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擬聲詞可以神救援嗎？
透過聲音擬似性習得華語動詞之研究

Can onomatopoeia come to rescue?
A study on Mandarin verb acquisition via sound iconicity

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本論文係蔡雨璇君（R07142008）在國立臺灣大學語言學研究所完成之碩士學位論文，於民國 111 年 7 月 18 日承下列考試委員審查通過及口試及格，特此證明

口試委員：馮怡蓁（簽名）
（指導教授）

劉惠美　李佳霖

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摘要

幼兒學習動詞較名詞來得困難，因為動詞較不具體，也較難產生意象。而華語因為缺乏動詞詞尾變位，更加劇了這個問題，使得新的動詞難以辨識。因為擬聲詞具豐富意象，本研究探討擬聲詞是否可藉此促進動詞學習。本研究招募了50位41.00到47.90個月學習華語的幼兒，並隨機分配到五組（三個動詞學習組及兩個名詞學習組）中的一組，以執行快速配對。在快速配對階段，每題皆會出現兩張圖片，一張是幼童熟悉的物件，另一張則是新奇的物件，共有六題。幼兒在聽到新詞後，透過排除法將新圖片與新詞做連結。隨後，我們讓幼童進行新詞表達與理解測驗。在動詞學習組中，新詞皆為擬聲疊詞，並且放置於句子的動詞位置（例如：哪個會__？）。三個動詞學習組中，一組僅以擬聲疊詞形式呈現（下稱VV），另一組以擬聲疊詞搭配其模仿的聲音呈現（下稱VVS），而最後一組則以擬聲疊詞搭配不匹配的聲音呈現（下稱VVX）。名詞學習組將新詞當作為名詞使用，放在句子中（例如：哪個是__？）。一組以單音節形式呈現新詞（下稱N），另一組以重疊詞形式呈現新詞（下稱NN）。結果顯示，幼兒保留VVS的能力優於VV與VVX，而N與NN的表現並無不同。此外，VVS與兩個名詞學習組間沒有顯著差異。這些結果顯示，只要聲音與意義之間建立連結，擬聲詞確實可以促進動詞學習。

關鍵字：擬聲詞、快速配對、動詞學習、重疊、語言習得、華語

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Abstract

Verbs are generally more difficult for young children to acquire than nouns due to lower concreteness and imageability. The lack of verb conjugation in Mandarin seems to only exacerbate the problem, making novel verbs even more challenging to identify. This study thus examined whether verb learning could be boosted by onomatopoeia, which is rich in imagery and claimed to facilitate language learning. Fifty Mandarin-learning children from age 41.00 to 47.90 months were recruited and randomly assigned to one of five groups (three verb-learning and two noun-learning) to perform a fast mapping task. In all five groups, children were presented with two pictures in each trial, one with a familiar item, and the other a novel item. There were in total six novel pictures. Upon hearing a novel word, children were expected to associate it with the novel item through deduction. Later, they were tested on their production and comprehension of the novel words. For the verb-learning groups, the novel words were all in the form of onomatopoeic reduplication, and were placed in a verbal sentence frame (e.g., *Nage hui ___?* 'Which makes the sound __?'). One group provided the novel label as is (VV hereafter), another provided both the label along with the novel sound it mimicked after (VVS hereafter), and the other provided the label along with a mismatching sound (VVX hereafter). The noun-learning groups placed the novel words in a nominal sentence frame (e.g., *Nage shi ___?* 'Which is a __?'). One group provided the novel label in monosyllabic form (N hereafter) and the other provided the novel label in reduplicative form (NN hereafter). Results showed that VVS performed better than VV and VVX, while no difference was found between N and NN. Crucially, VVS did not differ significantly from both of the noun-learning groups. The results thus implied that onomatopoeia can indeed facilitate verb learning as long as a sound iconic association between the mimicking label and the mimicked sound is established.

Keywords: onomatopoeia, fast mapping, verb learning, reduplication, language acquisition, Mandarin

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Chapter 1 Introduction

1.1 Research Background

The two main parts-of-speech in early word learning are nouns and verbs. Previous studies claimed that a noun bias, which suggests children prefer learning nouns over verbs, exists across languages (Bassano, 2000; Bates et al., 1994; Caselli et al., 1995; Colombo, Navarrete, & Arfé, 2017; Gentner, 1982; Klassert, Gagarina, & Kauschke, 2014; Sheng & McGregor, 2010). It is reported that compared to verbs, nouns are formed with simple concepts and natural categories. Also, they depend less on the context, and refer mostly to stable entities. For instance, nouns such as *cake* do not change its meaning when placed in different contexts. However, verbs such as *take* have different meanings, as in *take a bus* and *take a break*. Therefore, mapping a novel noun to its referent object is shown to be easier than mapping a verb to its referent action in many languages, including English (Childers & Tomasello, 2002; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996) and Japanese (Imai, Haryu, & Okada, 2005).

The case regarding Mandarin verb acquisition seems to be more controversial. Some studies claimed that Mandarin is a verb-friendly language because its argument can be dropped and its morphology is simple (Erbaugh, 1992; Li, Jin, & Tan, 2004; Ogura, 2001; Tardif, 1996), and that verbs are emphasized over nouns in the input (Tardif, Shatz, & Naigles, 1997). Others reported that the lack of verb conjugation in fact makes it even more challenging to identify (Imai et al., 2008). Past research also showed that context appeared to be a crucial factor for the distribution of word types regardless of the language spoken, as there are more nouns than verbs in book reading

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contexts and more verbs than nouns in toy playing contexts in both English and Mandarin children's conversations (Tardif, Gelman, & Xu, 1999).

Even though verbs are generally more difficult to learn, this part-of-speech commonly occurs in teaching materials for children. An example is the nursery rhyme "Old MacDonald Had a Farm". The song mentions several animals and repeats their calls in onomatopoeic forms, which imitate the animal noises and conveniently associate the noises with the actions of making these noises. In other words, onomatopoeia, which creates a connection between the sound and its meaning, might act as a propeller for learning novel verbs as it creates a straightforward mapping between an observable action and its consequence.

Extending the concept of connecting the sound to its meaning, there are also online learning websites claiming their teaching method can help children memorize an English word within a short period of time. They made videos based on each vocabulary, and designed Mandarin scenarios including sounds similar to its English pronunciation. For example, the video showed that dinosaurs are animals with thick heads, thereby calling them a *dainaoshou* (呆腦獸) 'animals with thick heads'. The scenario created a mapping of the sound and its meaning. This type of sound symbolism could as well strengthen our memorization.

Although neither onomatopoeia nor sound symbolism is considered as the core of an adult lexicon, it accounts for a large proportion of early speech production (Bonvillian, Garber, & Dell, 1997; Tardif et al., 2008; Werner & Kaplan, 1963). Menn and Vihman (2011) showed that 20% of the first five words in ten languages are onomatopoeias. Kern (2010) argued that over a third of the early output are in fact onomatopoeias. It is suggested that onomatopoeia can also function as a speech practice throughout language learning (Farrar, 1883; Stoel-Gammon & Cooper, 1984).

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The onomatopoeic form serves as an alternative word choice in languages such as Japanese (Ogura, 2006) and German (Laing, 2014). For instance, fricative sounds were used to represent the word *bee*, and a dog barking sound [vavaɯ] was used to refer to the word *dog* in German. It is also considered to be pronounced more accurately compared to the same phoneme in the conventional form (Kunnari, 2002). For instance, a German child produced the phoneme /k/ in an onomatopoeic word *kikeriki* 'cock-a-doodle-doo' accurately, but avoided it in a conventional word *kalt* 'cold' (Laing, 2014).

In children's speech perception, onomatopoeia also plays a role. The Sound Symbolism Bootstrapping Hypothesis proposed by Imai and Kita (2014) claimed that preverbal infants are sensitive to sound symbolism by nature, and sound symbolism helps them associate a sound with its referent and can thus bootstrap them into the lexicon. Such an ability can be observed in infants as early as four months old (Ozturk, Krehm, & Vouloumanos, 2013). Children performed better at mapping onomatopoeias to their referents than mapping their corresponding conventional forms at ten months old (Laing, 2017), and they performed well at learning Japanese verbs (Imai et al., 2008; Kantartzis, Imai, & Kita, 2011) and adjectives (Lockwood, Dingemanse, & Hagoort, 2016) using sound symbolism at the age of two. Children show a processing advantage for the onomatopoeic form *woof-woof* over its conventional counterparts *doggie* (Laing, 2017). However, the effectiveness of using onomatopoeic sound symbolism decreases after vocabulary development at around the end of the second year (Kauschke & Hofmeister, 2002).

The reason why onomatopoeia provides a boost for vocabulary acquisition probably lies in its form (Stoel-Gammon & Cooper, 1984). Onomatopoeia generally fits either one of the two properties, assuming a CV syllable structure, or using a

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reduplicated form, or both (Kent, 1992; Vihman, 1978). For example, in Dutch, Hebrew, and Greek, the call of a cow (i.e., *moo*) was realized as a CV structure of *moe, moo*, and *moo*, respectively, while the call of a dog (i.e., *woof-woof*) was represented by a reduplicated form of *woef-woef*, *how-how*, and *gav-gav*, respectively (Laing, 2019a; Laing, Vihman, & Keren-Portnoy, 2017). As for the case of Mandarin, disyllabic, trisyllabic, and quadrisyllabic reduplications are commonly used in onomatopoeia (Melloni & Basciano, 2018). For example, disyllabic forms include *hu-hu* 'the swooshing sound of the wind', trisyllabic forms include *ding-ding-dang* 'the ding-dong sound of a bell', and quadrisyllabic forms include *di-di-da-da* 'the pitter-patter sound of the rain'. Multisyllabic reduplication of onomatopoeic forms consists of either partial or full reduplication (Laing, 2015), but Mandarin structures mainly reduplicate only once. The reduplicated structure does not exist only in onomatopoeia but also in other lexical forms (Hsieh, 2017; Wang & Lin, 2013). For example, the reduplicated noun *gou-gou* 'dog-dog' is a synonym of *gou* 'dog', and is commonly used in child-directed speech (CDS).

The Taiwan Corpus of Child Mandarin (TCCM) from the Child Language Data Exchange System (CHILDES) showed that reduplications of Mandarin lexical forms such as nouns and verbs are produced both by experimenters and caregivers (i.e., the input) and by children themselves (i.e., the output). For example, caregivers prefer using the reduplicated form *gou-gou* 'dog-dog' other than its monosyllabic form *gou* 'dog' when talking to younger children, and younger children themselves prefer saying the reduplicated form to interact with their caregivers. At the age of three, when mentioning the word *gou* 'dog', there were 191 out of 264 reduplicated forms in the input, and 87 out of 127 reduplicated forms in the output (Cheung et al., 2011). Since reduplication doubles the occurrence of words, it is assumed that this form

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enhances the learnability of a new label (Axelsson & Horst, 2014; Bird, Franklin, & Howard, 2001; Naigles & Hoff-Ginsberg, 1998).

Most of the current studies on children learning through onomatopoeias focus on existing onomatopoeic and conventional words, such as *woof-woof* vs. *dog*. However, it is difficult to compare the effect of word acquisition in different parts-of-speech due to uncontrolled input. We do not know when and how each child first encountered a particular word, and thus could not make a generalization. In this study, we used fast mapping, a technique in which children learn novel terms through minimal exposure to word pairs (Spiegel & Halberda, 2011), to see whether onomatopoeias could facilitate Mandarin verb acquisition.

1.2 Purpose of the Study

Our study drew attention to the acquisition of novel nouns and verbs. In order to balance out the noun bias, we replaced verbs with onomatopoeias, and examined whether onomatopoeia boosted novel verb learning. The research questions that we addressed were as follows:

(1) Can onomatopoeia counteract the noun bias in novel verb learning?

(2) Does reduplication help retain novel words?

(3) In what way does sound iconicity help novel verb learning?

The first aim of this study was to examine the two radically different points of view: either Mandarin nouns perform better than onomatopoeias, or the other way around. The differences between this study and previous Japanese studies (e.g., Imai et al. 2008; Kantartzis et al., 2011) are that the selected Japanese verbs were limited to

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mimetics, which does not exist in Mandarin, whereas this study focused on onomatopoeias instead. If onomatopoeia helps, it could counteract the noun bias in novel verb learning; if it does not help, nouns would be learned better than verbs. The second aim of this study was to examine whether reduplication enhances novel word learning. We reduplicated the novel nouns and compared the learning performances between their monosyllabic and disyllabic forms. Since onomatopoeias were mostly in reduplicated forms across languages including Mandarin, we did not otherwise include their monosyllabic forms as a comparison. If reduplication helps, nouns in reduplicated forms should perform better than their monosyllabic forms; if it does not help, there would be no performance difference between the two forms. The third aim of this study was to examine whether sound iconicity is crucial to successful acquisition of onomatopoeia. If iconicity is a crucial factor, onomatopoeias with lower sound iconicity would cause lower performance scores, while onomatopoeias with higher sound iconicity would lead to better performance scores.

1.3 Organization

This thesis is organized into six chapters. Chapter 1 is an introduction of the research background and the purpose of this study. Chapter 2 includes the literature review of the noun bias, onomatopoeia, and CDS. Chapter 3 describes the method of recruiting participants and conducting experimental tasks. Chapter 4 reports and analyses the results of each experimental task. Chapter 5 and Chapter 6 discuss and conclude the findings of this study, respectively.

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Chapter 2 Literature Review

In this chapter, we summarized past studies on the effectiveness of learning through reduplication and iconicity in onomatopoeia. Section 2.1 discusses the noun bias and possible explanations for such a bias. Section 2.2 introduces the two main features of onomatopoeia. Section 2.3 compares the salient features of onomatopoeias to CDS.

2.1 Noun Bias

Children rely on both multisensory input and imageability to acquire language. Of the two, previous studies claimed that imageability is a more crucial factor in word learning (Eviatar, Menn, & Zaidel, 1990). As a result, concrete nouns, which are highly imageable, are easier to learn than all other lexical categories.

Concrete and abstract words differ in context availability (Schwanenflugel, Harnishfeger, & Stowe, 1988) and coding systems (Paivio, 1986). Concrete words involve sensory experiences and use both verbal and imagery codes to encode. However, abstract words are mainly described by concepts, contexts, and situations, and they only utilize the verbal code to encode. For example, the concrete noun "cake" can be described by its taste and smell, but the abstract noun "truth" is relatively difficult to frame. Therefore, the "concreteness effect" (Mestres-Missé, Münte, & Rodriguez-Fornells, 2014) has been proposed, claiming that concrete nouns can be processed faster (De Groot, 1989; De Groot & Keijzer, 2000; Kroll & Merves, 1986; Schwanenflugel & Shoben, 1983; Schwanenflugel, Harnishfeger, & Stowe, 1988) and they can be remembered and recalled better (Paivio, 1971; Schwanenflugel & Stowe, 1989; Wattenmaker & Shoben, 1987) than abstract nouns.

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Even though Mandarin was considered a verb-friendly language due to argument dropping and morphological simplicity (Tardif, 1996), there was still a tendency for a noun bias (Gentner, 1982). Imai and colleagues (2008) measured Mandarin, English, and Japanese children at different ages to see whether noun bias existed across languages. They tested children with novel nouns and novel verbs and found there was a potential universal noun advantage. Children at age three were able to map and extend novel nouns to new events but failed to do the same with novel verbs. At the age of five, English and Japanese children succeeded in mapping novel verbs. However, the result suggested that Mandarin children required more pragmatic and grammatical support to learn verbs. It was not until age eight did they succeed in mapping verbs. On the other hand, Lai and Liu (2022) compared Mandarin nouns to verbs and found that it was not the process of learning but the process of retaining that made verbs perform relatively worse. They demonstrated that three-year-old children successfully mapped the verbs to their referents but failed to retain them.

The issue of whether there is a noun bias also depends on contexts. Tardif and colleagues (1999) measured the usage of common nouns and main verbs in English and Mandarin book reading and toy free-play. Results showed that although Mandarin children and adults produced more verbs than English speakers, they still produced more nouns in book reading than in toy play contexts. Therefore, language was not the only factor that causes noun bias, and that Mandarin nouns play an important role in early language learning as well.

2.2 Onomatopoeia

Aside from concrete nouns, onomatopoeias can also be described by both sensory (Imai & Kita, 2014) and imagery (Motamedi et al., 2021) input. In most cases,

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onomatopoeias are verbs that mimic the action of making sounds, as in "the cat is meowing". If the referent is present, the listener could single out the correct referent; if the referent is absent, the listener could map the lexical item to a memory trace of the referent (Perniss, Lu, Morgan, & Vigliocco, 2018).

2.2.1 Reduplication

Given that reduplication is a universal feature of onomatopoeias (Brent & Siskind, 2001; Ferguson, 1983; Fernald & Kuhl, 1987; Kent, 1992; Soderstrom, 2007; Vihman, 1978), it facilitates the production and perception of a word (Behrens, 2006; Laing et al., 2017). Caregivers often use onomatopoeias to capture children's attention (Vihman, 2014), create turn-taking dialogues (Laing, 2019b), and emphasize specific elements (Lee, Davis, & Macneilage, 2008), all of which are likely done at a subconscious level (Fernald, 1989; Gleitman, Newport, & Gleitman, 1984; Kemler Nelson, Hirsh-Pasek, Jusczyk, & Wright-Cassidy, 1989). As children are more likely attracted to salient features (Fernald & Kuhl, 1987; Fernald & Simon, 1984), they also give more positive responses to onomatopoeic words than conventional words (Smith & Trainor, 2008).

Different from other languages, reduplications not only existed in Mandarin onomatopoeias but also in other parts-of-speech, especially CDS. As a tone language, there is a specific tonal frame for nominal reduplication in CDS (Erbaugh, 1982; Hsieh, 2017; Ma, Zhou, Golinkoff, Lee, & Hirsh-Pasek, 2019). For common nouns, reduplication of a Tone 2 (T2) or Tone 3 (T3) word would result in a T3-T2 sequence (Duanmu, 2007; Hsieh, 2017). For example, the reduplicated form of *niu2* 'cow' is pronounced as *niu3-niu2* and that of *gou3* 'dog' is *gou3-gou2*. For reduplicated kinship terms, this tonal frame is applied regardless of tones (Duanmu, 2007). For

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example, the reduplicated form of *ma1* 'mom' is pronounced as *ma3-ma2* and *ba4* 'dad' as *ba3-ba2*. Reduplicated nouns with the T3-T2 frame is a way of expressing cuteness in Mandarin and is a common device in CDS (Farris, 1988, 1992).

The token frequency of reduplication in Taiwan Mandarin spontaneous spoken data from CHILDES showed a very high negative correlation between children's age and their usage of reduplication. The data consist of 449 children aged 1;5-10;6 (*M* = 4;10, *SD* = 2;4) collected by Chang (1998, 2000, 2003, 2004, 2005), Chang and Huang (2016), Chang and McCabe (2013), Chen, Chang, and Chen (2012), Cheung (1998, 2003), Cheung, Chang, Ko, and Tsay (2011), Huang (2009), and Luo, Snow, and Chang (2012). We divided these children into ten groups based on their age recorded in the transcript. Age information was summarized in Table 2.1. Since sex was unspecified in some data, we did not incorporate it as a predicting factor.

Table 2.1 Age information of the children.

Group	Age 1	Age 2	Age 3	Age 4	Age 5
N	19	77	120	55	51
M	1;8	2;5	3;6	4;6	5;7
SD	0;2	0;3	0;3	0;3	0;3
Range	1;5-1;11	2;0-2;11	3;0-3;11	4;0-4;11	5;0-5;11
Group	Age 6	Age 7	Age 8	Age 9	Age 10
N	37	28	28	19	15
M	6;5	7;6	8;6	9;3	10;3
SD	0;3	0;3	0;4	0;3	0;2
Range	6;0-6;11	7;0-7;11	8;1-8;11	9;0-9;9	10;0-10;6

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We used Python 3.9.1 (Van Rossum & Drake, 2009) to collect data and divided the words into two categories: input and output. Inputs were the words investigators, relatives or family members said to the children, whereas outputs were the words spontaneously spoken by children themselves. There were 7005 reduplications in a total of 417516 input words (1.68%), and 13569 reduplications in a total of 160642 output words (8.45%). In other words, children produced more reduplication than adults. We further divided these words into four parts-of-speech: nouns (n), verbs (v), onomatopoeias (on), and others, and then transformed the raw data into percentages to compare the usage of reduplication at different ages. In these data, verbs include general verbs, auxiliary verbs, copular verbs, directional complements, and resultative complements, while onomatopoeias include words that imitate a sound. Our results showed that there was a higher proportion of reduplications in both inputs and outputs for younger children, and this usage gradually decreased through age.

The correlation between children's age and their reduplication input was a very highly negative correlation [$r = -.90$, $p < .001$]. As children grew older, they received fewer reduplication input. For each category, the correlation coefficients between different ages and different parts-of-speech were: $r = -.57$ for nouns, $r = -.60$ for verbs, $r = -.90$ for onomatopoeias, and $r = -.73$ for others. There were significant correlations in onomatopoeias and others, and there were marginal significant correlations in nouns and verbs (Figure 2.1). As children reached the age of seven, they seldom received reduplicated words in conversation with adults, especially onomatopoeias. If we further divided nouns into kinship terms (e.g., *ma-ma* 'mom') and non-kinship terms (e.g., *gou-gou* 'dog'), the result indicated that the input of reduplication in non-kinship terms gradually decreased, while the reduplication in kinship terms remained high. There was a very strong negative correlation between

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the age and non-kinship terms [r = -.92, p < .001] (Figure 2.2). However, most kinship terms in Mandarin were in reduplicated disyllabic forms, so the use of reduplication in these terms had little to do with speaking to children at different ages.

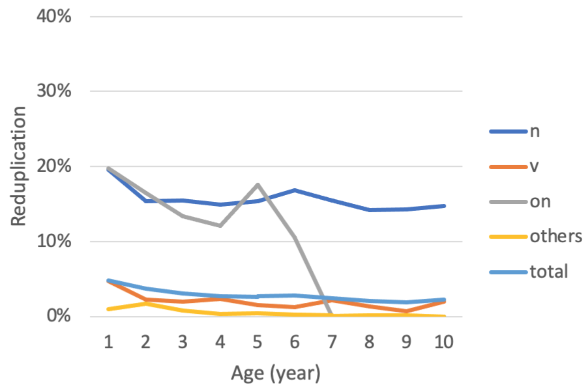

Figure 2.1 The percentage of reduplication input at different ages.

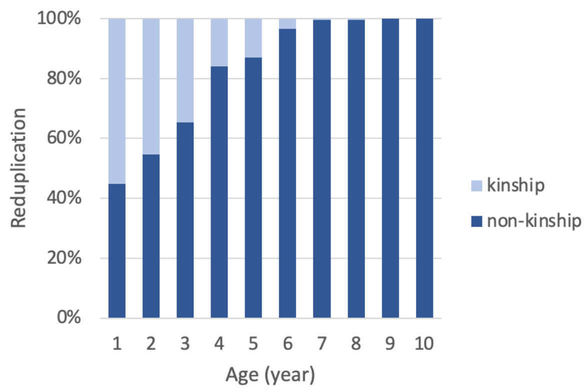

Figure 2.2 The input percentages of reduplicated kinship and non-kinship terms at different ages.

The correlation between children's age and the reduplication output was also a strong negative correlation [r = -.71, p < .05]. The statistics indicated that children

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themselves used fewer reduplicated forms as they grew up. The correlations between the age and each part-of-speech were: r = -.30 for nouns, r = -.66 for verbs, r = -.12 for onomatopoeias, and r = -.66 for others. There were significant negative correlations in verbs and others (Figure 2.3). In overall production, nouns and onomatopoeias have relatively higher reduplicated proportions. However, there was a huge fluctuation in onomatopoeias at age eight and ten. Even though reduplicating onomatopoeias might seem common for older children, the total number was actually declining. There were 11 onomatopoeic reduplications at the age of five, but two at the age of eight, and only one left at the age of ten. Therefore, the reduplicated form of onomatopoeia as a whole decreased through ages. Similar to the input of reduplication, by dividing nouns into kinship terms and non-kinship terms, we discovered that most of the reduplicated forms were kinship terms, and the proportion of reduplication in non-kinship terms decreased through age. There was also a strong negative correlation between the age and reduplication of non-kinship terms [r = -.86, $p < .01$] (Figure 2.4).

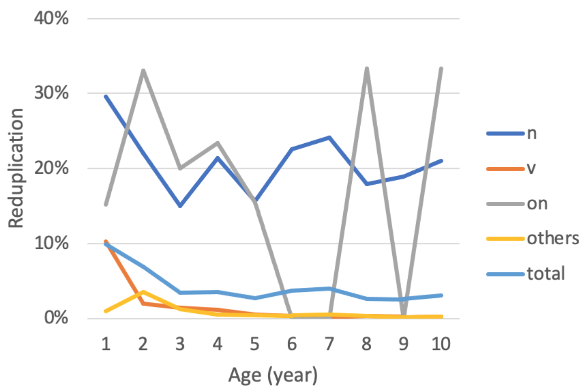

Figure 2.3 The percentage of reduplication output at different ages.

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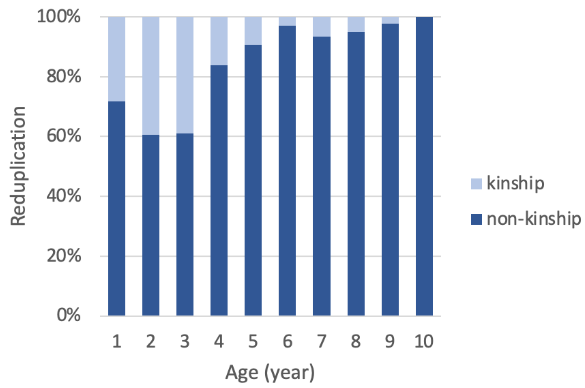

Figure 2.4 The output percentages of reduplicated kinship and non-kinship terms at different ages.

2.2.2 Iconicity

Another fundamental feature of onomatopoeias is that they are non-arbitrary words representing meaning through sounds (De Saussure, 2011; Monaghan, Shillcock, Christiansen, & Kirby, 2014). There are two types of onomatopoeias, standard and functional (Laing, 2014; Lemaitre & Rocchesso, 2014). Standard onomatopoeia is also known as tame imitation (Rhodes, 1994). It follows the phonotactic constraints of a language (Iwasaki, Vinson, & Vigliocco, 2007; Lemaitre, Jabbari, Misdariis, Houix, & Susini, 2016), which include conventionalized forms and fixed structures (Laing, 2014; Lemaitre & Rocchesso, 2014). It is very similar to a regular word (Iwasaki et al., 2007; Lemaitre et al., 2016) but the meaning is iconic (Sobkowiak, 1990). In contrast, functional onomatopoeia, also termed the wild imitation (Rhodes, 1994), is a non-conventional and creative vocalization with more expressive forms and flexible structures. It is constrained only by an individual's vocal abilities (Lass, Eastham,

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Parrish, Sherbick, & Ralph, 1982; Lass et al., 1983), as in [bvm] to imitate the sound of a car engine (Elsen, 1991).

Standard onomatopoeia is further divided into two subtypes, absolute and relative iconicity (Gasser, Sethuraman, & Hockema, 2010). Absolute iconicity is a transparent relationship between the sound referent and its vocal imitation, such as referring “woof-woof” to a dog bark (Imai & Kita, 2014), while relative iconicity is a smaller unit of a word that associates meaning with sounds (Nuckolls, 1999). For instance, the Japanese ideophone *kera-kera* refers to laughing (Iwasaki et al., 2007), and the English phonestheme *gl-* in “glitter”, “glow”, and “gleam” refers to vision and light (Lemaitre et al., 2016).

The two subtypes of iconicity are not mutually exclusive (Koriat & Levy, 1977; Vetter & Tennant, 1967). In some situations, the size of our mouth opening is correlated with the size of the target animal and the loudness of its noise (Maurer, Pathman, & Mondloch, 2006; Monaghan et al., 2014). It has been reported that English-speaking adults are more likely to use high-front vowels to refer to calls of smaller animals (e.g., “chirp” for chicks), and use low-back vowels to refer to calls of larger animals (e.g., “roar” for lions) (Monaghan et al., 2014).

Some East Asian languages extend the meaning from plain imitation to the entity that creates the sound (Akita, 2009; Ogura, 2006; Wang & Lin, 2013). For instance, Japanese- and Mandarin-speaking adults would use a dog barking sound (e.g., *wan-wan* in Japanese and *wang-wang* in Mandarin) to indicate a “dog” before children are familiar with this concept (Ogura, 2006; Wang & Lin, 2013). Some bird names in Japanese have onomatopoeic origins, as they mimic the vocalization of the birds (Yamaguchi, 1989). Although this usage of onomatopoeia is not universal

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(Monaghan et al., 2014), speakers of these languages might establish a better lexical representation associating a word with its referent (Imai & Kita, 2014).

2.3 Child-directed Speech (CDS)

Onomatopoeia is reported as being a lexical feature of CDS (Bornstein et al., 1992; Fernald & Morikawa, 1993). In most languages, CDS is acoustically identifiable due to its distinct prosodic features, including modifications in pitch, amplitude, duration, tempo, pause, and stress (Broesch & Bryant, 2015; Cooper & Aslin, 1990; Fernald & Simon, 1984; Fernald et al., 1989; Grieser & Kuhl, 1988; Kuhl et al., 1997; Papoušek & Hwang, 1991; Stern, Spieker, & MacKain, 1982; Stern, Spieker, Barnett, & MacKain, 1983). It is also linguistically different from normal speech, as it includes simplified structures and frequent reduplications (Cross, 1977; Ferguson, 1964; Snow, 1972). These modifications were suggested to build a parallel relationship between the word production of a child and the early input provided by his or her caregiver (Kauschke & Hofmeister, 2002; Kauschke & Klann-Delius, 2007).

Children prefer CDS over adult-directed speech (ADS) (Cooper & Aslin, 1990) as CDS adopts features such as higher pitch and wider pitch range, longer word duration, and full reduplication (Brent & Siskind, 2001; Ferguson, 1983; Fernald & Kuhl, 1987; Soderstrom, 2007). Laing and colleagues (2017) analyzed how mothers produced onomatopoeias in CDS. They found that onomatopoeic words were featured more saliently than their conventional counterparts. Laing (2014) also analyzed longitudinal diary data of a German infant. She compared the development of onomatopoeic words to their corresponding conventional words. Her results posited that structures in onomatopoeias served as a phonological and lexical bridge to their conventional forms.

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CDS is often used in early phonological development across many languages (Bornstein et al., 1992; Ferguson, 1964; Fernald & Morikawa, 1993; Kunnari, 2002; Vihman, 2010; Vihman & Keren-Portnoy, 2013). Before children experiencing the vocabulary spurt at around age 1;6 (Gopnik & Meltzoff, 1992; Lifter & Bloom, 1989; Stoel-Gammon, 2011; Woodward, Markman, & Fitzsimmons, 1994), adults raise their fundamental frequency and exaggerate their pitch contours when addressing them (Burnham, Kitamura, & Vollmer-Conna, 2002; Fernald & Kuhl, 1987; Han, De Jong, & Kager, 2018; Kuhl et al., 1997). However, adults gradually decrease their use of exaggerated prosody in the second year (Han et al., 2018), while retaining reduplicated forms until the end of preschool years (Erbaugh, 1982; Farris, 1992). The modifications establish positive interactions between adults and children and benefit language learning (Chang & Luo, 2020; Gottfried & Gottfried, 1984).

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Chapter 3 Method

In this chapter, we described the methodology used in our experiment. There were three general ability tasks and a fast mapping task. Section 3.1 shows the information of the participants. Section 3.2 illustrates how the stimuli were selected and how each task was measured.

3.1 Participants

We recruited 53 children from posts on Facebook pages and by word-of-mouth. Three failed to complete all tasks, and were excluded from further analyses. In the end, we had 50 valid participants aged between 41.00 and 47.90 months (M = 44.35 months, SD = 1.98 months), with half being female and half being male. Age information is summarized in Table 3.1. Age difference was not significant among the groups [$F(4, 40) = .53$, $p = .72$]. The reason for choosing children around this age was because it would be rather difficult to conduct an online experiment with younger children. All children used Taiwan Mandarin as their dominant language and none of them was diagnosed with language delay or impairment based on an online screening test modified after the Taipei City Pre-School Children Development Progress Evaluation Form specifically designed for children of this age (Department of Health, 2006) (see Appendix A).

Participants were further divided into five groups with different stimuli to avoid both practice and fatigue effects, and these five groups of stimuli were given to five different groups of subjects. There were nouns given in a monosyllabic form (N) and a reduplicated form (NN), and there were verbs given in a reduplicated form (VV), in

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a reduplicated form and accompanied by matching sounds (VVS), and in a reduplicated form and accompanied by non-matching sounds (VVX).

Table 3.1 Age information of the participants (in months).

Group	N	NN	VV	VVS	VVX
N	10 (5♂)	10 (5♂)	10 (5♂)	10 (5♂)	10 (5♂)
M	44.32	44.61	43.56	44.75	44.51
SD	2.48	2.62	1.75	1.84	0.98
Range	41.00-47.90	41.00-47.83	41.03-46.13	42.07-46.73	42.37-45.67

3.2 Experimental Tasks

There were four tasks in total, including digit span, fast mapping, productive phonology, and the Peabody Picture Vocabulary Test-Revised (PPVT-R), in that order. The four tasks were carried out in three sessions. The first and the second sessions were conducted at separate times with an interval between zero and three days (M = 0.90 day, SD = 0.61 day), and the third session was done following the second session after a short break. Each session lasted for about 20 minutes.

Due to the COVID pandemic, all tasks were done online using Google Meet and Microsoft PowerPoint. Before each trial, children received an instruction followed by at least two practice trials. The live presentation was narrated by the author, a native female Taiwan Mandarin speaker. We notified parents in advance to start the video call in a quiet room and asked them to audio record the whole process on their smartphone. We also designed a picker wheel game to encourage active participation. For children who responded to the questions, they could spin the wheel to collect stamps and stickers as rewards.

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Each task had two different orders. Children were randomly assigned to Orders A and B. The two differed only in trial orders, but not picture pairings. Half of the children received Order A, and the other half received Order B. If the task was done twice (e.g., fast mapping task), children switched to the other order the second time. In Session 1, children performed the digit span task and the first fast mapping task. In Session 2, they performed the second fast mapping task and the productive phonology task. In Session 3, they performed the PPVT-R. However, necessary adjustments were made based on the cooperativity and needs of the child (Figure 3.1).

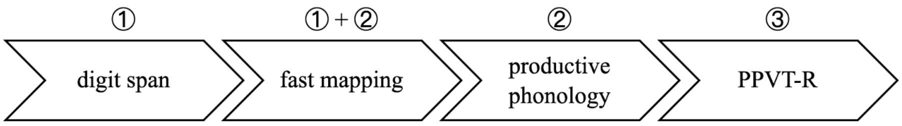

Figure 3.1 The procedure of each experimental task. Numbers above are the sessions in which the tasks were conducted.

3.2.1 Digit Span Task

We asked children to repeat several sets of numbers to test their short-term memory (Jones & Macken, 2015). They heard a series of nonadjacent numbers presented by a hand puppet, and they had to repeat as many as they could. The task started with a one-digit number. If the child repeated it correctly, a new number of two-digits would be presented. The number of digits would continue to increase until the child failed to repeat. If the child failed to repeat, he or she would be given one more chance to repeat a new number with the same digit span. The task would end when the child failed twice in a row. To accommodate younger children, this task only included numbers between one and five.

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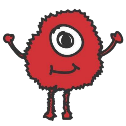
3.2.2 Fast Mapping Task

Fast mapping is a process of referent selection and referent retention. Children select and retain a novel label through a process of elimination (Carey & Bartlett, 1978; Wilkinson & Mazzitelli, 2003; Woodward & Markman, 1998). The task was conducted by pairing a familiar label with a novel label, as illustrated in Table 3.2. Children are supposed to deduce the pairing between a novel label and a novel object through logical reasoning. Based on previous literature, children at age two were able to learn as many novel terms as older children (Jaswal & Markman, 2001). The only factor that might influence children's performance was the knowledge of the lexical domain (Heibeck & Markman, 1987). In other words, if mappings in a particular domain were not firmly established, children had more difficulty doing elimination, and thus they learned fewer words from the domain. Horst and Samuelson (2008) indicated that children could succeed in referent selection but fail in referent retention. In order to rule out failures caused by unfamiliarity of a domain, we selected words from Laing (2014, 2017), Laing and colleagues (2017), Li (2015), and Spiegel and Halberda (2011), which worked on younger children. All the stimuli were translated into Mandarin.

Table 3.2 An example of fast mapping. The familiar picture is an umbrella, which is already known to children, so the nonword *bai* is matched to the novel picture.

Novel	Familiar	Instruction
		Which is a *bai* (nonword)?

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Previous fast mapping studies were done in various ways, such as pointing (Axelsson & Horst, 2014; Baldwin, 1993a; Leung & Rheingold, 1981; Spiegel & Halberda, 2011), gazing (Baldwin, 1991, 1993b; Dunham, Dunham, & Curwin, 1993), and contrasting (Au & Laframboise, 1990; Au & Markman, 1987; Carey & Bartlett, 1978; Heibeck & Markman, 1987). It was also done in several domains, including color (Au & Laframboise, 1990; Carey & Bartlett, 1978), material (Au & Markman, 1987), shape and texture (Heibeck & Markman, 1987), and novel nouns (Axelsson & Horst, 2014; Spiegel & Halberda, 2011). Some studies showed that children remembered new words one week after the encounter (Carey & Bartlett, 1978), and other studies showed that they retained novel labels one month after the exposure (Markson & Bloom, 1997).

In this study, we used pointing as a way of indication, and divided the process into four phases. There were two phases in each of the referent selection and referent retention. Each phase contained different numbers of trials, and each trial included different numbers of pictures. Referent selection was composed of a warm-up phase and a learning phase, while referent retention consisted of a production phase and a comprehension phase. In the warm-up phase, there were six trials with one picture per trial; in the learning phase, there were 20 trials with two pictures per trial; in the production phase, there were 14 trials with one picture per trial; in the comprehension phase, there were six trials with six pictures per trial. Since previous studies showed a low retention score at the first exposure (e.g., Carey & Bartlett, 1978), we executed the task in both Session 1 and Session 2. The two sessions included all phases except for the warm-up phase, which was not executed during the second session (Figure 3.2). The numbers of trials and pictures were summarized in Table 3.3.

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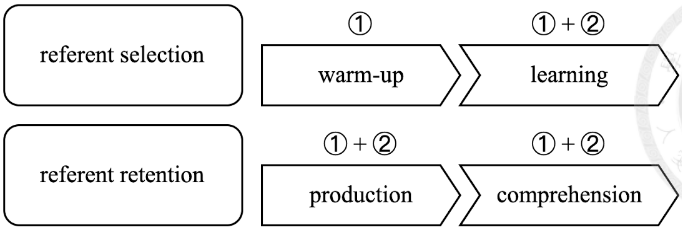

Figure 3.2 The procedure of the fast mapping task. Numbers above are the sessions in which the task was conducted.

Table 3.3 The numbers of trials in each phase and the numbers of pictures in each trial of the fast mapping task.

	Referent selection		Referent retention	
	Warm-up	Learning	Production	Comprehension
Session	1	1 + 2	1 + 2	1 + 2
Trial	6	20	14	6
Picture	1	2	1	6

3.2.2.1 Stimulus and Equipment

The focus of this study was on the comparison of learning nouns and verbs. Each group contained 14 familiar labels (i.e., words) and six novel labels (i.e., nonwords). Example stimuli of familiar label *niu* ‘cow’ and novel label *bai* (nonword) and their noises were listed in Table 3.4. The N group heard *niu* ‘cow’ and *bai* (nonword), the NN group heard *niu-niu* ‘cow-cow’ and *bai-bai* (nonword), the VV group heard *mou-mou* ‘moo-moo’ and *yi-yi* (nonword), and the VVS group heard *mou-mou* ‘moo-moo’ and *yi-yi* (nonword) with audio files they mimicked after. The VVX group was similar to the VVS group in that there were accompanying sounds, but they were irrelevant to the nonword labels with which they were paired. For instance, children

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heard a sound similar to “yi-yi” but it was labeled as *lu-lu* (nonword). Each stimulus was presented with a hand puppet.

Table 3.4 Example stimuli of *niu* ‘cow’ and *bai* (nonword) and their noises. Note: ✓ = matching sound; ✗ = non-matching sound.

Group	Word	Sound	Nonword	Sound
N	*niu* ‘cow’	N/A	*bai* (nonword)	N/A
NN	*niu-niu* ‘cow-cow’	N/A	*bai-bai* (nonword)	N/A
VV	*mou-mou* ‘moo-moo’	N/A	*yi-yi* (nonword)	N/A
VVS	*mou-mou* ‘moo-moo’	✓	*yi-yi* (nonword)	✓
VVX	*mou-mou* ‘moo-moo’	✓	*lu-lu* (nonword)	✗

Pictures of familiar labels were downloaded from https://ellii.com/flashcards, and pictures of novel labels, including aliens and UFOs, were downloaded and edited from https://www.vecteezy.com/members/hollymollylisted (see Appendix B). The pictures of the novel labels and their monosyllabic verb and noun forms were shown in Table 3.5. The novel noun labels had no existing semantic representation in either monosyllabic or reduplicated forms. The novel verb labels were selected from a sound rating pretest, as described below.

We recruited 50 native Taiwan Mandarin speakers aged between 18 and 30 (M = 22.67 years, SD = 2.45 years) from posts on Facebook pages for the sound rating pretest. It was conducted in a computer room and the stimuli were presented using Microsoft PowerPoint on a desktop computer and SONY MDR-7506 dynamic stereo headphones. We adapted animal sounds from https://g.co/kgs/dvtoHg and inanimate sounds from the YouTube Audio Library by normalizing the duration and loudness of

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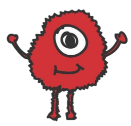
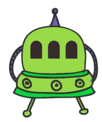
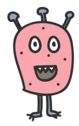
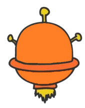
the audio files using Praat version 6.2.03 (Boersma & Weenink, 2021). A 1000 ms sound was repeated once, with a 200 ms pause in-between, resulting in a total duration of 2200 ms. All loudness was equalized at 70 dB (Figure 3.3).

Table 3.5 Novel pictures in the fast mapping task.

Stimulus	N	V	Stimulus	N	V
	*bai*	*yi*		*nei*	*lu*
	*gao*	*nou*		*fang*	*pu*
	*mu*	*hua*		*deng*	*zi*

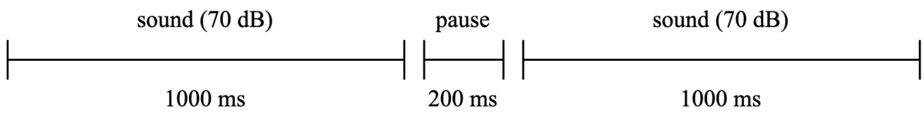


Figure 3.3 Layout of the audio file.

There were 20 audio files. Each file could be played for an unlimited number of times, and could also be replayed at any time. Upon hearing the sound, participants had to write down one syllable using Mandarin phonetic symbols (i.e., bopomofo) and describe the being or object that made the sound. If the sound source was difficult to identify, participants could fill in a question mark. The reason for transcribing in

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phonetic symbols was to limit the onomatopoeic production to those in the Mandarin sound inventory.

3.2.2.2 Prediction

For our first research question, it is rather controversial whether onomatopoeia can counteract the noun bias in novel verb learning in Mandarin. Some studies claimed that there is a noun bias (e.g., Imai et al., 2008), while other studies supported that onomatopoeias could boost word learning (e.g., Laing, 2014). Since the base form of the noun is the non-reduplicated N, and the base form of the onomatopoeia is the reduplicated VV with a matching sound, we compared the performance between general N *niu* 'cow' and onomatopoeic VVS *mou-mou* 'moo-moo' accompanied by a matching sound. However, it is unknown whether nouns or onomatopoeias perform better in novel word learning.

For our second research question, previous studies claimed that reduplication is helpful for word learning. We compared the monosyllabic N *niu* 'cow' to the reduplicated NN *niu-niu* 'cow-cow', and predicted that if reduplication really helps, NN should perform better than N. The reason why we only compared the noun form but not the verb form is because putting a monosyllabic V in a sentence frame is usually ungrammatical. For example, *huibuhui wang-wang* 'Can it woof-woof?' occurred in spontaneous speech (Chang, 2005), but *huibuhui wang* 'Can it woof?' violated the grammar of Mandarin. In most cases, a monosyllabic V only exists in wild imitation. For example, imitating a dog barking sound (Chang, 2005). The other reason that we compared only the noun forms is because reduplicating a noun generally does not affect its core meaning, but reduplicating a verb does make a difference in expressing degree.

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For our third research question, past studies claimed that iconicity helps children learn novel words. It is supposed that the higher the iconicity, the better the performance. By comparing VVS to VV, which does not include a sound, and VVX, which is accompanied by non-matching sounds, VVS should perform the best if iconicity helps. Therefore, it is not any neutral stimulus (e.g., VVX) but the similarity between the sound and the label (e.g., VVS) that helps novel verb learning.

3.2.2.3 Procedure

In the beginning of the referent selection, we did a warm-up phase to check whether the pictures that were paired with the novel pictures were familiar to the child. In this way, we could make sure that the selected answers in the learning phase were not random guesses. For all groups of children, they heard two questions: *Zhe shi shenme?* 'What is this?' and *Ta hui fachu shenme shengyin?* 'What sound does it make?'. Any reasonable answer would be scored as it was just to confirm if the child knows the picture. For example, whether the child said the umbrella itself did not make a sound, or that it made a *di-di-da-da* 'pitter-patter' sound due to the rain, both answers were considered as correct and received a score.

After that, we did the learning phase. There were a total of 20 trials composed of eight familiar trials, six novel trials, and six no-distractor trials. Both familiar and novel trials consisted of two pictures placed side by side. The familiar trials showed two familiar pictures, while the novel trials changed one of the pictures into a novel one. The no-distractor trials had only one picture on either the left or the right side. These single pictures were used to keep children attentive and to avoid a side bias, and thus they were not tested in the production and comprehension phases.

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We drew a colored circle above each picture and instructed children to say the corresponding color of the picture they selected. To make sure that there was no difficulty in identifying the colors, we inserted a slide divided vertically by two colors before the practice trials and asked the children to name both colors. It was red (#EF4736) on the left hand side, and blue (#3991CE) on the right hand side. Children were allowed to use any wordings to name or describe the colors as long as what they said was clear and consistent. For example, there was a child who used cartoon characters Roy (a red fire truck) to represent the color red and Poli (a blue police car) to represent the color blue.

On each learning trial, children were asked to repeat after the recorded label, and then select the picture. Repeating was to make sure that children heard the labels clearly and they had no difficulty pronouncing them. Children heard different questions according to their groups. The N and NN groups were asked *Nage shi __?* 'Which is a __?', whereas the VV, VVS, and VVX groups were asked *Nage hui __?* 'Which makes the sound __?'. Some examples were presented in Table 3.6.

Afterwards, we played a picker wheel game and moved on to the referent retention. There were production and comprehension phases to test how well children remembered the labels. The two phases were in a fixed order to control for the number of exposures to the novel labels. Since the comprehension phase tested novel pictures by asking questions containing all the labels, we put the production phase before the comprehension phase to avoid increasing the exposures. The production phase tapped all labels in familiar and novel trials. Children saw one picture on each slide and they received different questions based on their groups. The N and NN groups heard *Ganggang tingdao zhe shi shenme?* 'What word did you just hear?', whereas the VV, VVS, and VVX groups heard *Ganggang tingdao ta hui fachu*

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shenme shengyin? 'What sound did you hear it just made?'. The comprehension phase tapped only the novel labels. Children saw six pictures paired up with six colored circles on each slide. To make sure the children were familiar with the colors, a slide with six rectangle shapes of the six colors, white (#FFFFFF), red (#EF4736), yellow (#FDB716), green (#8EC65E), blue (#3991CE), and black (#354143), were shown to them before the practice trials. They were asked to identify the colors accordingly before proceeding. Then, the N and NN groups were asked *Nage shi __?* 'Which is a __?', whereas the VV, VVS, and VVX groups were asked *Nage hui __?* 'Which makes the sound __?'. For each trial, there were three familiar and three novel pictures, and each picture was paired up with a colored circle. All of the novel pictures were evenly spaced between trials and were not juxtaposed. An example was presented in Table 3.7.

Table 3.6 Three example trials of the learning phase for the N group. The target pictures for three example trials are the blue circles in the familiar and the novel trials, and the red circle in the no-distractor trial.

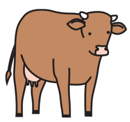
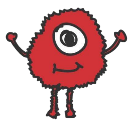
Trial			Instruction
Familiar			*Nage shi niu?* 'Which is a cow?'
Novel			*Nage shi bai?* 'Which is a *bai*?'
No-distractor			*Nage shi mi-fong?* 'Which is a bee?'

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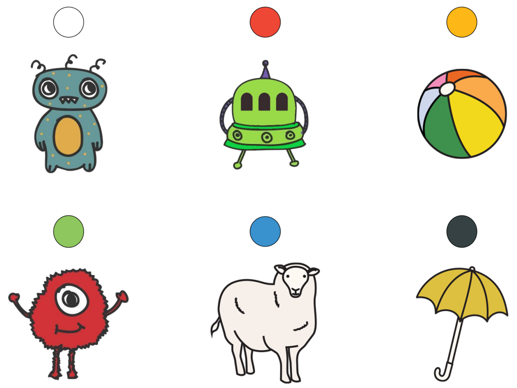
Table 3.7 An example from the comprehension phase for the N group. The target picture is the red circle.

Stimulus	Instruction
	*Nage shi fang?* 'Which is a *fang*?'

3.2.3 Productive Phonology Task

We adapted a picture naming task from Li (2015) to check how children produce Mandarin onsets and rhyme structures. There were 42 disyllabic words in the original stimuli, testing 21 Mandarin syllable-initial onsets and six rhyme structures in the first and the second syllable. To avoid fatigue, we downsized the number of trials to elicit and score only onsets and rhyme structures in the first syllable. For onsets, each accurately pronounced phoneme received one point, with a maximum score of 21. For instance, if the pronunciation of the phoneme /p/ in *ban-ma* 'zebra' was accurate, the child received one point. As for rhyme structures, the score of each rhyme structure (i.e., V, VN, VG, GV, GVN, and GVG) was averaged, with a maximum score of six. For instance, the V rhyme structure included /ɑ/, /ə/, /i/, /u/, and /y/, and thus the accuracy rate of these five rhymes was averaged to obtain a score. The reason for calculating one point each for onsets but averaging the score of rhyme structures was because children at this age were still developing their onsets but presented rather stable rhyme productions (Li, 2015).

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Children saw one picture on each slide and they had to name the picture after hearing *Zhe shi shenme?* ‘What is it?’. From their responses, we were able to find out production errors in each child. If the mispronunciation of a child in the production phase was caused by a production error or a dialectal variation, that answer would still be scored. For example, if the child spontaneously pronounced the onset /f/ as /hw/, which could be caused by either immature production or the influence of Taiwan Southern Min, novel words such as /fang/ pronouncing as /hwang/ would not be considered to be a retention failure. We could also generalize common phonetic error types as a reference for cross-group comparisons.

3.2.4 Peabody Picture Vocabulary Test-Revised (PPVT-R)

We adopted the standardized test from Lu & Liu (1998) for children aged 3 to 12 to measure vocabulary knowledge. There were Forms A and B, and we used Form A. Each form contained 125 trials, and each trial consisted of four line drawings. We started with three practice trials, and then moved on to the base trial of 3.5-year-old. All children received the same trial order, but ended when one made six errors among eight consecutive trials. They heard the instruction *Nayige shi __?* ‘Which is a __?’. After hearing a target word, children had to choose one of the four pictures and say its corresponding number. Each correct answer received one point, and the scores were later transformed into percentile ranks.

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Chapter 4 Results

In this chapter, we ran a multi-way ANOVA test for each task, and carried out a post-hoc Tukey HSD test if there was any significance. Section 4.1 presents the results of the general ability tasks, including digit span, PPVT-R, and productive phonology. Section 4.2 analyzes the data of the fast mapping task.

4.1 General Ability Tasks

In order to confirm there were no underlying patterns with regard to the assignment, we looked at whether the performance of digit span, PPVT-R, and productive phonology had no significant difference among the groups. We also ran correlation tests between the score of each task and the score of the comprehension phase in the fast mapping task. Our statistical results showed no significance for sex in any of the tasks, hence it was not specified in the following analyses.

4.1.1 Digit Span Task

The average number of digits the children memorized was 5.24 (SD = 0.96, range = 4-8). Statistics revealed that there was no significant difference among the groups [$F(4, 40) = 1.87$, $p = .13$] (Table 4.1). There was no correlation between the digit span and the raw scores of the novel labels in Session 1 [$r = .13$, $p = .38$] and Session 2 [$r = .06$, $p = .70$] in the learning phase, Session 1 [$r = .14$, $p = .34$] and Session 2 [$r = .11$, $p = .44$] in the production phase, and Session 1 [$r = .04$, $p = .79$] and Session 2 [$r = -.003$, $p = .98$] in the comprehension phase.

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Table 4.1 Children’s performance of the digit span task.

Group	N	NN	VV	VVS	VVX
M	5.20	5.10	5.10	4.90	5.90
SD	1.03	0.57	1.10	0.74	1.10
Range	4-8	4-6	4-7	4-6	5-8

4.1.2 PPVT-R

The average percentile score children obtained in the PPVT-R was 74.62 (SD = 28.08, range = 2-99). Statistics revealed that there was no significance among the groups [$F(4, 40) = .41$, $p = .80$] (Table 4.2). There was no significant correlation between the PPVT-R and the raw scores of the novel labels in Session 1 [$r = .22$, $p = .13$] in the learning phase, in Session 1 [$r = .02$, $p = .86$] and Session 2 [$r = -.04$, $p = .76$] in the production phase, and in Session 1 [$r = .04$, $p = .80$] and Session 2 [$r = .11$, $p = .43$] in the comprehension phase. However, there was a low but significant correlation between the PPVT-R and the raw scores in the second session of the learning phase [$r = .283$, $p = .047$]. As a whole, the influence of vocabulary knowledge on the fast mapping task was relatively weak.

Table 4.2 Children’s performance of the PPVT-R.

Group	N	NN	VV	VVS	VVX
M	80.50	67.60	68.50	78.00	78.50
SD	19.27	32.26	33.80	26.44	29.58
Range	32-96	19-97	2-99	19-99	4-96

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4.1.3 Productive Phonology Task

We scored each onset and rhyme structure by picking out mispronunciations based on subjective listening, and graphed the average production accuracy rate for the groups (Figure 4.1). Points would still be deducted if syllables were unanswered due to children not being familiar with the pictures or the sounds. Several common dialectal variations were accepted, such as de-retroflexion and syllable-final nasal mergers. Statistics revealed that there were no significant differences among groups for the onset production score [$F(4, 40) = .11$, $p = .98$] and the rhyme structure production score [$F(4, 40) = .34$, $p = .85$].

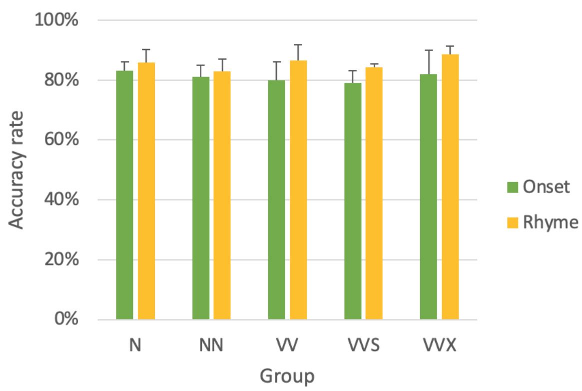

Figure 4.1 Children's performance in the productive phonology task.

For the onsets, the average production score children achieved was 17.00 (*SD* = 3.28, range = 5-21). There were two dialectal variations in the onsets. First, voiceless retroflex sibilants /tʂ/, /tʂ^{h}/, and /ʂ/ were substituted by voiceless dental sibilants /ts/, /ts^{h}/, and /s/ (Chuang, 2009). Accordingly, the de-retroflexion of a word (e.g., /tʂwo tsɨ/ 'table' → [tswo tsɨ]) would not be considered incorrect. Second, the voiced

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retroflex sibilant /ʐ/ had merged with voiced alveolar lateral approximant /l/ (Lu, 2018). As a result, pronouncing /ʐ/ as /l/ (e.g., /ʐə koʊ/ 'hot dog' → [lə koʊ]) would also receive the score. The most common onset error types included fronting and backing (e.g., /tɕiɛn tɑʊ/ 'scissors' → [tiɛn tɑʊ] & [kiɛn tɑʊ]).

As for the rhyme structure, the average production score children achieved was 5.14 (*SD* = 0.70, range = 3.35-6.00). There were two dialectal variations in rhymes. First, the syllable-final nasal /iŋ/ and /in/ had merged in Taiwan Mandarin (Fon, Hung, Huang, & Hsu, 2011). Second, the two mid back vowels /oʊ/ and /o/ had merged in Taiwan Southern Min (Hsu, 2015). Moreover, monophthongs were more unmarked than diphthongs in Taiwan Mandarin, native speakers tended to simplify /oʊ/ as /o/ and /eɪ/ as /e/ in spontaneous speech (Hsiao, 2011). Therefore, if a child merged the nasal /iŋ/ as /in/ (e.g., /p^hiŋ kwo/ 'apple' → [p^hin kwo]) or diphthong /oʊ/ as /o/ (e.g., /hoʊ tsɨ/ 'monkey → [ho tsɨ]), they still got the score because the apparent missed target was likely due to merging, not due to a delay in phonological development. The most common rhyme structure error type was nasal deletion (e.g., /nan kuɑ/ 'pumpkin' → [na kuɑ]).

4.2 Fast Mapping Task

We analyzed the familiar labels (i.e., words) and the novel labels (i.e., nonwords), and displayed the results by bar charts. As the performance of referent selection and referent retention was sequentially bound, the responses in the production and comprehension phases were scored only if the labels were correctly selected in the learning phase. In other words, if the child chose the wrong picture during the learning phase, that label would be considered a learning failure, and thus answers in the following phases would be considered random guesses. There was no significance

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for the difference score between the two sessions in any of the phases (Learning: $F(4, 40) = 1.94$, $p = .12$, Production: $F(4, 40) = 1.38$, $p = .26$, and Comprehension: $F(4, 40) = .15$, $p = .96$), we thereby comparing the average score of the two sessions in each phase. Statistical analyses revealed that there was no significant difference among the familiar labels and between sexes in any of the phases, and thus we focused only on the novel labels and the labels that were paired with the novel labels.

4.2.1 Warm-up Phase

In the warm-up phase, children could receive a maximum score of six for both picture naming (i.e., noun) and sound mimicking (i.e., verb). Nouns and verbs were scored separately because these labels represented different word categories. Statistics revealed that there was no significance for groups in both nouns [$F(4, 40) = .94$, $p = .45$] and verbs [$F(4, 40) = 1.55$, $p = .21$] but there was a correlation between the performance of nouns and verbs [$r = .43$, $p < .01$] (Figure 4.2).

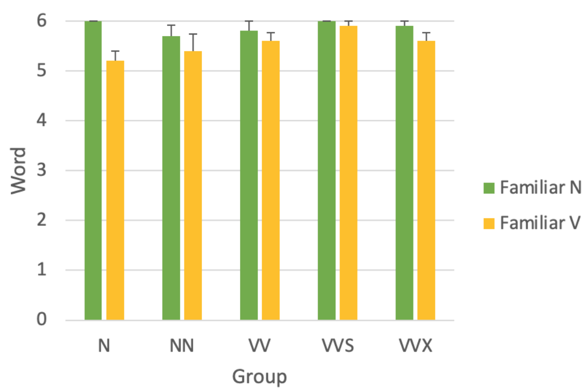

Figure 4.2 Children's performance in the warm-up phase.

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4.2.2 Learning Phase

In the learning phase, the maximum score for the novel labels was six. Statistics revealed that there was a significant group effect [$F(4, 40) = 2.92$, $p < .05$]. Post-hoc analyses showed that there were significant differences between VV and N ($p < .05$), VV and NN ($p < .05$), and VV and VVS ($p < .05$) (Figure 4.3). The VVX did not perform worse than the noun groups.

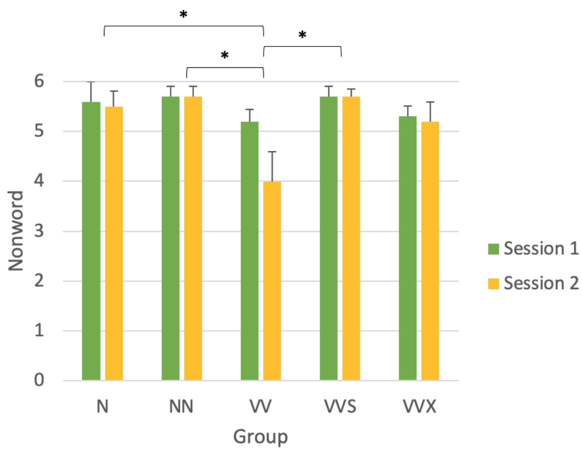

Figure 4.3 Children's performance of novel labels in the learning phase.

4.2.3 Production Phase

In the production phase, the maximum score for novel labels was six. Children received one point for each correct response regardless of the number of repetitions. For instance, if the child saw a duck and said it made the sound "gua-gua-gua" instead of "gua-gua", the response would still be marked as correct. Statistics revealed that there was a significant effect of session [$F(1, 40) = 10.91$, $p < .01$] and a near-significant effect of group [$F(4, 40) = 2.37$, $p = .07$] (Figure 4.4). Session 2 was better than Session 1.

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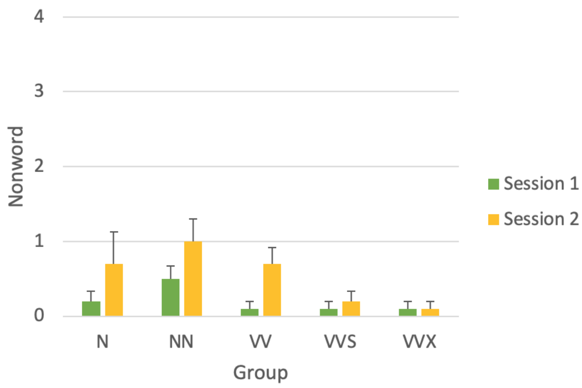

Figure 4.4 Children's performance of novel labels in the production phase.

Past studies (e.g., Carey & Bartlett, 1978; Heibeck & Markman, 1987) also showed low performance scores during production phases. The significant progression in the second session illustrated that there was an effect of exposure on retaining novel words. However, the ability of naming and identifying novel labels was not mutually related. It was not surprising that naming requires much more explicit knowledge, and thus the average score of the production phase was worse than the comprehension phase. Even though there was a marginal significance for the group, it was difficult to see a clear trend with only six novel labels in such a low score.

4.2.4 Comprehension Phase

In the comprehension phase, the maximum score for novel labels was six. Statistics revealed that there was significance for both groups [$F(4, 40) = 4.10$, $p < .01$] and session [$F(1, 40) = 11.71$, $p < .01$] (Figure 4.5). Post-hoc analyses showed that there were significant differences between VV and NN ($p < .05$), VVX and N ($p < .01$), and

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VVX and NN ($p < .01$); there was also a marginal significant difference between VVX and VVS [$p < .1$]. In this phase, Session 2 was better than Session 1.

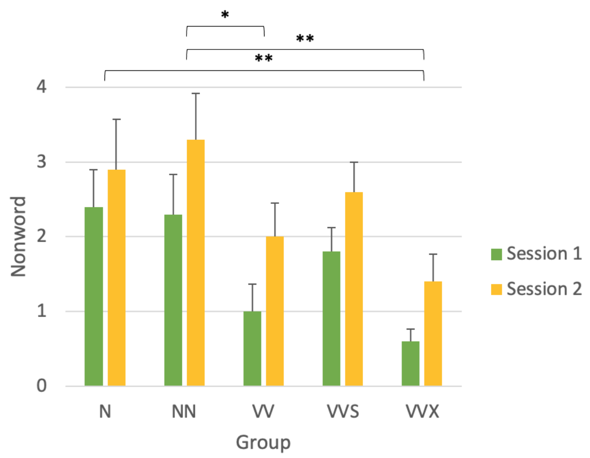

Figure 4.5 Children's performance of novel labels in the comprehension phase.

4.2.5 Online Mandarin Chinese Dictionary (Ministry of Education, 1995)

In the fast mapping task, there were 12 novel labels (i.e., nonwords) in total. The six novel noun labels were: *bai*, *gao*, *mu*, *nei*, *fang*, and *deng*, and the six novel verb labels were: *yi*, *nou*, *hua*, *lu*, *pu*, and *zi*. Some studies claimed that there is a frequency effect in language acquisition (e.g., Ambridge, Kidd, Rowland, & Theakston, 2015), and hence we took this factor into consideration. During the experiment, there was no written character provided. Therefore, we counted each label on a syllable basis disregarding tones, and summed up the token frequency from the frequency list in the online Mandarin Chinese Dictionary (Ministry of Education, 1995) to see whether the frequency of a syllable affected children's learning. The token frequency of each novel label was summarized in Table 4.3.

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Statistical results showed that the significance for the group mainly lied in the comprehension phase, we thereby aimed at comparing the novel labels for the two session scores and the difference score between the two sessions in this phase. The labels were divided into noun syllables and verb syllables. Noun syllables included labels in N and NN, and verb syllables included labels in VV, VVS, and VVX. We then ran a Pearson correlation coefficient to see whether there was a correlation between token frequency and the scores of noun and verb, respectively. The results showed that there was little correlation for either syllable type. For nouns, none of the correlation tests were significant (Session 1: $r = .11$, $p = .84$, Session 2: $r = .28$, $p = .59$, and difference scores between Session 1 and Session 2: $r = .38$, $p = .46$) (Figure 4.6). As for the verbs, the correlation tests were not significant, either (Session 1: $r = -.24$, $p = .65$, Session 2: $r = .30$, $p = .56$, and difference scores between Session 1 and Session 2: $r = .48$, $p = .32$) (Figure 4.7). This indicates that within a phonetic inventory, the familiarity of a syllable did not affect the retention of a nonword.

Table 4.3 Token frequency of the novel labels.

	N	Frequency	V	Frequency
Red alien	*bai*	3974	*yi*	49319
Blue alien	*gao*	7289	*nou*	1
Pink alien	*mu*	6460	*hua*	11904
Yellow alien	*nei*	2066	*lu*	5571
Green UFO	*fang*	9775	*pu*	1445
Orange UFO	*deng*	2955	*zi*	22067

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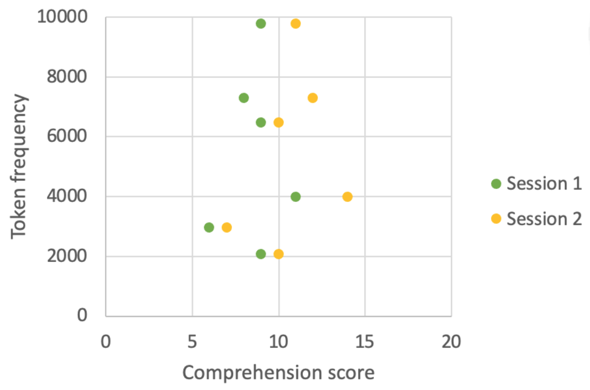

Figure 4.6 The correlation between N token frequency and comprehension score.

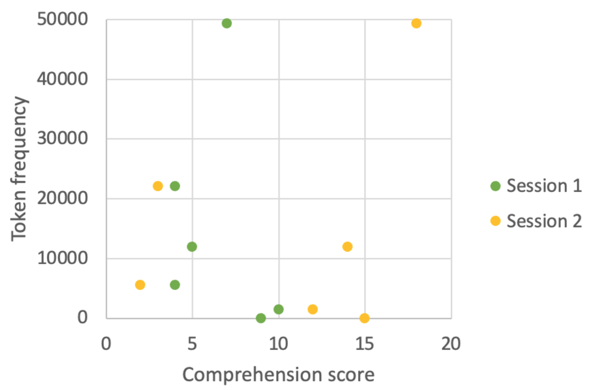

Figure 4.7 The correlation between V token frequency and comprehension score.

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Chapter 5 Discussion

In this chapter, we interpreted the results of the fast mapping task in response to the research questions. Section 5.1 discusses whether reduplication and iconicity affected novel word learning. Section 5.2 summarizes whether onomatopoeias come to rescue in Mandarin verb acquisition.

5.1 Reduplication and Iconicity

To answer our research questions, we discussed our results in three conditions: N vs. VVS, N vs. NN, and VVS vs. VV vs. VVX. Since there was no significance for familiar labels in any of the phases, we focused only on the average scores of the novel labels in both sessions in the fast mapping task. The phases that included novel labels were the learning, production, and comprehension phases. The learning phase had a significant effect on group, the production phase had a significant effect on session, and the comprehension phase had significant effects on both group and session. The discussion of each condition and some possible explanations for the results were given in the following analyses.

5.1.1 N vs. VVS

There were no significant differences between N and VVS in all three phases. At the learning phase, the significant differences between VV and N, VV and NN, and VV and VVS showed that noun bias caused an impact on learning but iconicity could help bridging the gap. It was obvious that VV performed the worst even with the help of reduplication. Both N and NN performed better than VV due to noun bias, but VVS suggested that adding a sound before the sentence enhanced the performance of

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selecting verbs. Even though VVX had a low iconicity between the sound and the label, the sound caught children's attention and helped them perform equally well as VVS in this phase. If children only heard *Nage hui __?* 'Which one will __?', they could not tell from the carrier sentence whether the novel label was an action verb or an onomatopoeia. This result indicated that iconicity played a more crucial role than reduplication in verb learning.

5.1.2 N vs. NN

There were no significant differences between N and NN in all three phases, and VV as a whole did not perform well among the three phases. Even though reduplication is commonly used in Mandarin CDS, this property did not help achieve a better retention score in either nominal or onomatopoeic forms. Moreover, our results from the CHILDES showed that the use of reduplication decreases significantly with age. Non-kinship nominal reduplications and onomatopoeic reduplications account for a limited proportion in 3-year-old children's reduplication. The input of reduplicated non-kinship nouns were 22.79% and onomatopoeias were 1.40%, whereas the output of reduplicated non-kinship nouns were 25.58% and onomatopoeias were 3.01%. It could be either children at this age do not rely much on reduplicated forms when learning words or the ceiling effect of learning nouns make reduplication seem less helpful for acquisition.

5.1.3 VV vs. VVS vs. VVX

There were no significant differences between VV and VVX in all three phases, but VVS performed relatively well in the learning and comprehension phases. At the comprehension phase, the significant differences between VV and NN, VVX and N,

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VVX and NN, and VVX and VVS implied that the iconicity of onomatopoeia boosted novel verb learning to a certain extent. Both VV and VVX had a relatively low retention score, while VVS performed equally well as the noun groups. Although the matching sound made VVS stand out, it only enhanced verbs to the same performance level as nouns. It was also interesting to note that there was a difference between non-iconic VVX and iconic VVS. Both groups received a sound cue before the carrier sentence, which means there was no ambiguity for the word category of the stimuli. However, adding a mismatching sound to the novel label made VVX difficult to retain. This might be because mismatching sounds are not only less helpful but also confusing. Therefore, it was not the occurrence of a sound but the connection between the sound and the label that made a difference.

5.2 Summary of Findings

This study examined whether onomatopoeias balance out the noun bias, and whether reduplications and iconicities boosted novel word learning. Based on our results, onomatopoeias performed equally well as nouns and that iconicity seemed to be a better propeller than reduplication in learning novel words. By adding a sound connection to the verb, the performance of verb learning could be as good as noun learning. Therefore, we drew a conclusion that onomatopoeias could bridge the gap of learning novel verbs if iconicity exists.

The findings of the current study contributed to novel verb learning that aside from numbers of exposure, creating sound connections help children perform better at retrieving their memory. Different from classical conditioning, in which the response is elicited by neutral stimulus, our findings demonstrated that without a relationship between novel sounds and novel labels, adding random sounds to the labels did not

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help learning. In particular, the token frequency of a syllable is not a crucial factor of novel word acquisition. As long as the syllable is a part of the phonetic inventory, it did not make much difference for children to learn.

Using reduplicated nouns did not actually aid novel word learning in Mandarin, but there might be other purposes during conversation, such as setting up rapport (e.g., Laing, 2019b) and processing segmentations (e.g., Ota & Skarabela, 2018). On the other hand, the iconicity of onomatopoeias can balance out the noun bias and come to the rescue for verb learning with several limitations. However, the effect of using onomatopoeia might not be as effective when there is a low connection between a sound and its label, and when the children have expanded their vocabulary. Most importantly, onomatopoeias could only boost the performance of action verbs equally well as that of regular nouns, but never more.

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Chapter 6 Conclusion

The significance of this study is that we discovered that it is powerful to learn novel words through iconicity. When a sound connection is established, the novel word could be learned with less effort. However, this study aimed only to map sounds to verbs. A potential application is to use a similar sound to connect to other types of target labels. For example, calling a dinosaur with a similar sound *dainaoshou* (呆腦獸) 'animals with thick heads' might be a possible stepping stone for beginners to learn novel words.

Our main limitation of this study would be the online experiment. Even though we asked the parents to start the video call in a quiet room and audio record the entire process, we had no control over the disturbances caused by the surroundings. Children at such a young age could be easily distracted by ambient noise, such as the traffic. It was also difficult to control the sound equipment and network quality. Since every family used different speakers, there might be some influences to the sound each child received. Moreover, unlike recording in a sound attenuated room using a digital audio tape recorder, the best recordings we could get were the ones uploaded from the parents. In other words, these recordings were done on different devices in different environments. Another limitation was the small number of children in each group. The recruitment became relatively difficult because some parents felt it was not suitable for their children to sit in front of the computer for a long time. It also took more time for children to get into the swing of things without face-to-face interaction. In the future, we should put more effort in controlling individual differences between subjects.

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The low score in the production phase could be caused by the testing order of referent retention. It was without a doubt that memorizing a label in a single exposure was relatively more difficult than identifying it, thereby putting the production phase before the comprehension phase might lead to lower answering rate due to uncertainty and frustration. Even though it was assumed that all children received the same exposure during the comprehension phase, we repeated the stimuli again if there was any internet connection error. Moreover, in actual situations, when children heard an unfamiliar label, they might intuitively say they did not hear the stimuli clearly enough. Consequently, if conducting the experiment face-to-face and switching the two retention phases, children could perhaps have a better performance score.

In future studies, we could follow up the result and do an experimental group of physical learning and compare the results with this current one. Since online learning is a trend nowadays, if there is no difference between the two ways of learning, there should be less worry about the learning results of online studies for young children. However, if there is a difference, we could look into whether the negative effect decreases with age. We could also explore whether sound connections boost novel word learning in other parts-of-speech, as in the *dinosaur* example mentioned above. These further studies could help children learn words in a more efficient and effective way without being restricted by the environment.

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Appendices

Appendix A

The Taipei City Pre-School Children Development Progress Evaluation Form (Department of Health, 2006)

臺北市學齡前兒童發展檢核表

3.5

3歲半（3歲5個月16天～3歲11個月15天）

檢查單位：＿＿＿＿＿＿＿＿ 單位電話：＿＿＿＿＿＿＿＿
填表人姓名：＿＿＿＿＿＿ 身分：□醫療人員 □老師 □社政人員 □家長 □其他＿＿＿＿＿＿
家長國籍(稱謂＿＿＿＿＿)：□本國籍□大陸□泰國□印尼□越南□柬埔寨□緬甸□其他：請註明：＿＿＿＿＿＿
家長國籍(稱謂＿＿＿＿＿)：□本國籍□大陸□泰國□印尼□越南□柬埔寨□緬甸□其他：請註明：＿＿＿＿＿＿

兒童基本資料

兒童姓名：＿＿＿＿＿＿＿＿ 性別：□男 □女 檢核日期：＿＿年＿＿月＿＿日
身分證字號：□□□□□□□□□□ 出生日期：＿＿年＿＿月＿＿日 (早產)預產日期：＿＿年＿＿月＿＿日
實足年齡：＿＿歲＿＿個月＿＿日(請務必填寫)
戶籍住址：臺北市＿＿區＿＿里＿＿鄰＿＿＿＿＿＿
聯絡住址：＿＿＿＿＿＿＿＿ 電話：（日）＿＿＿＿＿＿（夜）＿＿＿＿＿＿

發展遲緩高危險因子

1. ①□早產(懷孕期未滿37週) ②□出生體重未滿2500公克 ③□以上皆無
2. 先天性異常：
①□染色體異常(如唐氏症、特納氏症等) ②□頭顱顏面異常(如唇顎裂、外耳異常等)③□先天性新陳代謝異常(如苯酮尿症、甲狀腺功能低下等) ④□水腦脊柱裂 ⑤□頭骨提早密合 ⑥□先天性心臟病 ⑦□手足缺損畸形 ⑧□其他＿＿＿＿＿＿ ⑨□以上皆無
3. 產前、產程或產後問題：
①□孕期前3個月感染德國麻疹 ②□母親妊娠期有不正常出血安胎、糖尿病、妊娠毒血、梅毒、酗酒、抽煙 ③□產程有胎心音下降、吸入胎便、呼吸窘迫、窒息缺氧須急救、住保溫箱＿＿＿天 ④□Apgar分數過低:5分鐘後<7(或小於等於6);請參考兒童健康手冊的出生狀況紀錄表 ⑤□出生後有痙攣、無呼吸、反覆嘔吐、低體溫或哺乳不良等 ⑥□重度黃疸需換血者 ⑦□其他＿＿＿＿ ⑧□以上皆無
4. 腦部疾病或受傷：
①□水腦 ②□出血或缺氧 ③□腦部感染 ④□癲癇 ⑤□腦瘤 ⑥□其他＿＿＿＿＿＿ ⑦□以上皆無
5. 家族史或環境因素：
①□近親有視聽障礙、智能不足、精神疾病 ②□社經不利狀況 ③□孤兒或受虐兒 ④□以上皆無

發展里程檢核

兒童符合該項目描述的現象圈選「是」，若不符合或沒有該項目描述的現象圈選「否」，註記（實作）的題項表示附有圖形，請實地測試，再紀錄兒童反應。

★	1. 能不須扶東西輕易地蹲下玩玩具然後恢復站的姿勢	是	否
	2. 稍微扶欄杆或牆壁就能走上樓梯	是	否
	3. 能跑（姿勢怪異或常跌倒均不算通過）	是	否
	4. 能雙腳離地連續跳躍（雙腳必須能同時離地然後同時著地，若明顯的力量不對稱而造成兩腳高低不一，則不算通過）	是	否
	5.（實作）模仿畫一條平穩的橫線（圖1：大人先做示範，在蜜蜂和花盆間畫一橫線，然後讓兒童模仿畫：線條兩端連接蜜蜂和花盆，大體為不斷裂橫線就算通過）	是	否
★	6. 通常可以和人一問一答持續對話，使用3至4個單詞的短句，且回答內容切題	是	否
	7. 能主動用至少一種句子問問題（例如：為什麼…？…在哪裡？）	是	否
	8.(實作)能說出至少三種東西的用途(圖4:大人用手依序指著杯子、鞋子、鑰匙、鉛筆的圖形，並問「這個是做什麼用的？」如果兒童第一題答不出，可以給提示「杯子是用來喝水的」，之後就不再給提示)	是	否
	9.（實作）能理解「大」（圖2：問「哪個比較大？」必須詢問兩次均正確才通過。評估表必須轉到不同的方向詢問，避免兒童隨便選一個固定位置的答案而猜對）	是	否
	10.（實作）能正確指認一個顏色（圖3：依序問「哪一個是紅色？黃色？藍色？綠色？」亦可替換為「哪一個是蘋果的紅色？香蕉的黃色？天空的藍色？樹葉的綠色？」全部問完再從頭問一輪，必須兩次均指對的顏色才算對，以避免兒童因亂指而猜對）	是	否
★	11. 口齒不清，說話連最親近的大人也聽不懂	是	否
★	12. 經常自言自語說出一些固定的話，和當時情境無關、也不具溝通功能	是	否
	13. 檢核過程中非常不合作，出現下列任一行為如（1）不聽說明、不看示範（2）眼睛不跟隨大人手指方向（3）不肯指給大人看（4）把大人的東西搶過去自己玩（5）跑來跑去抓不住（6）似乎聽不懂指令	是	否

圖1


圖3

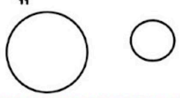
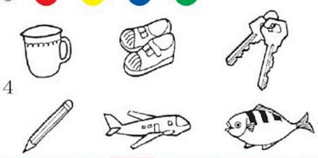

圖2


圖4


有任何2題答案是圈選在網底欄內，或有上列表內題號前有★之任何1題答案是圈選在網底欄內，或填寫人認為兒童有其他不尋常的功能或行為表現，請至本表背面所列之醫療院所做進一步檢查。請填寫是否領有身心障礙手冊：

□是（身心障礙類別＿＿＿＿＿等級＿＿＿＿） □否 □申請中

若沒有2題以上答案圈選在網底欄內，且無任何1題有★的答案是圈選在網底欄內，表示通過此階段的檢測。
日後仍請隨著小孩的發展，以不同年齡層使用的檢核表持續追蹤發展情形。

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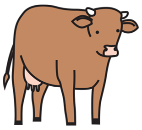
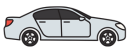
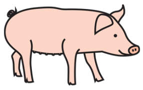
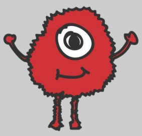
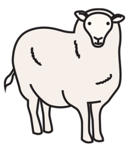
Appendix B

Stimuli in the Fast Mapping Task. Shaded ones are the novel labels.

Target	Distractor	N	V
		*niu*	*mou*
	x	*mi-fong*	*wong*
		*che*	*ba*
		*bai*	*yi*
	x	*lao-shu*	*zhi*
		*qiu*	*bong*
		*gao*	*nou*
		*yang*	*mie*

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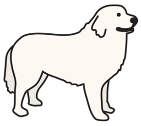
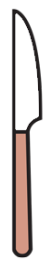
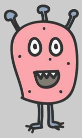
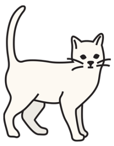
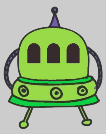
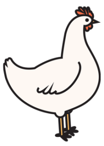
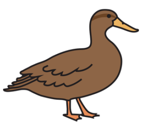
	x	*dian-hua*	*ling*
		*gou*	*wang*
		*mu*	*hua*
	x	*huo-che*	*du*
		*nei*	*lu*
		*mao*	*miao*
		*fang*	*pu*
	x	*gong-ji*	*gu*
		*ya*	*gua*

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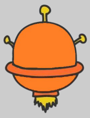
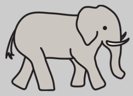
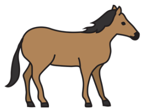
		*deng*	*zi*
		*chuan*	*wu*
	x	*qing-wa*	*guo*

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Appendix C

Stimuli in the Productive Phonology Task adapted from Li (2015).

Onset	Rhyme	Stimuli	
/p/	VN	*ban-ma*	zebra
/p^h/	VN	*ping-guo*	apple
/m/	VG	*mao-zi*	hat
/f/	VG	*fei-ji*	airplane
/t/	GVN	*dian-nao*	computer
/t^h/	VG	*tai-yang*	sun
/n/	VN	*nan-gua*	pumpkin
/l/	V	*la-zhu*	candle
/k/	GV	*guo-zi*	pot
/k^h/	V	*ku-zi*	pants
/h/	VG	*hou-zi*	monkey
/tɕ/	GVN	*jian-dao*	scissors
/tɕ^h/	GVN	*qian-bi*	pencil
/ɕ/	V	*xi-gua*	watermelon
/tʂ/	GV	*zhuo-zi*	table
/tʂ^h/	GVN	*chuang-hu*	window
/ʂ/	V	*shi-zi*	lion
/ʐ/	V	*re-gou*	hot dog
/ts/	GVG	*zui-ba*	mouth
/ts^h/	VG	*cao-mei*	strawberry
/s/	VN	*song-shu*	squirrel

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