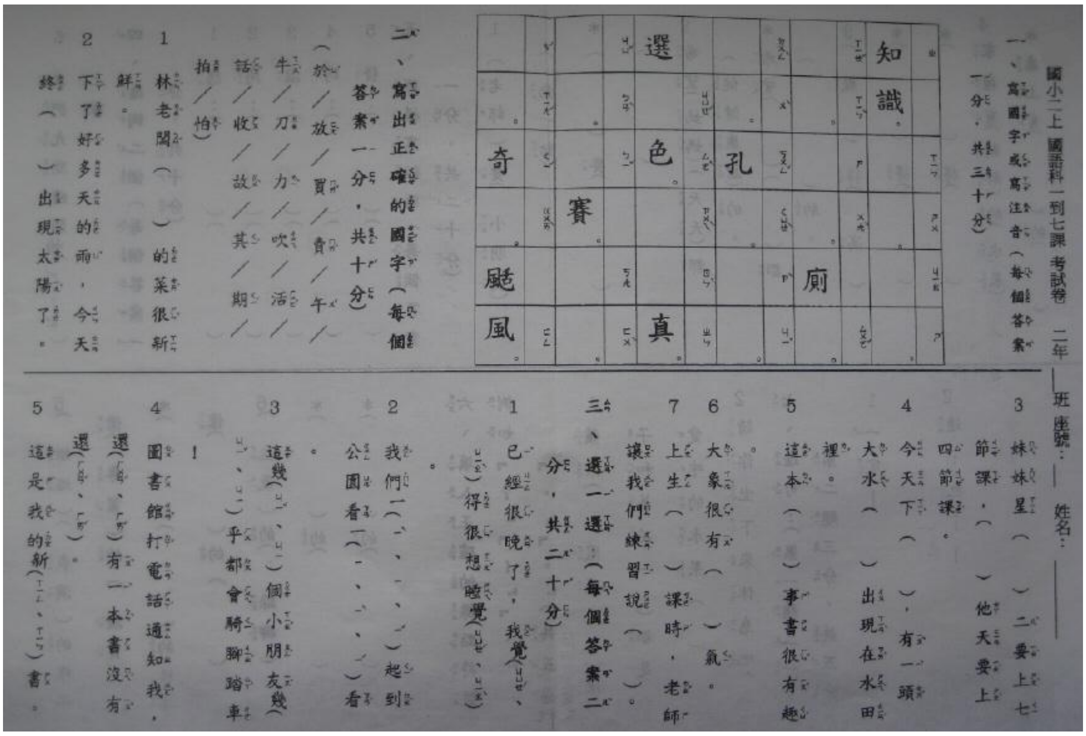
年 班 座號： 姓名：

四、(二十分)


五、(二十分)

六、(二十分)

## 2:10b Year 2 (2 pages)

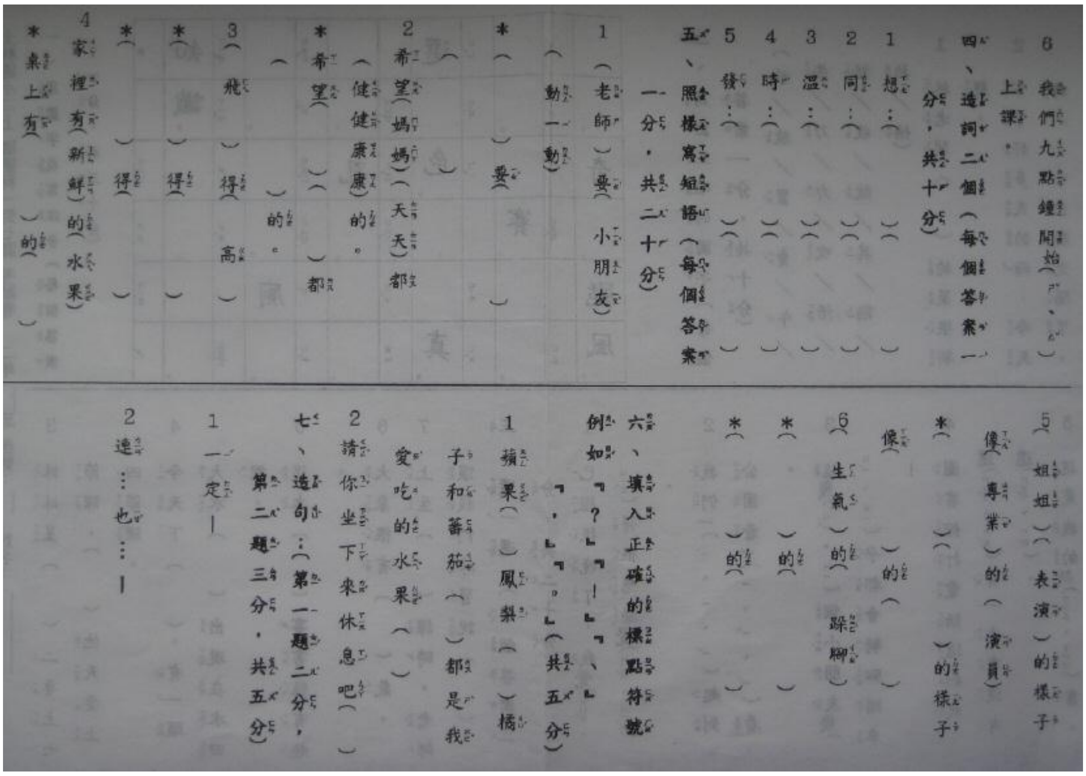


國小二上 國語科一到七課 考試卷 二年 班 座號： 姓名：

一、寫國字或寫注音（每個答案一分，共三十分）

二、寫出正確的國字（每個答案一分，共十分）

三、選一選（每個答案二分，共二十分）



四、造詞二個（每個答案一分，共十分）

五、照樣寫短語（每個答案二分，共二十分）

六、填入正確的標點符號（共五分）

七、造句：第一題二分，第二題三分，共五分

## Appendix 2:11 ZF Plus CH Reading Comprehension (2 pages)

【　】一、小明每次都不寫作業，老師對他說：「你真是讓我頭痛！」意思是
(1)老師感冒了，頭很痛　(2)小明不寫作業，老師不知道怎麼辦
(3)小明因為頭痛才不寫作業　(4)老師碰到小明，頭就會痛

【　】二、我忘了帶橡皮擦，旁邊的同學剛好有兩塊，我可以跟他
(1)搶 (2)賣 (3)借 (4)要

【　】三、太陽出來了，天亮了。太陽下山了，天「　」了。空格裡面應該填什麼？
(1)熱 (2)冷 (3)暗 (4)白

【　】四、上課了，他還一直在玩玩具。句子中「一直」的意思是？
(1)直直的 (2)一條直線 (3)很直 (4)不停

【　】五、小朋友們和愛心媽媽們，合力抬著大蛋糕，看到老師走進教室，就大聲的說：「祝您生日快樂！」句子中的「您」是指誰？(1)小朋友 (2)愛心媽媽 (3)大蛋糕 (4)老師

【　】六、可愛的小精靈有一雙神奇的眼睛，不管多麼平凡的東西，看起來都會很美麗。他是個小魔術師，喜歡揮舞著魔棒，玩色彩和形狀的把戲。句子中的「他」是指誰？
(1)眼睛 (2)平凡的東西 (3)魔棒 (4)可愛的小精靈

【　】七、星期六晚上，一家人在一起閒話家常，三個小孩子興奮地說：「明天又是休息的日子！」請問句子中的「明天」是指哪一天？
(1)星期六 (2)星期日 (3)星期一 (4)星期五

【　】八、晚上，大家都累壞了，很快地就進入甜美的夢鄉。大家怎麼了？
(1)生病了 (2)走進家鄉 (3)睡著了 (4)做了惡夢

【　】九、「我和媽媽去買衣服，弟弟也跟來了。」這句話和下面哪一句話意思是一樣的？
(1)我和媽媽兩個人去買衣服　(2)媽媽和弟弟一起去買衣服
(3)我、媽媽和弟弟一起去買衣服　(4)哥哥陪我和媽媽去買衣服。

【　】十、春天校園裡開滿了花，有紅花、有白花、有黃花，還有紫色的花。全部有幾種顏色的花呢？(1)一種 (2)二種 (3)三種 (4)四種

【　】十一、妹妹在吃牛奶糖，哥哥說：「巧克力和棉花糖都比這個好吃，特別是巧克力，我最愛了！」請問哥哥最喜歡吃哪一種糖果？
(1)牛奶糖 (2)巧克力 (3)棉花糖 (4)哥哥不喜歡吃糖

貳、閱讀測驗

甲、窗子開開，暖暖的太陽照進來。早安！藍藍的小碟子。早安！白色的衛生紙。早安！黑色的小種子。還有什麼顏色都沒有，透明的自來水。嗯！早安！早安！

【　】十二、自來水是什麼顏色？(1)藍色 (2)白色 (3)黑色 (4)無色透明的

乙、「噹噹噹！」下課鈴響了，小朋友都跑出來玩。突然，華華從教室裡衝出來，撞到走廊上的明明，兩個人都跌倒了，華華掉了一顆牙齒，另一個卻流鼻血了，老師看到了，叫兩個人趕快去健康中心找護士阿姨。

【　】十三、這件事發生在什麼時候？
(1)上課時間 (2)下課時間 (3)放學的時候 (4)午休睡覺的時候

【　】十四、「華華掉了一顆牙齒，另一個卻流鼻血」。請問「另一個」指的是誰？
(1)華華 (2)明明 (3)老師 (4)護士阿姨

丙、和別人在一起並沒有那麼可怕嘛！修修好開心，她發現自己不再害羞，不再容易臉紅了。真是開心的一天，修修下定決心，以後再也不把自己關在房間裡了。

【　】十五、修修原本是一個怎樣的人？(1)交很多朋友的人 (2)天天開心的人
(3)常常出去玩 (4)很膽小又很害羞的人

丁、「完了！完了！」力氣嚇得緊閉雙眼，不停的叫、、、突然間，力氣從睡夢中驚醒過來，冒了一身冷汗。

【　】十六、文中的「力氣」怎麼了？
(1)做了一個美夢 (2)做了一個惡夢 (3)被壞人捉到 (4)跑得很累

戊、爸爸摟著她的肩，媽媽握著她的手，不斷輕輕的告訴她：「不要緊張，不要害怕。」修修覺得自己的心，慢慢的、慢慢的、平靜了下來。

【　】十七、修修的心，為什麼可以平靜下來？
(1)爸爸摟著修修睡覺
(2)媽媽握著修修的手走開
(3)媽媽、爸爸的愛心和鼓勵給了修修勇氣
(4)修修的心本來就平靜的

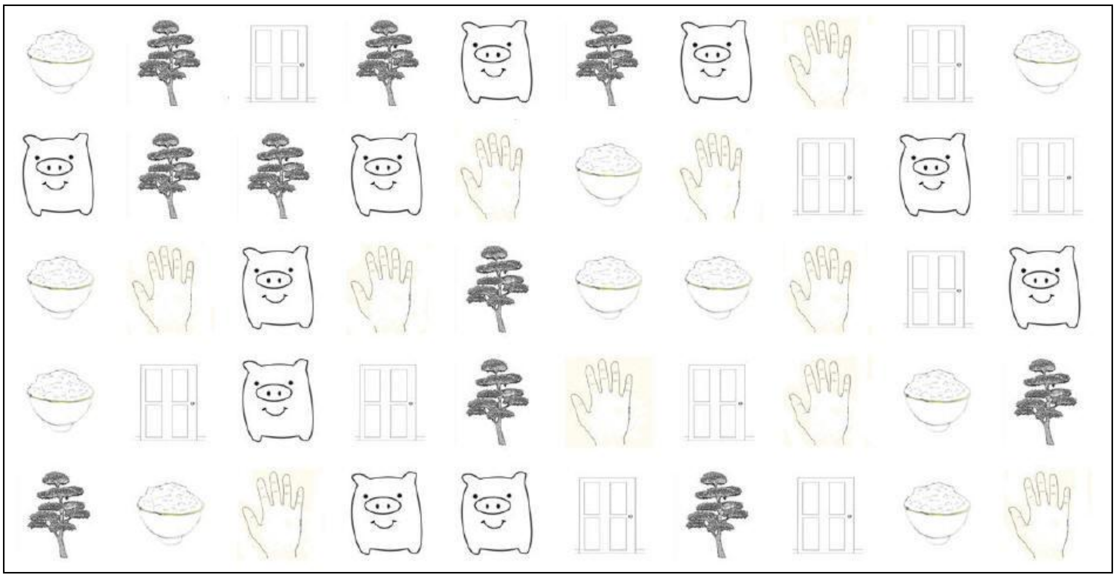
**Appendix 2:12 Rapid Automatized Naming**

**2:12a Digit**

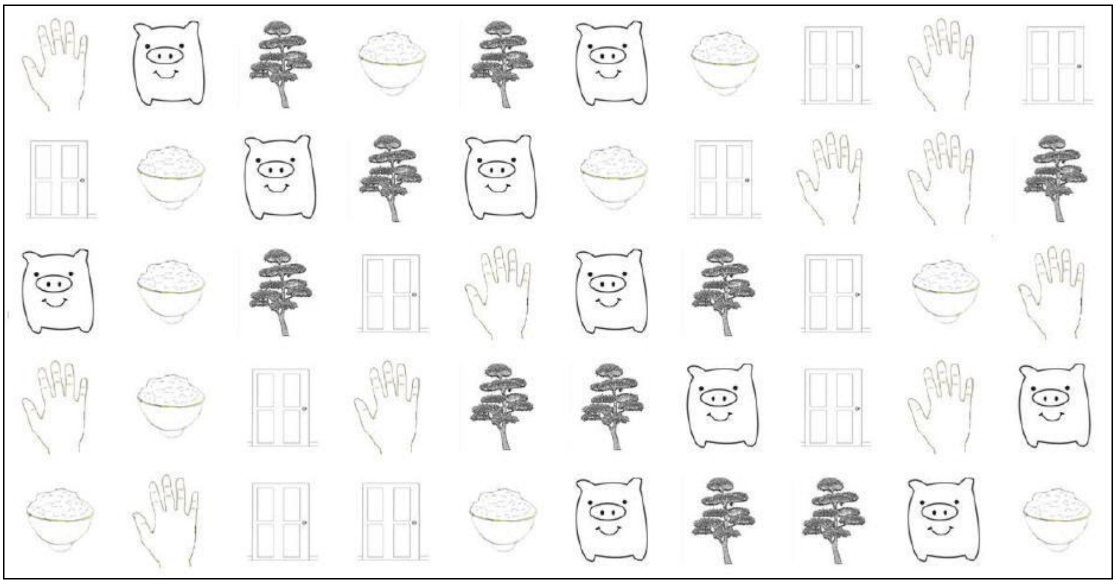
| A. | B. |
|---|---|
| 23929 | 58869 |
| 54635 | 29852 |
| 55852 | 24651 |
| 91549 | 54919 |
| 12856 | 36849 |
| 85811 | 49354 |
| 45932 | 26892 |
| 48431 | 12463 |
| 83659 | 81845 |
| 28896 | 29496 |

## 2:12b Object

**A.**



**B.**



**2:12c ZF**

**A.**

ㄅㄨㄧㄚㄇㄅㄧㄨㄇㄚ

ㄇㄚㄅㄧㄨㄚㄇㄅㄨㄧ

ㄧㄇㄨㄅㄚㄨㄚㄧㄅㄇ

ㄨㄧㄚㄇㄅㄧㄨㄇㄚㄅ

ㄚㄅㄇㄨㄧㄇㄅㄚㄧㄨ

**B.**

ㄧㄅㄚㄨㄇㄇㄚㄧㄨㄅ

ㄇㄨㄧㄚㄅㄅㄨㄇㄧㄚ

ㄚㄇㄅㄧㄨㄧㄅㄚㄇㄨ

ㄅㄚㄨㄇㄧㄚㄧㄨㄅㄇ

ㄨㄧㄇㄅㄚㄨㄇㄅㄚㄧ

**2:12d CH**

**A.**

小去了天乙去乙天小了

乙天小了去了小去天乙

了乙去小天天了乙去小

去了天乙小乙天小了去

天小乙去了小去了乙天

**B.**

小了乙天去天乙去了小

去天小乙了小了天去乙

乙去了小天去小乙天了

了乙天去小乙去了小天

天小去了乙了天小乙去

**Appendix 2:13 Quantitative Coding Systems of Explicit Phonological Awareness Tasks**

**2:13a Table of how to give scores**

| | 2 points | 1 point | 0 |
|---|---|---|---|
| Syllable | -Correct syllable with right tone<br>- Distorted answer due to intelligibility problem | -Segment of correct syllable<br>- Two features different from the target sound at maximum<br>- Taiwanese effect<br>- The most similar true word | Others |
| Phoneme_2 | -Correct voiced consonant<br>-VC structure (letter name) with correct consonant<br>- CV structure with correct consonant and as a letter name | - CV structure with correct consonant but not a letter name<br>- One feature different from the correct letter name | Others |
| Onset | -Correct letter name(ZYFH or English) with or without the tone<br>- Correct voiceless consonant<br>- Distorted answer due to intelligibility problem | - One feature different from the target sound at maximum<br>- Taiwanese effect<br>- The most similar true word | Others |
| Rime | Correct vowel with or without the tone | - Segment of correct vowel<br>- Correct vowel with extra nasal consonant<br>- One features different from the target sound at maximum<br>- Taiwanese effect<br>- The most similar true word | Others |
| Tone | Correct tone number | - Confusion between $2^{nd}$ tone and $3^{rd}$ tone | Others |

**2:13b Examples of 1 point Answer in the Explicit Phonological Awareness Tasks**

(1) Syllable

| Item | Answer | Spectrum of answer |
|---|---|---|
| 1 | [fɔ] | [xɔ],[fə],[fu] |
| 2 | [fi] | [xui], [xi] |
| 3 | [k'ia] | [k'ua]1, [k'a] ,[tɕia], [tɕ'ia] |
| 4 | [t'ɛ] | [t'i], [t'ei], [tɛ]1, [p'ɛ], [p'ei] |
| 5 | [sən] | [sʌŋ], [sin]3, [sɔŋ] |
| 6 | [tsi] | [tsɘ], [ts'i]1, [ti]1, [tɕi] |
| 7 | [nɔ] | [nu], [nə] |
| 8 | [tɕya] | [tsua]1, [tʂua] |
| 9 | [ki] | [t'i], [k'i] |
| 10 | [tʂ'y] | [ts'y] |

(2)Onset

| Item | Answer | Spectrum of answer |
|---|---|---|
| 1 | [ʐɘ] | [lə] |
| 3 | [t'ə] | [p'ə], [ts'ɘ] |
| 4 | [p'ə] | [pə], [t'ə] |
| 5 | [nə] | [mə] |
| 7 | [tɕi] | [tsɘ], [tʂɘ], [tɕ'i] |
| 8 | [mə] | [nə] |
| 9 | [ɕi] | [ʂɘ], [sɘ], [tɕi] |
| 10 | [tsɘ] | [ts'ɘ], [tʂɘ] |
| 11 | [fə] | [pə] |
| 12 | [ts'ɘ] | [tsɘ], [t'ə], [tɕ'i] |
| 13 | [tʂɘ] | [tsɘ] ,[ʂɘ] ,[tɕi], [tʂ'ɘ] |
| 14 | [ʂɘ] | [sɘ], [ʐɘ] |
| 15 | [tʂ'ɘ] | [ts'ɘ], [tɕ'i] |

(3)Rime

| Item | Answer | Spectrum of answer |
|---|---|---|
| | [ə] | [ɔ] |
| 3 | [ei] | [ai], [ɛ], [iɛ] |
| 4 | [y] | [i], [ə], |
| 5 | [ɛ] | [ei], [i] |
| 6 | [i] | [ə], [ɛ], [y] |
| 7 | [ɔ] | [ou], [ə] |
| 8 | [y] | [i], [ə] , [ɛ] |
| 9 | [ɔ] | [ou], [u] |
| 10 | [ai] | [ei] |

(4)Phoneme

| Item | Answer | Spectrum of answer |
|---|---|---|
| 8 | [n] | [m] |
| 10 | [n] | [m] |

## Appendix 6:1 Performance of the speech difficulty and typical developing groups on all measures (Significant differences are highlighted in grey)

| | Speech difficulty (N=7) | | Typical group (N=85) | | Cohen's D | U | p value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Age | 6.52 | 0.35 | 6.6 | 0.28 | -0.28 | | |
| Non verbal intelligence | 93 | 7.18 | 103.04 | 11.04 | -0.93 | 113 | 0.02 |
| **Literacy (Max)** | | | | | | | |
| ZF_LK_Y1 (37) | 30.57 | 3.6 | 34.46 | 2.91 | -1.32 | 101.5 | 0 |
| CH_Y1 (T score) | 40 | 6.73 | 52.83 | 18 | -0.74 | 133 | 0.02 |
| School exam_Y1 (100) | 82.14 | 7.2 | 93.75 | 5.8 | -1.98 | 64.5 | 0 |
| Spelling_Y1 (20) | 7 | 3.83 | 9.87 | 3.48 | -0.82 | 159 | 0.04 |
| RA_ZF_Y1_pr (24) | 7.17 | 2.64 | 9.1 | 3.3 | -0.59 | 157.5 | 0.14 |
| RA_ZF_Y1_po (24) | 9.14 | 3.39 | 12.22 | 3.31 | -0.93 | 150 | 0.03 |
| CH_Y2 (T score) | 44.86 | 5.34 | 56.32 | 13.89 | -0.85 | 132 | 0.02 |
| School exam_Y2 (100) | 90 | 5.2 | 95.39 | 5.15 | -1.05 | 103 | 0 |
| Read_compr_Y2 (T score) | 52.43 | 9.78 | 61.15 | 5.24 | -1.55 | 86.5 | 0 |
| RA_ZF_Y2 (24) | 13.43 | 3.87 | 12.66 | 3.22 | 0.24 | 297.5 | 1 |
| RA_CH_Y2 (24) | 13.86 | 3.08 | 13.48 | 2.94 | 0.13 | 264 | 0.65 |
| Place_RT_Y2(sec) | 59.43 | 18.79 | 64.64 | 17.58 | -0.3 | 220 | 0.25 |
| Place _accuracy_Y2(20) | 16 | 2.38 | 16.21 | 2.44 | -0.09 | 263.5 | 0.61 |
| Form_RT_Y2(sec) | 45.57 | 9.95 | 53.76 | 1.8 | -0.77 | 239 | 0.39 |
| Form _accuracy_Y2(20) | 17.86 | 3.13 | 18.42 | 2.35 | -0.23 | 275 | 0.74 |
| **Phonological awareness (Max)** | | | | | | | |
| IPA_S_Y1 (10) | 8.29 | 1.38 | 8.27 | 1.59 | 0.01 | 273 | 0.83 |
| IPA_P_Y1 (10) | 4.14 | 2.04 | 4.52 | 1.69 | -0.22 | 237.5 | 0.44 |
| IPA_O_Y1 (15) | 7.43 | 1.62 | 8.83 | 3.18 | -0.45 | 163.5 | 0.06 |
| IPA_R_Y1 (10) | 5.71 | 1.6 | 6.45 | 2.27 | -0.33 | 205.5 | 0.21 |
| IPA_T_Y1 (10) | 4 | 2.24 | 4.61 | 2.62 | -0.24 | 238.5 | 0.46 |
| EPA_S_Y1 (20) | 13.43 | 4.65 | 15.85 | 2.84 | -0.81 | 180.5 | 0.09 |
| EPA_P_Y1 (20) | 2.33 | 1.97 | 5.9 | 4.2 | -0.87 | 119.5 | 0.03 |
| EPA_O_Y1 (30) | 5.43 | 7.07 | 14.74 | 9.85 | -0.97 | 126 | 0.01 |
| EPA_R_Y1 (20) | 8.86 | 5.55 | 11.6 | 6.31 | -0.44 | 200.5 | 0.16 |
| EPA_T_Y1 (20) | 8.57 | 6.21 | 11.54 | 5.79 | -0.51 | 174 | 0.07 |
| IPA_S_Y2 (10) | 9.57 | 0.79 | 9.06 | 1.24 | 0.42 | 228.5 | 0.27 |
| IPA_P_Y2 (10) | 3.86 | 1.46 | 4.81 | 1.66 | -0.58 | 194.5 | 0.12 |
| IPA_O_Y2 (15) | 9.29 | 2.14 | 11.64 | 2.63 | -0.91 | 142.5 | 0.02 |
| IPA_R_Y2 (10) | 5.86 | 2.27 | 7.74 | 1.6 | -1.14 | 152 | 0.03 |
| IPA_T_Y2 (10) | 6.86 | 1.35 | 7.4 | 1.81 | -0.3 | 220.5 | 0.25 |
| EPA_S_Y2 (20) | 17.86 | 0.9 | 17.84 | 1.5 | 0.01 | 269 | 0.66 |
| EPA_P_Y2 (20) | 8 | 4.32 | 9.28 | 4.52 | -0.29 | 260 | 0.58 |
| EPA_O_Y2 (30) | 15.43 | 7.35 | 2.04 | 6.98 | -0.66 | 184 | 0.09 |
| EPA_R_Y2 (20) | 10.57 | 5.35 | 15.68 | 5.22 | -0.98 | 147 | 0.03 |
| EPA_T_Y2 (20) | 17.29 | 1.6 | 17.11 | 2.57 | 0.07 | 271.5 | 0.7 |
| **Rapid Automatised Naming (Sec)** | | | | | | | |
| RAN_Digit_Y1 | 44.29 | 19.29 | 36.84 | 11.41 | 0.62 | 233 | 0.39 |
| RAN_Obj_Y1 | 70.07 | 21.93 | 59.07 | 16.64 | 0.65 | 202.5 | 0.18 |
| RAN_Digit_Y2 | 36.57 | 15.64 | 30.89 | 8.43 | 0.63 | 239 | 0.41 |
| RAN_Obj_Y2 | 61.07 | 17.3 | 52.4 | 11.75 | 0.71 | 206.5 | 0.19 |
| RAN_ZF_Y2 | 48.57 | 16.54 | 39.14 | 8.2 | 1.05 | 196.5 | 0.16 |
| RAN_CH_Y2 | 37.5 | 1.29 | 33.97 | 7.14 | 0.48 | 207.5 | 0.2 |
| **Spoken Language skills (Max)** | | | | | | | |
| Semantic_fluency | 12 | 2.94 | 13.26 | 4.58 | -0.28 | 236.5 | 0.47 |
| Mem_span | 9.71 | 4.54 | 11.46 | 4.48 | -0.39 | 246 | 0.43 |
| Auditory_memory | 7.33 | 1.63 | 9.98 | 2.57 | -1.05 | 94.5 | 0.01 |
| vocabulary | 109 | 7.14 | 112.58 | 7.54 | -0.48 | 212.5 | 0.24 |

**Appendix 6:2 Performance of the poor and average ZF reading groups on all measures (Significant differences are highlighted in grey)**

| R_ZF_10_G | Poor group (N=16) | | Average group (N=25) | | Cohen's D | U | p Value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Age | 6.65 | 0.27 | 6.53 | 0.29 | -0.4 | 153.5 | 0.21 |
| Non-verbal intelligence | 96.31 | 9.68 | 104.04 | 12.07 | 0.7 | 126 | 0.07 |
| **Literacy (Max)** | | | | | | | |
| ZF_LK_Y1 (37) | 32.13 | 3.9 | 34.92 | 1.93 | 0.99 | 103.5 | 0.01 |
| CH_Y1 (T score) | 44.73 | 25.48 | 49.5 | 14.46 | 0.25 | 141.5 | 0.47 |
| School exam_Y1 (100) | 88.44 | 8.36 | 93.16 | 5.16 | 0.73 | 110 | 0.02 |
| Spelling_Y1 (20) | 7.88 | 3.24 | 10.36 | 4.43 | 0.63 | 109.5 | 0.02 |
| RA_ZF_Y1_pr (24) | 6.67 | 2.92 | 9.28 | 3.18 | 0.86 | 108.5 | 0.03 |
| RA_ZF_Y1_po (24) | 9.63 | 2.22 | 12.16 | 3.22 | 0.89 | 107 | 0.01 |
| CH_Y2 (T score) | 50.38 | 14.64 | 54.2 | 13.32 | 1.04 | 164.5 | 0.34 |
| School exam_Y2 (100) | 94.56 | 4.16 | 94.84 | 4.4 | 0.07 | 186 | 0.71 |
| Read_compr_Y2 (T score) | 59.13 | 7.88 | 61.04 | 4.25 | 0.33 | 187.5 | 0.73 |
| RA_CH_Y2 (24) | 10.69 | 2.82 | 13.2 | 2.16 | 0.28 | 97.5 | 0.01 |
| Place_RT_Y2(sec) | 67.06 | 24.79 | 67.96 | 18.15 | 0.04 | 178 | 0.56 |
| Place _accuracy_Y2(20) | 16.25 | 1.61 | 15.84 | 3.02 | -0.16 | 193.5 | 0.86 |
| Form_RT_Y2(sec) | 58.75 | 12.21 | 55.48 | 12 | -0.27 | 167 | 0.38 |
| Form _accuracy_Y2(20) | 18.75 | 1.34 | 18.12 | 2.64 | -0.29 | 193.5 | 0.86 |
| **Phonological awareness (Max)** | | | | | | | |
| IPA_S_Y1 (10) | 8.31 | 1.66 | 8.56 | 1.39 | 0.17 | 189 | 0.76 |
| IPA_P_Y1 (10) | 5 | 1.26 | 4 | 1.55 | -0.7 | 113.5 | 0.02 |
| IPA_O_Y1 (15) | 9.06 | 2.02 | 8.61 | 3.33 | -0.16 | 181 | 0.93 |
| IPA_R_Y1 (10) | 5.63 | 2.31 | 6.88 | 1.86 | 0.62 | 129.5 | 0.05 |
| IPA_T_Y1 (10) | 3.19 | 2.34 | 5.32 | 2.39 | 0.91 | 104 | 0.01 |
| EPA_S_Y1 (20) | 14.63 | 4.54 | 16.44 | 2.08 | 0.56 | 151 | 0.18 |
| EPA_P_Y1 (20) | 4.75 | 3.99 | 5.28 | 3.26 | 0.15 | 180 | 0.59 |
| EPA_O_Y1 (30) | 10.38 | 9.18 | 14.96 | 10.93 | 0.45 | 155.5 | 0.23 |
| EPA_R_Y1 (20) | 7.75 | 6.86 | 12.64 | 6.24 | 0.76 | 117 | 0.03 |
| EPA_T_Y1 (20) | 6.56 | 6.42 | 13.8 | 3.73 | 1.48 | 69.5 | 0 |
| IPA_S_Y2 (10) | 9.31 | 1.08 | 9.12 | 1.42 | -0.15 | 192 | 0.81 |
| IPA_P_Y2 (10) | 4.13 | 1.93 | 4.92 | 1.41 | 0.49 | 152 | 0.19 |
| IPA_O_Y2 (15) | 10.69 | 2.65 | 11.68 | 2.17 | 0.42 | 147.5 | 0.16 |
| IPA_R_Y2 (10) | 6.75 | 1.39 | 8.12 | 1.64 | 0.9 | 106.5 | 0.01 |
| IPA_T_Y2 (10) | 6.75 | 1.77 | 7.36 | 1.98 | 0.33 | 156 | 0.23 |
| EPA_S_Y2 (20) | 18.06 | 1.06 | 17.8 | 1.38 | -0.21 | 178.5 | 0.55 |
| EPA_P_Y2 (20) | 7.75 | 4.06 | 9.32 | 4.03 | 0.39 | 145 | 0.14 |
| EPA_O_Y2 (30) | 16.81 | 8.39 | 19.88 | 7.85 | 0.39 | 150 | 0.18 |
| EPA_R_Y2 (20) | 11.25 | 6.22 | 16.4 | 4.59 | 0.99 | 98 | 0.01 |
| EPA_T_Y2 (20) | 15.69 | 3.55 | 17.84 | 1.46 | 0.88 | 134 | 0.07 |
| **Rapid Automatised Naming (Sec)** | | | | | | | |
| RAN_Digit_Y1 | 42.03 | 12.63 | 36.92 | 11.58 | -0.43 | 128 | 0.1 |
| RAN_Obj_Y1 | 61.81 | 20.61 | 60.22 | 17.87 | -0.09 | 198 | 0.96 |
| RAN_Digit_Y2 | 34 | 7.73 | 33.86 | 10.67 | -0.01 | 181.5 | 0.87 |
| RAN_Obj_Y2 | 57.1 | 12.02 | 55.18 | 13.35 | -0.15 | 163.5 | 0.5 |
| RAN_ZF_Y2 | 42.8 | 6.3 | 41.52 | 10.48 | -0.14 | 154 | 0.35 |
| RAN_CH_Y2 | 38 | 5.82 | 34.98 | 8.6 | -0.4 | 128.5 | 0.1 |
| **Spoken Language skills (Max)** | | | | | | | |
| Semantic fluency_Y1 | 11.56 | 3.69 | 14.13 | 3.63 | 0.71 | 125.5 | 0.07 |
| Vocabulary_Y1(T-score) | 110.53 | 8.78 | 114.76 | 6.22 | 0.59 | 138.5 | 0.17 |
| Auditory_memory_Y1(17) | 8.56 | 2.5 | 9.8 | 2.86 | 0.46 | 156 | 0.23 |
| Picture Naming_Y1 (30) | 28.5 | 1.32 | 27.36 | 3.17 | -0.44 | 167.5 | 0.37 |
| Mem_span_Y2 | 10.75 | 4.67 | 10.88 | 4.73 | 0.03 | 194.5 | 0.88 |

## Appendix 6:3 Performance of the poor and average CH reading groups on all measures (Significant differences are highlighted in grey)

| R_CH_10_G | Poor group (N=12) | | Average group (N=25) | | Cohen's D | U | p Value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Age | 6.52 | 0.32 | 6.66 | 0.27 | 6.66 | 111.5 | 0.21 |
| Non-verbal intelligence | 95.75 | 9.98 | 101.08 | 9.16 | 101.08 | 101 | 0.15 |
| **Literacy (Max)** | | | | | | | |
| ZF_LK_Y1 (37) | 33.08 | 3.7 | 34.67 | 2.28 | 34.67 | 107.5 | 0.21 |
| CH_Y1 (T score) | 31 | 14.76 | 51.83 | 13.86 | 51.83 | 35.5 | 0 |
| School exam_Y1 (100) | 86.5 | 10.12 | 93.12 | 5.82 | 93.12 | 81 | 0.02 |
| Spelling_Y1 (20) | 7.83 | 4.84 | 9.92 | 3.62 | 9.92 | 117 | 0.28 |
| RA_ZF_Y1_pr (24) | 5.91 | 2.81 | 9.16 | 3.17 | 9.16 | 59.5 | 0.01 |
| RA_ZF_Y1_po (24) | 10.25 | 3.19 | 12.44 | 2.9 | 12.44 | 76 | 0.02 |
| CH_Y2 (T score) | 40.42 | 6.67 | 54.44 | 10.06 | 54.44 | 28 | 0 |
| School exam_Y2 (100) | 93.67 | 5.03 | 94.8 | 3.88 | 94.8 | 134.5 | 0.61 |
| Read_compr_Y2 (T score) | 54.92 | 11.33 | 60.92 | 4.3 | 6.92 | 111.5 | 0.2 |
| RA_ZF_Y2 (24) | 9.08 | 3.06 | 12.76 | 2.91 | 12.76 | 55 | 0 |
| Place_RT_Y2(sec) | 73 | 25.21 | 64.28 | 14.47 | 64.28 | 120.5 | 0.34 |
| Place _accuracy_Y2(20) | 16 | 2.27 | 15.48 | 2.77 | 15.48 | 122 | 0.36 |
| Form_RT_Y2(sec) | 58 | 12.85 | 51.76 | 10.51 | 51.76 | 116.5 | 0.28 |
| Form _accuracy_Y2(20) | 19 | 1.62 | 18.4 | 2.31 | 18.4 | 136 | 0.63 |
| **Phonological awareness (Max)** | | | | | | | |
| IPA_S_Y1 (10) | 8.92 | 1.24 | 8.33 | 1.63 | 8.33 | 114.5 | 0.3 |
| IPA_P_Y1 (10) | 3.83 | 0.94 | 4.63 | 1.56 | 4.63 | 96 | 0.1 |
| IPA_O_Y1 (15) | 8.92 | 1.98 | 8.87 | 3.06 | 8.87 | 124.5 | 0.63 |
| IPA_R_Y1 (10) | 6.08 | 2.39 | 6.58 | 1.82 | 6.58 | 131 | 0.66 |
| IPA_T_Y1 (10) | 3.5 | 2.47 | 5.42 | 2.45 | 5.42 | 82.5 | 0.04 |
| EPA_S_Y1 (20) | 14.67 | 4.19 | 16.08 | 2 | 16.08 | 127.5 | 0.46 |
| EPA_P_Y1 (20) | 4.55 | 3.47 | 4.56 | 3.08 | 4.56 | 136.5 | 0.97 |
| EPA_O_Y1 (30) | 12.58 | 10.64 | 13.64 | 9.66 | 13.64 | 140.5 | 0.76 |
| EPA_R_Y1 (20) | 10.67 | 6.61 | 10.4 | 5.66 | 1.4 | 138.5 | 0.71 |
| EPA_T_Y1 (20) | 8.5 | 7.33 | 12.16 | 4.94 | 12.16 | 106 | 0.15 |
| IPA_S_Y2 (10) | 9.33 | 1.07 | 9.12 | 0.93 | 9.12 | 125 | 0.38 |
| IPA_P_Y2 (10) | 4.08 | 1.62 | 4.8 | 1.22 | 4.8 | 113 | 0.22 |
| IPA_O_Y2 (15) | 10.33 | 3.03 | 11.2 | 2.36 | 11.2 | 112 | 0.21 |
| IPA_R_Y2 (10) | 7.17 | 2.04 | 7.32 | 1.86 | 7.32 | 146.5 | 0.91 |
| IPA_T_Y2 (10) | 7.08 | 1.98 | 7.24 | 1.94 | 7.24 | 141.5 | 0.78 |
| EPA_S_Y2 (20) | 18.33 | 0.49 | 17.8 | 1.47 | 17.8 | 120 | 0.3 |
| EPA_P_Y2 (20) | 8.5 | 4.91 | 8.12 | 4.11 | 8.12 | 144.5 | 0.86 |
| EPA_O_Y2 (30) | 19.92 | 7.55 | 19.32 | 7.95 | 19.32 | 142 | 0.79 |
| EPA_R_Y2 (20) | 13.83 | 5.08 | 14.32 | 5.96 | 14.32 | 136 | 0.65 |
| EPA_T_Y2 (20) | 17.08 | 2.02 | 16.8 | 2.27 | 16.8 | 139 | 0.72 |
| **Rapid Automatised Naming (Sec)** | | | | | | | |
| RAN_Digit_Y1 | 47.17 | 14.02 | 36.82 | 10.77 | 36.82 | 70.5 | 0.01 |
| RAN_Obj_Y1 | 68.38 | 21.06 | 57.22 | 15.3 | 57.22 | 93 | 0.06 |
| RAN_Digit_Y2 | 38.95 | 10.66 | 30.46 | 8.13 | 3.46 | 68.5 | 0.02 |
| RAN_Obj_Y2 | 60.27 | 14.9 | 50.12 | 12.04 | 5.12 | 83.5 | 0.06 |
| RAN_ZF_Y2 | 43.68 | 8.66 | 38.44 | 9.62 | 38.44 | 85 | 0.07 |
| RAN_CH_Y2 | 39.82 | 6.34 | 32.36 | 6.77 | 32.36 | 58 | 0.01 |
| **Spoken Language skills (Max)** | | | | | | | |
| Semantic fluency_Y1 | 12 | 3.57 | 13.12 | 5.46 | 13.12 | 145 | 0.87 |
| Vocabulary_Y1(T-score) | 108.5 | 9.45 | 112.28 | 7.41 | 112.28 | 104 | 0.13 |
| Auditory_memory_Y1(17) | 9 | 2.1 | 10.32 | 2.56 | 1.32 | 94.5 | 0.07 |
| Picture Naming_Y1 (30) | 25 | 6.58 | 27.56 | 3.15 | 27.56 | 111 | 0.2 |
| Mem_span_Y2 | 11 | 5.49 | 11.92 | 4.49 | 11.92 | 129.5 | 0.49 |

**Appendix 6:4 Performance of the poor and average reading comprehension groups on all measures (Significant differences are highlighted in grey)**

| ZF and CH comprehension | Poor group (N=12) | | Average group (N=37) | | Cohen's D | U | p value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Age | 6.66 | 0.34 | 6.56 | 0.3 | -0.33 | 175.5 | 0.28 |
| Non verbal intelligence | 92.08 | 6.2 | 105.19 | 9.65 | 1.48 | 51 | 0 |
| **Literacy (Max)** | | | | | | | |
| ZF_LK_Y1 (37) | 32.25 | 4 | 34.64 | 2.93 | 0.75 | 134 | 0.047 |
| CH_Y1 (T score) | 38.55 | 4.23 | 53.5 | 13.49 | 1.26 | 49 | 0 |
| School exam_Y1 (100) | 89.67 | 7.85 | 93.97 | 4.75 | 0.77 | 139.5 | 0.05 |
| Spelling_Y1 (20) | 8.92 | 2.94 | 10.57 | 3.36 | 0.51 | 152.5 | 0.1 |
| RA_ZF_Y1_pr (24) | 7.73 | 3.61 | 9.06 | 3.27 | 0.4 | 161.5 | 0.36 |
| RA_ZF_Y1_po (24) | 10.42 | 3.6 | 12.41 | 2.85 | 0.66 | 143 | 0.06 |
| CH_Y2 (T score) | 43.75 | 9.07 | 57.38 | 12.23 | 1.19 | 76 | 0 |
| School exam_Y2 (100) | 91.42 | 5.09 | 96.38 | 2.86 | 1.43 | 87.5 | 0 |
| RA_ZF_Y2 (24) | 12.33 | 4.23 | 12.59 | 2.62 | 0.09 | 193 | 0.5 |
| RA_CH_Y2 (24) | 12.17 | 2.66 | 13.72 | 2.42 | 0.63 | 138 | 0.06 |
| Place_RT_Y2(sec) | 71.58 | 22.69 | 64.76 | 16.93 | -0.37 | 183 | 0.36 |
| Place _accuracy_Y2(20) | 16.58 | 2.54 | 16.16 | 2.43 | -0.17 | 193 | 0.49 |
| Form_RT_Y2(sec) | 56.5 | 11.09 | 52.86 | 10.47 | -0.35 | 184 | 0.38 |
| Form _accuracy_Y2(20) | 18.75 | 1.29 | 18.84 | 1.83 | 0.05 | 191.5 | 0.45 |
| **Phonological awareness (Max)** | | | | | | | |
| IPA_S_Y1 (10) | 8.92 | 1.31 | 8.26 | 1.58 | -0.44 | 157.5 | 0.19 |
| IPA_P_Y1 (10) | 3.83 | 1.59 | 4.8 | 1.59 | 0.62 | 136 | 0.07 |
| IPA_O_Y1 (15) | 7.25 | 3.08 | 9.71 | 2.38 | 0.97 | 100.5 | 0.01 |
| IPA_R_Y1 (10) | 5.33 | 2.27 | 6.49 | 2.12 | 0.54 | 150 | 0.14 |
| IPA_T_Y1 (10) | 3.67 | 2.67 | 4.69 | 2.87 | 0.37 | 163 | 0.25 |
| EPA_S_Y1 (20) | 14.5 | 4.1 | 16.05 | 2.09 | 0.58 | 181.5 | 0.34 |
| EPA_P_Y1 (20) | 2.91 | 2.74 | 6.38 | 4.02 | 0.93 | 98 | 0.01 |
| EPA_O_Y1 (30) | 8.25 | 10.01 | 14.86 | 10.25 | 0.66 | 126 | 0.02 |
| EPA_R_Y1 (20) | 8.67 | 4.96 | 11.11 | 6.08 | 0.42 | 159 | 0.14 |
| EPA_T_Y1 (20) | 10.42 | 6.6 | 11.73 | 5.15 | 0.24 | 186.5 | 0.4 |
| IPA_S_Y2 (10) | 9 | 1.13 | 8.89 | 1.31 | -0.09 | 216.5 | 0.89 |
| IPA_P_Y2 (10) | 4.5 | 1.31 | 5.05 | 1.68 | 0.35 | 173.5 | 0.25 |
| IPA_O_Y2 (15) | 10.33 | 2.46 | 11.59 | 2.51 | 0.51 | 149.5 | 0.09 |
| IPA_R_Y2 (10) | 6.67 | 2.1 | 7.73 | 1.5 | 0.65 | 154.5 | 0.11 |
| IPA_T_Y2 (10) | 7 | 2.22 | 7.49 | 1.77 | 0.26 | 194 | 0.51 |
| EPA_S_Y2 (20) | 17.17 | 1.53 | 18.11 | 1.54 | 0.62 | 134.5 | 0.04 |
| EPA_P_Y2 (20) | 6.5 | 4.52 | 9.7 | 4.58 | 0.71 | 139.5 | 0.05 |
| EPA_O_Y2 (30) | 15.25 | 7.25 | 20.16 | 6.19 | 0.77 | 141.5 | 0.06 |
| EPA_R_Y2 (20) | 10.33 | 5.88 | 16.08 | 4.99 | 1.11 | 86 | 0 |
| EPA_T_Y2 (20) | 16.75 | 1.91 | 17.3 | 2.62 | 0.22 | 161.5 | 0.15 |
| **Rapid Automatised Naming (Sec)** | | | | | | | |
| RAN_Digit_Y1 | 43.13 | 16.7 | 35.17 | 9.22 | -0.7 | 155.5 | 0.15 |
| RAN_Obj_Y1 | 71.75 | 23.54 | 56.46 | 14.24 | -0.91 | 129.5 | 0.04 |
| RAN_Digit_Y2 | 36.54 | 12.95 | 29.96 | 7.18 | -0.75 | 157.5 | 0.13 |
| RAN_Obj_Y2 | 57 | 14.11 | 51.85 | 12.12 | -0.41 | 174 | 0.26 |
| RAN_ZF_Y2 | 43.71 | 9.82 | 38.41 | 8.59 | -0.6 | 147.5 | 0.08 |
| RAN_CH_Y2 | 38.75 | 9.56 | 32.8 | 5.68 | -0.89 | 141 | 0.06 |
| **Spoken Language skills** | | | | | | | |
| Semantic fluency_Y1 | 11.42 | 4.34 | 14.29 | 4.74 | 0.62 | 131.5 | 0.05 |
| Vocabulary_Y1(T-score) | 105.17 | 7.69 | 113.78 | 7.79 | 1.12 | 86 | 0 |
| Auditory_memory_Y1(17) | 8.82 | 1.17 | 9.95 | 2.62 | 0.48 | 143.5 | 0.14 |
| Picture Naming_Y1 (30) | 24.08 | 7.15 | 28.51 | 1.71 | 1.19 | 106 | 0.01 |
| Mem_span_Y2 | 9.17 | 4.78 | 12.05 | 4.77 | 0.61 | 144.5 | 0.06 |