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Development of Mandarin Onset-rime Detection in Relation to Age and Pinyin Instruction

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Abstract

Development of explicit phonological awareness (PA) is thought to be dependent on formal instruction in reading or spelling. However, the development of implicit PA emerges before literacy instruction and interacts with how the phonological representations are constructed within a certain language. The present study systematically investigated the development of implicit PA of Mandarin onset-rime detection in relation to age and Pinyin instruction, involving 70 four- to seven-year-old kindergarten and first-grade children. Results indicated that the overall rate of correct responses in the rime detection task was much higher than that in the onset detection one, with better discrimination ability of larger units. Moreover, the underlying factors facilitating the development of Mandarin onset and rime detection were different, although both correlated positively with Pinyin instruction. On one hand, with age, development of rime detection appeared to develop naturally through spoken language experience before schooling, and was further optimized to the best after Pinyin instruction. On the other hand, the accuracy of onset detection exhibited a drastic improvement, boosting from 66% among preschoolers to 93% among first graders, establishing the primacy of Pinyin instruction responsible for the development of implicit onset awareness in Mandarin.

Index Terms: phonological awareness, onset-rime detection, age, Pinyin instruction

1. Introduction

Phonological awareness (PA) generally refers to the ability to perceive and manipulate the sounds of spoken words in a language [1, 2]. It incorporates awareness of the most basic speech units - phonemes - as well as larger units such as rimes, tones (in tonal languages) and even syllables. Moreover, it is necessary to make the distinction between implicit and explicit awareness of phonological units (e.g., [3-5]). The "awareness" constituent of the term is as important as the "phonological" constituent, for the skill is proposed to involve, not simply unconsciously discriminating speech sounds (implicit PA, i.e., the ability to detect whether two segments are the same or different), but also explicitly and deliberately processing and acting upon them (explicit PA, i.e., the ability to explicitly segment, delete, blend segments).

How is the developmental trajectory of PA? Development of explicit PA in Indo-European languages is thought to be mainly dependent on the knowledge of grapheme-phoneme correspondences, and therefore unlikely to develop without formal instruction in reading or spelling (e.g., [6-8]). For example, Morais and colleagues [9] asked participants to explicitly add or delete a phone at the beginning of a syllable. Results showed that Portuguese adults who were illiterate performed much more poorly than comparable people who had been illiterate as adults but had subsequently learned to read. Moreover, for children whose native language is Chinese, which is logographic and the representations of orthography and phonology are relatively independent [10], the results are also consistent with this interpretation. Read, Zhang, Nie, and Ding [11] found that Chinese adults literate only in Chinese characters could not add or delete individual consonants in spoken Chinese words, while a comparable group of adults, literate in alphabetic spelling (Pinyin) as well as characters, could perform the same tasks readily and accurately. Huang and Hanley [12] demonstrated that Taiwan children taught to use a phonological coding system (*Zhuyin-Fuhao*) were significantly better able to delete phonemes from Chinese syllables than were Hong Kong children, who do not learn a phonological coding system in school. Similarly, in both syllable deletion and onset deletion tasks, children from Xi'an who received Pinyin training performed much better than Hong Kong peers [13]. In conclusion, explicit PA of speech is thus not attained spontaneously but is probably provided by learning to read or spell.

The development of implicit PA affirmatively emerges before literacy instruction and reflects children's phonological representations. For instance, Anthony and colleagues [14, 15] have found that implicit PA in English is measurable in children as young as two-year-old. Furthermore, many studies concerning Indo-European languages, in which the orthographic and phonological information are unavoidably confounded, demonstrated that implicit PA increases are attributable to both age and reading experience (see [5], for a review). From a developmental perspective, it may be that different aspects of implicit PA are more or less influenced by age changes as compared to educational experiences (e.g., [16]). For example, in English, although awareness of syllables seems to emerge naturally with age phoneme-level awareness is at least partly attributable to literacy instruction (e.g., [16-17]).

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Few studies have focused specially on the development of implicit PA in Chinese. Shu et al. [18] adopted phonological detection tasks of two-alternative forced choice (2AFC) in Mandarin-speaking children from kindergarten (three- to five-year-olds) and primary school (six- to seven-year-olds). Results indicated that different levels of implicit PA appear to have different developmental trajectories. In particular, the development of syllable awareness and rime awareness appeared to depend primarily upon maturational age. In contrast, awareness of phoneme onset increases strongly when children were six-year-old in first grade of primary school. However, there were some limitations of their research. First, the reliability estimates of their 2AFC tasks were relatively low, given that only two pictures were used for each trial. Besides, both the onset and rime detection tasks consisted of only eight experimental trials, while there were totally 21 onsets and 39 rimes in modern Mandarin. Finally, in Mainland China, none of the children from kindergarten had received Pinyin training, whereas all first graders had. Consequently, in their study, six-year-old first graders showed a significant enhancement in their onset detection task, which could be potentially attributed to two factors: physiological maturation at the age of six and/or explicit instruction in phonological coding (i.e., Pinyin) in the first grade. However, which of these factors (if either) plays the most important role for the improvement of implicit onset awareness has not been definitively disentangled yet.

In the current study, we modified the 2AFC paradigm by using three picture choices for each trial to increase reliability estimates. Moreover, the onset and rime detection tasks included all the 21 onsets and 39 rimes in Mandarin. Finally and most importantly, in order to shed light upon the underlying factor responsible for implicit PA development, and to determine whether there is a milestone during the developmental trajectory of implicit onset-rime awareness in the context of age growth and Pinyin education, young children involved in the current study were consequently divided into five different age groups: four-, five- and six-year-olds in kindergarten, and six- and seven-year-olds in the first grade.

2. Methods

2.1. Participants

Seventy young children aged four to seven years were recruited, with Mandarin as their native language. Informed consent was obtained from all parents and children. The children were recruited from two kindergartens and one primary school, which had students from roughly equivalent family backgrounds in terms of both socioeconomic status and the parents' education levels. Of these, 14 children were in the four-year-old group from kindergarten (seven girls), 14 were in the five-year-old group from kindergarten (nine girls), and 14 were in the six-year-old group from kindergarten (eight girls). Another 14 children were also in the six-year-old group but from a primary school in the first grade (six girls), and 14 were in the seven-year-old group also in the first grade (six girls). We refer to these five groups as: four yr, five yr, six yr (K), six yr (P), and seven yr throughout this paper.

The nonverbal intelligence of the children had been assessed by the local administrant hospital before children went to school using Raven's Standard Progressive Matrices [19], with all child participants showing normal nonverbal intelligence. Moreover, since Gathercole and Baddeley [20] argued that children with specific language impairments (SLI) have reduced phonological storage in their working memory, every child's language ability (LA) was screened with the '*Tests of Language Ability in young children*' [21] which consists of five subtests (including grammatical competence, basic vocabulary, semantic application, verbal cognition, and language expression). Results indicated all child participants showed normal language development. The basic information of the child participants is shown in Table 1.

2.2. Materials and Procedures

Very young children are most appropriately tested using forced-choice paradigms because such receptive tasks tend to be easiest for them to understand and/or respond to. Selected materials for the detection tasks were line drawings of common objects or actions which were familiar to young children to ease memory load, mainly from Snodgrass database [22]. During the tasks, children firstly heard a target Mandarin syllable paired with the corresponding picture and were asked to tell which of the other three syllable choices, also paired with pictures, sounded more similar to the target one.

All the sound files were derived from natural recordings of a female native Mandarin speaker from the Northern China (22050 Hz sampling rate, 16-bit resolution). The four pictures in each trial were semantically unrelated, and the tone category of the four syllables in each trial was kept constant.

Two tasks about implicit phonological awareness, the onset detection task and the rime detection task, were carried out in a quiet room at kindergarten or school which lasted around 20 min and 30 min respectively (following [18]). The onset detection task consisted of three practice trials and 21 testing trials, and the rime detection task included three practice trials and 39 testing trials given that there are 21 onsets and 39 rimes in Mandarin. In the onset detection task, none of the three choices had the same rime as the target. Similarly, in the rime detection task, none of the choices had the same onset as the target. The order of the onset detection task and the rime detection task was counterbalanced across child participants.

For instance, in the rime detection task, after hearing the target sound, *bao 1* (bag), and the other three sound choices, *yan 1* (cigarette), *dao1* (knife) and *xin 1* (heart), children were asked to select the similar one from the three choices and to point at the corresponding picture (see Fig. 1). In this case, the answer is *dao 1* (knife), because the target syllable *bao 1* (bag) and *dao 1* (knife) share the same rime, i.e., *ao 1*. Similarly, in the onset detection task, the target sound *hei 1* (black), the correct choice *hua 1* (flower), and two other distracter choices *ji 1* (chicken) and *che 1* (car) were randomly presented to child participants.

Figure 1: *An example of the rime detection task.*

Table 1: *Characteristics of children in five age groups*

	Four yr	Five yr	Six yr (K)	Six yr (P)	Seven yr
Number	14	14	14	14	14
Age (year ; month)	4;1 – 4;11	5;2 – 5;10	6;1 – 6;10	6;2 – 6;11	7;1 – 7;10
Mean age （year）	4.52 ± 0.24	5.53 ± 0.21	6.24 ± 0.19	6.4 ± 0.23	7.25 ± 0.21
Accuracy of LA (%)	91.24 ± 3.88	92.58 ± 4.54	95.58 ± 3.21	95.28 ± 3.6	95.86 ± 2.98

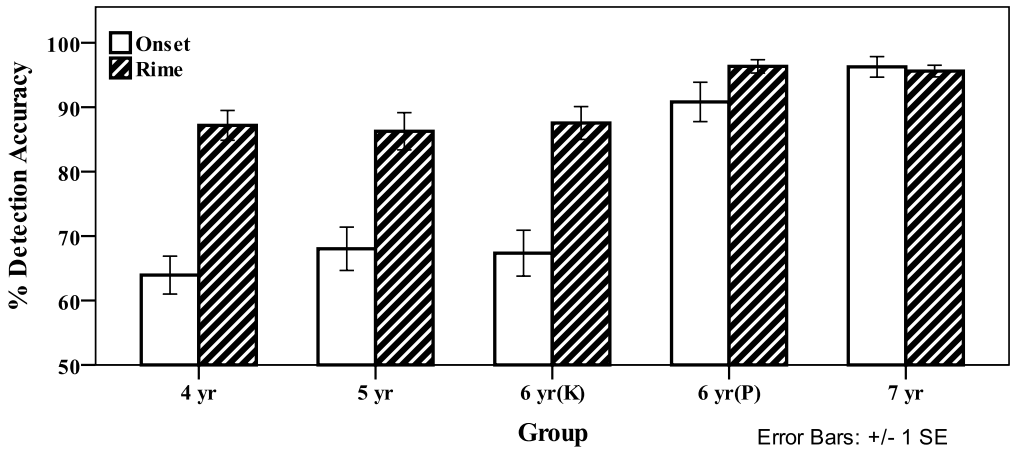

Figure 2: *Accuracy of onset and rime detection pooled across different age groups.*

3. Results

Rates of correct responses were quantified as the average ratios of the correct responses in the onset and the rime detection tasks respectively. Figure 2 showed the correct response rates of the two tasks among different age groups. Because the tasks were three-choice forced choice tasks, the chance level was approximately 33.3%. Results showed that performance of all children groups was significantly above the chance level in both tasks (all *ps* < 0.001).

A two-way 5 (age group) × 2 (detection task) ANOVA was carried out with the rates of correct responses as the dependent variable, detection task as a within-subjects factor and age group as a between-subjects factor. Significant main effect was found for age group [F (4, 65) = 19.05, p < .001] and task [F (1, 65) = 150.24, p < 0.001], as well as a significant interaction effect [F (4, 65) = 18.066, p < 0.001], indicating different age groups scored differently, and the overall rate of correct responses in the rime detection task was much higher than that in the onset detection one. Tukey post-hoc comparisons indicated that the first graders at the age of six and seven, performed significantly better than the kindergarten-level groups, at the ages of 4, 5, and 6, on both the onset detection (all *ps* < 0.001) and the rime detection (all *ps* < 0.05) tasks. However, the kindergarten-level children did not differ from one another on the two tasks (all *ps* > 0.05), nor did the first-grade children between six and seven years of age (all *ps* > 0.05).

The three kindergarten-level age groups performed similarly, and the same went to the two first-grade age groups. Consequently, the five age groups were further divided into two levels of groups: kindergarten group and first-grade group. Means and standard deviations of the rates of correct responses for the onset and rime detections between the two groups were shown in Table 2. The accuracy of onset detection was dramatically improved from 66.44 % for preschoolers to 93.54 % for first graders (p < 0.001). Although preschoolers scored a high accuracy of around 86.99 % in the rime detection task, with Pinyin instruction in first grade, the accuracy increased to 95.98 % (p < 0.01), some first-graders even reaching the ceiling level.

Table 2: *Means and standard deviations of the rates of correct responses for the onset-rime detection between kindergarten and first-grade groups*

Tasks	**Preschoolers**		**First Graders**	
	Mean	SD	Mean	SD
Onset Detection (%)	66.44	12.30	93.54	8.69
Rime Detection (%)	86.99	9.66	95.98	3.63

4. Discussion

The English writing system is clearly phonemically based, whereas the Mandarin writing system is characterized as ‘morphosyllabic’, with each Mandarin character representing both a morpheme and a syllable simultaneously. It offers an opportunity to investigate the sensitivity to the phonological structure of a spoken language that is relatively free from influences of an alphabetic orthography in children learning non-alphabetic languages such as Mandarin.

In the present study, we examined Mandarin children's implicit PA at the levels of onset and rime in kindergarten and first-grade children aged four to seven in a systematic way. Our preschoolers were divided into three age groups from aged four to six and had received no formal literacy instruction at school. In comparison, the six- and seven-year-olds were in first grade and were receiving training in Pinyin.

4.1. The developmental trajectory of implicit onset-rime awareness in Mandarin

Although a lack of the grapheme-phoneme correspondence in Mandarin makes a fine-grained phonological awareness at the phoneme level impossible, the Mandarin character maps onto a monosyllable, which has traditionally been conceived as two sub-syllabic units, the onset and the rime [23]. Modern Mandarin linguists also follow this traditional basic conception and analyze the phonology of modern Mandarin as initial (i.e., the onset) and final (i.e., the rime) rather than the phonemic inventory of consonants and vowels [24]. Unlike the English syllable, the Chinese syllable has no consonant clusters (sequences of consonants). The onset refers to the beginning consonant with only one phoneme, and the rime (the final part of a syllable excluding the onset) refers to the remaining vowel(s) or vowel(s) plus an ending nasal consonant with one to three phonemes. Consequently, within the phonological system of modern Mandarin, the Mandarin rime refers to a much larger unit compared with the onset.

The present study suggests two important facets of implicit onset-rime awareness among Mandarin-speaking children and its relation to age and Pinyin instruction. First, the overall rate of correct responses in the rime detection task was much higher than that in the onset detection one, indicating that the phonological sensitivity varied in terms of the type of the segments. The sequence of PA development is considered to be linguistically universal from larger units (e.g. syllables, rimes) to smaller units (e.g. onset) of phonological representation over time [25].

Second, different levels of implicit PA appeared to exhibit different developmental trajectories and were influenced by literacy instructional experiences. On one hand, the preschoolers scored a high accuracy of around 86.99 % in the rime detection task, indicating that the development of rime awareness appears to depend primarily upon maturational age, which is in line with others' findings in English (e.g., [17]). Moreover, results indicated that the sensitivity of rime awareness may reach ceiling levels among first graders, emphasizing the role of Pinyin instruction for the perfection and refinement of rime detection. On the other hand, the accuracy of onset detection was around 66.44 % for preschoolers. Not surprisingly, after entering the primary school in first grade, largely due to the systematic and extensive phonological coding (i.e., Pinyin) training, the Mandarin implicit onset sensitivity increased significantly to over an accuracy of 90%. Our study firstly established the primacy of instruction for improvement of implicit onset awareness in Mandarin. The results corresponded to those documented previously for implicit onset awareness in English (e.g., [16]).

4.2. Mutual influence between PA and reading ability

It has been well-documented that PA plays a causal role in reading acquisition, enabling, or at least assisting, the acquisition of early reading skills. It was deemed that, since letters are usually on behalf of individual phonemes in alphabetic languages, children need to be aware of different phonemic segments in spoken words before further studying their correspondences with letters and graphemes. Greater PA tends to be associated with more advanced word reading or spelling in English (e.g., [26]) and even in Chinese (e.g., [18, 27, 28]) at some later date.

On the contrary, many researchers have also proposed that it is the process of learning to read or spelling itself that enables the beginning readers to explicitly segment, delete, or blend segments in both Indo-European languages (e.g., [6-9]) and Chinese ([11-13]). Moreover, the present study extended this interpretation by focusing on the implicit onset-rime awareness in the Chinese language. On the whole, results indicated that not only the refinement of rime detection, but also enhancement of onset detection increased with alphabetic spelling (i.e., Pinyin) instruction. All of the above findings have supported the conclusion that, at the very least, there is mutual influence between PA and reading or spelling achievement [29-30].

5. Conclusions

Using an implicit detection task, we have systematically examined the developmental trajectory of Mandarin onset-rime awareness in relation to age growth and Pinyin instruction. First, the overall rate of correct responses in the rime detection task was much higher than that in the onset detection one, indicating that implicit phonological sensitivity varied in terms of the type of the segments, with a better discrimination ability of larger units within a syllable. Second, all preschoolers aged from four to six showed a high accuracy of more than 80% in the task of rime detection, indicating children learning Mandarin could develop rime level sensitivity naturally through spoken language experience at a pretty young age. Moreover, with Pinyin instruction, the sensitivity of rime awareness may reach ceiling levels among first graders aged six to seven, emphasizing the role of literacy instruction for the perfection and refinement of rime detection. Third, the onset detection accuracy exhibited a huge increase, growing from 66% among preschoolers to 93% among first graders, establishing the primacy of Pinyin instruction responsible for the development of implicit onset awareness in Mandarin. Findings of our study further supported the viewpoint that there is mutual influence between PA and reading or spelling learning.

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