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Sound Effect, Onomatopoeia, and Iconic Prosody in Chinese: Emerging Vocal Iconicity in Child-Directed Speech and Child Production

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Abstract

Iconicity plays an important role in language acquisition and cognition. This study aimed to better understand the use of three types of vocal iconicity in language input and child production: sound effects (e.g., making the sound of eating), onomatopoeia (e.g., meow), and iconic prosody (e.g., faaar). We coded these aspects in a corpus of Chinese adult-directed speech (ADS) and child-directed speech (CDS), in which mothers semi-spontaneously told the same story to an adult and their 18-month-old (N = 21) or 24-month-old (N = 19) children. We examined whether mothers' vocal iconicity differs between CDS and ADS and how it emerges in child production. We found that (1) mothers used significantly more sound effects and iconic prosody, but not onomatopoeias, in CDS compared to ADS; (2) In CDS, the proportions of the three types of iconicity ranked as iconic prosody > sound effects > onomatopoeias, whereas the proportions for children emerged as sound effects > iconic prosody and onomatopoeias; (3) Chinese children aged 18 or 24 months produced little onomatopoeia and iconic prosody (except for one instance at 24 months). In conclusion, iconicity is more prevalent in CDS than in ADS, and iconic prosody is an advanced prosodic skill that is not typically developed by two-year-old children.

Index Terms: vocal iconicity, child-directed speech, child production, iconic prosody

1. Introduction

Iconicity refers to "the perceived resemblance between the form and meaning of a sign." [1, p. 270]. While arbitrariness has traditionally been considered the main characteristic of human language [2], there is a growing body of evidence indicating that iconicity is more deeply rooted in human communication than previously thought. Iconicity is prevalent in sign languages and can be found in both gestural and vocal modalities in spoken languages [3]. Research has shown the role of iconic gestures in early language acquisition [4], [5], [6], but there is a lack of research on the development of vocal iconicity, particularly in terms of iconic prosody (e.g., looong) [7]. For example, our understanding of how common vocal iconicity is in early language input and how children develop it is limited. This paper presents a systematic comparison of three types of vocal iconicity between Chinese adult-directed speech (ADS) and child-directed speech (CDS): onomatopoeia, sound effects, and iconic prosody. Additionally, the paper examines the emergence of vocal iconicity in child production.

1.1. Vocal iconicity and early word learning

When children learn new words, they need to map the sounds to their meanings. Most of these mappings appear to be arbitrary, except for onomatopoeias, which are words imitating sounds of animals, objects, or other noises, like "meow" and "buzz" in English. Relatedly, sound effects are the sounds produced when speakers imitate the sounds of an action or an animal, such as the sound of eating or barking. While previous studies often categorize sound effects under the umbrella of onomatopoeias [8], we further make a clear distinction between the two for the following reasons: First, compared to onomatopoeias, sound effects may be easier or funnier to produce, and second, onomatopoeias are lexicalized whereas sound effects are not, resulting in different lexical representations. Nevertheless, these iconic mappings between form and meaning may bootstrap learning [9]. As Motamedi *et al*. [8] proposed, onomatopoeias (including sound effects) may support children's early word learning by allowing them to access the sensory properties of real-world referents. They help children understand the speech sounds they hear, which can refer to objects or actions in the world [9]. In addition, children acquire a lexical repertoire based on onomatopoeia; for example, "choo choo" refers to a train in English and "miao" refers to a cat in Chinese.

In addition to onomatopoeia and sound effects, recent studies have revealed that iconic prosody is another important element of vocal iconicity. Iconic prosody refers to the use of pitch, speech rate, stress, and rhythm in speech to imitate or reflect the characteristics of what is being described. It is typically shown in semantic dimensions such as spatial position/direction (e.g., up, down, high, low), size (e.g., big, small), amount (all, more, full), speed (quick, fast, slow, lazy), distance (far, close, long, short), loudness (noisy, loud, quiet, asleep), etc. For example, speakers may elongate the word "long" as "looong" or raise the pitch when saying "up." Iconic prosody is rooted in sensorimotor properties [10], and it can aid children in learning words in these dimensions by offering a simulation or embodiment of the meanings [11]. These words are more abstract than concrete words, which are harder to learn [12]. However, by using iconic prosody to mark these words, their degree of abstractness decreases, making it easier for children to extract them from speech and, therefore, to learn.

In general, children are perceptually biased towards words that have a higher degree of iconicity [13], [14], and they learn iconic words earlier [15]. They might employ different forms of vocal iconicity as a foundation for language learning. Nevertheless, the questions remain: how does vocal iconicity manifest in children's language input, and when do children start to use it in their production?

1.2. Vocal iconicity in language input

When addressing children, mothers often use a unique speaking style known as child-directed speech (CDS), which plays a

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crucial role in language acquisition [16]. CDS differs from adult-directed speech (ADS) in acoustic features, lexical choices, prosody, syntactic features, etc. [17], [18], [19]. So far, studies that have explored vocal iconicity in CDS have focused on onomatopoeia. Onomatopoeia generally occurs more frequently in CDS than ADS, and the frequency decreases between 18 and 36 months as children's vocabulary size increases rapidly [8], [20]. Many child-directed specific words are in onomatopoeic forms [21]. Also, they are prosodically more salient compared to conventional words in CDS [22].

The most prominent feature of CDS is its exaggerated prosody. Recent studies indicate that mothers use prosody to highlight unfamiliar words compared to familiar words [23], [24], [25], and that the prosodic adaptation in CDS can predict children's learning outcomes [25], [26]. Furthermore, mothers adjust their use of CDS based on the age of their children [24]. Using a shared-book reading task, Herold *et al*. [27] measured the prosody of dimensional adjectives (e.g., big, small, hot, cold) in CDS and found that mothers modulate amplitude and duration to distinguish dimensional adjectives. This study only used a specific set of target words to elicit contrastive adjectives in CDS rather than examining how mothers naturally incorporate iconic prosody in CDS.

1.3. Vocal iconicity in child production

Cross-linguistically, onomatopoeias are among the first words that young children produce [28], [29]. Perry *et al*. examined the relationship between frequency and iconicity for about 2000 English words and discovered that younger children tend to use more iconic words [15]. In relation to iconic vocal production, children start to produce iconic gestures relatively late, usually around 26 months of age [30], although children who speak verb-biased languages such as Turkish master them as early as 19 months [31]. It seems that despite children's perceptual bias towards learning iconic forms, producing them is a more advanced skill that is acquired later in life. As no study has specifically focused on the onset of iconic prosody in children before 24 months of age (though see [11] for an ongoing study of English-learning children aged 24 to 52 months), its developmental trajectory remains unclear.

1.4. Current study

To sum up, examining vocal iconicity in CDS will reveal the iconic language environment a child is exposed to. Also, understanding the emergence of iconicity in language production will provide us with a window into children's early language and cognitive development. Importantly, previous studies on the role of iconicity in child language acquisition have predominantly been done on English-learning children. However, languages (especially non-Indo-European languages) differ vastly in the prevalence of vocal iconicity (e.g., sound symbolism [9]). The aim of this study is to better understand the use of three forms of vocal iconicity—sound effects, onomatopoeia, and iconic prosody—in Chinese CDS and child production. Specifically, we ask the following questions:

(1) What are the differences in the frequency of vocal iconicity between CDS and ADS? Based on previous studies indicating that caregivers tend to use more iconic gestures ([32] [33]) or iconic signs [34] in child-directed language than adult-directed language, we predict that mothers use more vocal iconicity in CDS than in ADS.

(2) Does the frequency of vocal iconicity change in CDS addressed to 18- and 24-month-old children? Based on previous research on the age-related changes of CDS and the evidence that English mothers' use of onomatopoeia decreases while iconic gesture increases as children get older [6], [8], we predict that Chinese mothers' use of onomatopoeia and sound effect will decrease between 18 and 24 months. The trajectory for iconic prosody is less clear, as it is more abstract. If it follows a pattern similar to that of iconic gestures, it will increase with children's age. However, a recent study did not show an age effect [35].

(3) What is the distribution of the three types of iconicity in CDS? Previous research has shown that onomatopoeia is frequent in both child production and CDS (see [22] for a review) and iconic prosody is rare [35]. Therefore, we hypothesize that mothers will use more onomatopoeias (and sound effects) than iconic prosody.

(4) Given the lack of research on children's vocal iconicity production, we ask if 18- and 24-month-old children begin to produce the three types of vocal iconicity, especially iconic prosody. Since onomatopoeia is the most common word class in children's early lexicon and iconic gestures emerge later, we predict that children begin producing onomatopoeias at 18 and 24 months before producing iconic prosody.

2. Method

2.1. Speech corpus and participants

To address the research questions, we used a corpus of ADS and CDS [36]. Participants included forty Mandarin-Chinese-speaking mother-child dyads. The child participants were divided into two age groups: 18-month-old (N = 21, 9 girls and 12 boys; mean age = 18;15, age range = 17;21–18;27) and 24-month-old (N = 19, 10 girls and 9 boys; mean age = 24;13, age range = 23;27–24;30). All children were typically developing and had no reported language impairments or hearing problems.

A 12-page picture book was created to elicit ADS and CDS. Each page featured a word on the left side and an illustration of the word on the right side. Mothers were free to construct the story, as no other script was provided besides the words. Mothers were required to include the words given on each page. As such, both ADS and CDS were semi-spontaneously speech.

Each participant mother told the story twice, once in ADS and once in CDS. To elicit CDS, the mothers were instructed to tell the story to their child as they normally would at home. To elicit ADS, the mothers told the same story to an adult (female, a Mandarin native speaker), while the child was not present. The order of the two speech registers was counterbalanced across participants. Since the mothers told the same story in both ADS and CDS, we can compare their adaptation when the content was similar in the two speech registers.

2.2. Data coding

2.2.1. Speech transcription and annotation

We used an automatic Chinese speech recognition tool developed by Iflytek (https://www.iflyrec.com) to transcribe speech data. The speech data consisted of 6740 utterances. Following Martin *et al*. [37], utterances were defined as "[…] any pause longer than 200 ms which is preceded by an intonational phrase boundary (pauses not accompanied by an IP boundary were considered utterance-internal)". In ADS, the speech of the mother was transcribed, while in CDS, the speech of both mothers and children was transcribed. All utterances were manually aligned with the speech data in Praat, and a third

native speaker listened to each utterance to verify the accuracy of the transcription.

2.2.2. *Onomatopoeia and sound effect*

Each utterance was coded for the presence of onomatopoeia (1 = with onomatopoeia; 0 = no onomatopoeia) and sound effects (1 = with sound effect; 0 = no sound effect) in Praat by a native speaker. A second coder went through all the data, and the intercoder reliability was 100%.

2.2.3. *Iconic prosody*

Iconic prosody was subjectively judged by three Chinese speakers, as was done in [35]. We created a list of Chinese words that could elicit iconic prosody, including seven abstract dimensions: amount (e.g., *duo* 'many'), directions/position (e.g., *gao* 'high'), distance (e.g., *yuan* 'far'), loudness (e.g., *qing* 'quiet' and whispering), size (e.g., *da* 'big'), speed (e.g., *kuai* 'quick'), and strength (*shijin* 'hard') [38]. Additionally, we included verbs that denote upward and downward movement, as well as fast or slow movement (e.g., *tiao* 'jump') [39]. Next, a trained research assistant (a native speaker) listened to all the utterances containing target words and marked a "1" whenever there was iconic prosody produced by the mother or the child in Praat [40]. The first author listened to all the target words and identified those with agreements. Subsequently, the first author and the third author listened through all the utterances marked with iconic prosody and included only those on which they both agreed (1 = with iconic prosody; 0 = no iconic prosody). Thus, only the items that were agreed upon by three native speakers were included in the analysis. Intercoder agreement reached 93.33%, with a Cohen's Kappa of 0.87, indicating strong consistency. For these items, we further coded their dimensions.

2.3. Data analysis

We used R [41] for data analysis. First, we compared the frequency of vocal iconicity across speech registers (ADS/CDS) and ages (18 months/24 months). The response variable was a binary code indicating whether an utterance contained each type of vocal iconicity (if yes, coded as 1; otherwise, 0). To compare the differences in the proportion of vocal iconicity, we used a generalized linear mixed model (GLMM) implemented through the 'glmer' function from the 'lme4' package [42]. The fixed effects were Speech Register (ADS/CDS), Age (18 m/24 m), as well as their interaction. The interaction between Speech Register and Age was dropped when it did not significantly improve the model. Participant was added as a random intercept. Second, to compare the number of dimensions between ADS and CDS, we used the Wilcoxon signed-rank test.

3. Results

3.1. Vocal iconicity in ADS and CDS

3.1.1. *Proportions of vocal iconicity between ADS and CDS*

We did not observe any age-related changes in mothers' use of vocal iconicity, as the effect of age was not significant for any of the three types. As such, the effect of age was removed from the models. When comparing the two speech registers (Figure 1), the results showed that mothers used significantly fewer sound effects (*beta* = -1.05, $p = 0.019$) and iconic prosody (*beta* = -0.91, $p = 0.003$) in ADS ($N_{SE} = 6$; $N_{IP} = 13$) compared to CDS ($N_{SE} = 36$; $N_{IP} = 75$). However, there was no difference in the proportions of onomatopoeia between the two speech registers ($p = 0.31$, $N_{ADS} = 4$; $N_{CDS} = 18$).

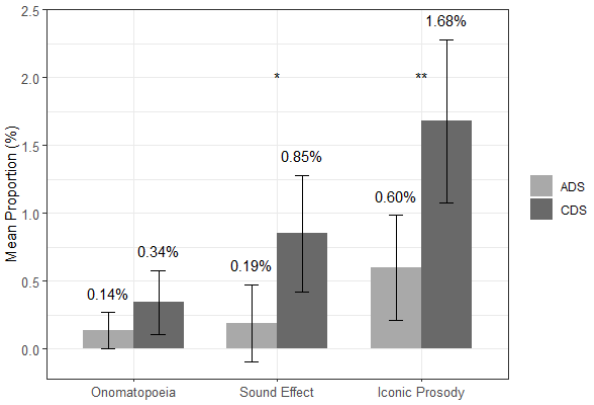

Figure 1: *Mean proportions (95% CI) of onomatopoeia, sound effects, and iconic prosody in ADS and CDS.*

Furthermore, iconic prosody was significantly more frequent than sound effects ($W = 78.5$, $p = 0.001$), which in turn were more frequent than onomatopoeias ($W = 32.0$, $p = 0.011$). These findings indicate that iconic prosody, although understudied in previous research, seems to be the most preferred form of vocal iconicity, at least in this Chinese CDS corpus.

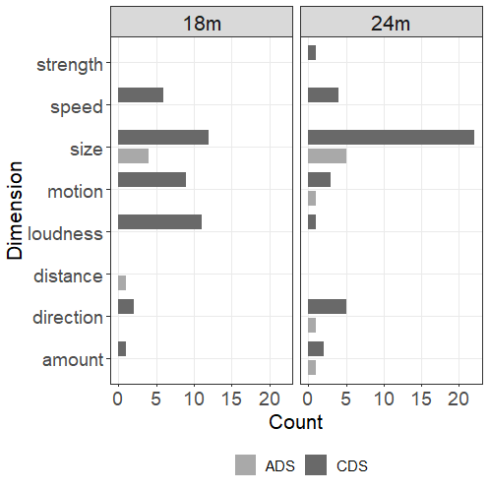

Figure 2: *Number of cases with iconic prosody (by dimension) in ADS and CDS.*

3.1.2. *The dimensions of iconic prosody in CDS*

As shown in Figure 2, in general, CDS had a broader range of dimensions compared to ADS: iconic prosody in ADS was restricted to amount, direction, distance, motion, and size, while CDS included seven dimensions. When aggregating the number of dimension types per condition per participant, the Wilcoxon signed-rank tests revealed that both at 18 and 24 months, CDS (18m: $M = 1.14$, $SD = 1.06$; 24m: $M = 1.26$, $SD = 1.59$) had significantly more dimensions than ADS (18m: $M = 0.19$, $SD = 0.4$; $p < 0.001$; 24m: $M = 0.37$, $SD = 0.6$, 18m: $p = 0.002$, 24m: $p = 0.022$). This suggests that there are more types of dimensions in CDS compared to ADS. Additionally, a Mann-Whitney U test showed that there was no significant effect of

age on the number of dimensions ($p = 0.8$), suggesting that there were no age-related changes in the number of dimension types.

In summary, besides the more frequent occurrence of iconic prosody in CDS, this speech register also has a wider variety and greater number of dimensions of iconic prosody.

3.2. Vocal iconicity in child production

During the CDS condition, children had a total of 531 speech productions (including utterances and verbal productions that were unclear). There was no significant effect of age on the proportions of the three types of vocal iconicity. As shown in Figure 3, the most common type of child production was sound effects, with a total of 13 cases, accounting for 2.45% of all child productions. However, none of these productions included onomatopoeia, the lexicalized form of natural sounds. Interestingly, there was a single instance of iconic prosody at 24 months: using an extremely high pitch when producing "high". It should be noted that in this case, the child repeated the mother's iconic high-pitched prosody. This suggests that children may not start using iconic prosody until at least 24 months of age.

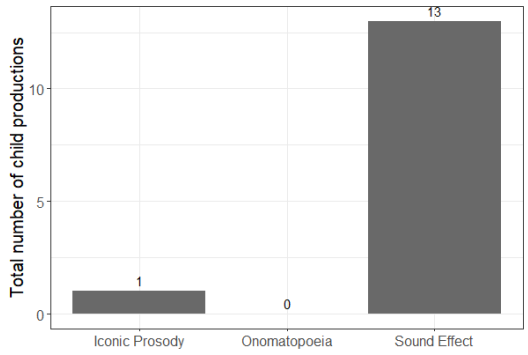

Figure 3: *Onomatopoeia, sound effects, and iconic prosody in 18- and 24-month-old children's production.*

4. Discussion

The current study examines the development of vocal iconicity in language acquisition. Specifically, we conducted a systematic comparison of the use of vocal iconicity in CDS and ADS with similar contents and investigated how vocal iconicity emerges in young children. Importantly, we extended previous research to include iconic prosody, a type of vocal iconicity that has received little attention in existing literature.

As predicted, CDS is generally more iconic than ADS. In particular, mothers employed a higher frequency of sound effects and iconic prosody in CDS as compared to ADS. Furthermore, CDS had a greater variety and more dimensions of iconic prosody than ADS. These findings indicate that CDS is tailored to the developmental stage of children, with mothers employing more iconic features that could potentially enhance language learning.

When it comes to child production, we have shown that children produced more sound effects compared to the other two types of iconicity, though the overall production of iconicity was not frequent before the age of two. Similar to iconic gestures, iconic prosody is also something that children learn later on. We have observed one instance of a child imitating their mother's iconic prosody at 24 months old, which is the first time iconic prosody has been documented in Chinese children. It is possible that because iconic prosody is often linked to more abstract concepts, children acquire these concepts later than more concrete words. Since the emergence of iconic gestures varies across cultures, it is necessary to further investigate whether the developmental trajectory of iconic prosody is specific to Chinese or culturally independent.

While onomatopoeias are often considered to be words that children learn early on and are more prevalent in CDS compared to ADS, our findings indicate that the frequency of lexicalized onomatopoeia is not significantly higher in CDS than in ADS. Instead, it is the sound effects that are significantly more frequent in CDS. It remains to be seen whether a similar pattern exists in other languages. Furthermore, despite previous research suggesting that onomatopoeias are among the first words uttered by children, the children in this specific study, aged 18 and 24 months, did not produce any onomatopoeic words. Instead, they produced sound effects during mother-child interaction. It is important to note that previous research did not differentiate between sound effects and onomatopoeia, so it would be beneficial to explore these distinctions in other studies and other languages. Also, since studies on early vocabulary often rely on parental reports, such as the M-CDI, it is possible that parents may not differentiate between these two types of lexical representations. This suggests that future research should differentiate between onomatopoeia and sound effects when studying early lexical development, as they may have different roles in language production. In addition, we used subjectively judged iconic prosody in the current study. Further acoustic analyses are required to determine the salience of items with iconic prosody compared to those same items that are not judged as iconic.

5. Conclusions

In conclusion, iconicity is more prevalent and variable in CDS than in ADS, and iconic prosody is an advanced prosodic skill that is typically not developed by two-year-old children. Moreover, children are able to produce sound effects, but they do not yet produce lexicalized onomatopoeias by this age. Despite language being predominantly arbitrary, speakers, especially caregivers, use iconicity to bridge the mapping between words and the world. Consequently, the significance of vocal iconicity, particularly iconic prosody, in language acquisition calls for further investigation.

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