

Tonal alternations in child Mandarin: A view from a morpheme-specific tone sandhi rule

In generative phonology, a central question is how children rapidly and accurately acquire the phonological rules of their native language (Albright & Hayes, 2011), among which one important set of rules concerns the phonological alternations in their language. Prior research mainly focused on children's acquisition of segmental alternations (e.g., Berko, 1958; Zamuner et al., 2006), and much less is known about the acquisition of suprasegmental alternations, e.g., tone sandhi (TS) (Wewalaarachchi & Singh, 2016; Tang et al., 2019). As a tonal language, Mandarin is well suited for investigating children's acquisition of suprasegmental alternations. In addition to a general rule that applies to Tone 3 (T3) syllables, whereby a T3-T3 sequence is realized as T2-T3, Mandarin also has morpheme-specific TS rules. For example, the negative marker, *bu* (meaning "not"), changes from T4 to T2 when followed by another T4, but it undergoes no tonal change when followed by a non-T4 syllable. To our knowledge, no research has investigated the acquisition of this morpheme-specific TS rule. To fill the gap, the present study explores preschool Mandarin-speaking children's comprehension of this rule. We also examine how children's performance is related to their cognitive abilities like working memory (WM), because individual WM differences are widely reported to affect child language processing (e.g., Gathercole & Baddeley, 2014).

A total of 20 trials were created for the experimental session. On a typical trial, participants (24 4-year-olds, 28 5-year-olds, 23 6-year-olds and 29 adults) were presented a visual stimulus of two pictures in **Figure 1** on the laptop screen while listening to a corresponding recorded test sentence (see the **example**) produced by a female Mandarin native speaker in a child-directed manner. After hearing the sentence, they were asked to indicate "which was the rope bought by the speaker?" by selecting one of the pictures. Test sentences had three crucial features. First, the two monosyllabic adjectives (*xi* in T4, 'thin', vs. *cu* in non-T4, 'thick') constituted an antonym pair. Second, all the nouns and adjectives were picturable. Third, *bu* is presented either in T4 or T2 Condition. Participants' task was to identify which adjective, though not spoken at the end, should follow the specific tonal variant of *bu*. The idea is that, if children had a robust knowledge of the tonal contrast in *bu*, then on the example trial where the T2 *bu* was presented, it should prime the T4 adjective *xi* 'thin', thereby leading children to select the picture featuring the thick rope, and vice versa. Children's WM capacity was assessed using a 1-back task (adapted from Forns et al., 2014) and a nonword repetition task (adapted from Jiang, 2017).

Figure 2 presents the mean proportion of correct responses by different age-groups. Generalized linear mixed models (GLMMs) were used to analyze the data. **Table 1a** presents the results of the best minimal model (adults as the baseline). A significant age effect was observed, with adults performing significantly better than all the child groups. GLMMs were then applied to assess the connection between tonal alternation and WM in children (see **Table 1b**). We observed a main effect of age (i.e., 6-year-olds performed significantly better than 5-year-olds), and a main effect of 1-back score (i.e., children with higher WM capacity performed significantly better than those with lower WM-capacity). These findings indicate a developmental trajectory in children's comprehension of the TS rule specific to *bu*. Findings are discussed in relation to an interaction between children's knowledge of tonal alternations and WM capacity. These findings also provide insights into children's acquisition of phonological alternations.

An example test sentence:

Zuo-bian shi yi-gen **xi-de** shengzi, you-bian shi yi-gen **cu-de** shengzi, wo mai-de na-gen shengzi, **bu...**

left-side is one-CL **thin-DE** rope, right-side is one-CL **thick-DE** rope, I bought-DE that-CL rope, **not...**

‘On the left is a thin rope, and on the right is a thick rope. The rope I bought is not ...’

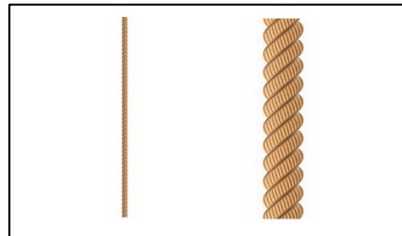


Figure 1. An example visual image, a thin rope in the left panel and a thick rope in the right panel

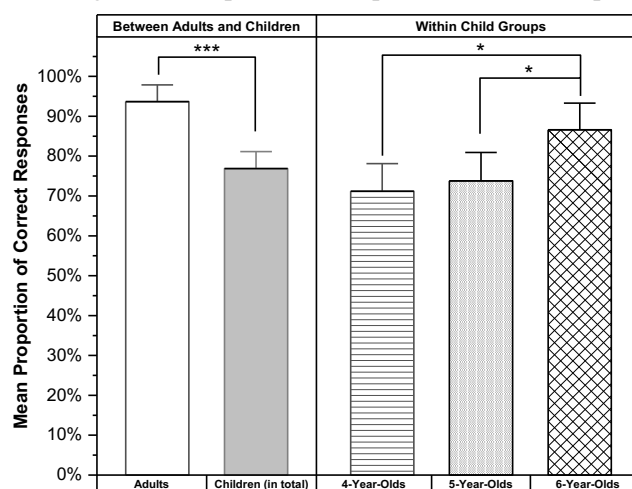


Figure 2. Mean proportion of correct responses by the adults and the children. Error bars indicate SEs. Asterisks indicate a significant difference between the two groups ($*p < .05$, $***p < .001$)

Table 1. Statistical results of the observed effects

Fixed effects:					Fixed effects:					
	Estimate	Std. Error	z value	Pr(> z)		Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	3.2866	0.3670	8.955	< 2e-16	***	(Intercept)	-0.32635	0.73167	-0.446	0.6556
agegroupfive	-1.9996	0.4112	-4.863	1.16e-06	***	agegroupfour	0.04257	0.32763	0.130	0.8966
agegroupfour	-2.1951	0.4232	-5.186	2.14e-07	***	agegroupsix	0.87830	0.34814	2.523	0.0116
agegroupsix	-0.9581	0.4422	-2.167	0.0302	*	onebackscore	0.04875	0.02137	2.282	0.0225
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Signif. codes:	0	****	0.001	***	0.01	**	0.05	.	0.1	' ' 1

(a)

(b)

Selected references

Albright, A., & Hayes, B. (2011). Learning and Learnability in Phonology. In J. Goldsmith, H. Riggle, & A. C. L. Yu (Eds.), *The Handbook of Phonological Theory (Second Edition)* (pp. 661-690). Chichester: Wiley-Blackwell.

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