Infant-Directed Speech Is Not Always Slower: Cross-linguistic Evidence from Dutch and Mandarin Chinese

Mengru Han, Nivja H. de Jong, and René Kager

1. Introduction

Slow speaking rate is commonly considered a typical characteristic of infant-directed speech (IDS). This stereotypical feature of IDS, however, has been generalized from only a small number of studies on a small selection of languages, without the support of data from other languages such as Japanese and Sri Lankan Tamil (Martin, Igarashi, Jincho, and Mazuka, 2016; Narayan and McDermott, 2016). Therefore, it is still unclear whether IDS is universally slower than ADS cross-linguistically.

Furthermore, if speaking rate is indeed slower in IDS, how might this influence word learning? There is evidence to suggest that a slower speaking rate is beneficial to lexical development. Specifically, the slow speaking rate of American English IDS at 7 months predicts children's vocabulary size at two years of age (Raneri, 2015, to review later). The question remains, however, whether mothers adapt a slower speaking rate specifically to highlight words that are unfamiliar to children and facilitate word learning.

This study revisits speaking rate in IDS and its potential relevance for word learning by examining two typologically distant languages: Dutch and Mandarin Chinese. We raise two research questions: (1) Is IDS slower than adult-directed speech (ADS) in Dutch and Mandarin Chinese? (2) Do Dutch and Mandarin Chinese mothers slow down their speaking rates to highlight unfamiliar words in support of word learning?

The first research question concerns whether slow speaking rate is a common prosodic feature of IDS across all languages. Previous investigations suggest that IDS is slower than ADS in languages such as English, German, Cantonese, Korean, and Tagalog, but not so much in Sri Lankan Tamil or Japanese. To date, no studies have compared speaking rate in IDS cross-linguistically under the same experimental conditions. Before we review the relevant studies on IDS speaking rate it is important to distinguish two common measurements of speaking rate: (1) speech rate, which combines speed of speech with number and duration of silent pauses, and (2) articulation rate, which is the speed of speech only, exclusive of silent pauses. Studies usually adopt one of the

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two measurements and ignore the other. In this paper, we distinguish these two measurements and use "speaking rate" as a general term when necessary.

A number of studies suggest that IDS is slower than ADS. The IDS speech samples in these studies were usually collected from natural mother-child interactions, while the ADS samples were conversations between a mother and an experimenter. Fernald and Simon (1984) showed that German IDS addressed to newborns (3 to 5 days old) had shorter utterances, longer pauses, and slower articulation rate (syllables/second) compared with ADS. American English addressed to toddlers (17 to 20 months of age) was also found to have a slower speech rate (words/minute) in comparison with ADS (Bernstein-Ratner, 1985).

Slow speaking rate has not only been found in the IDS of Germanic languages. Tang and Maidment (1996) measured the speech rate of Cantonese IDS addressed to 12- to 20-month-old children and compared it to the speech rate when the same speaker addressed an adult. The results suggest that Cantonese-speaking mothers spoke more slowly in IDS compared with ADS. In a longitudinal study on IDS articulation rate, Narayan and McDermott (2016) showed that Tagalog and Korean mothers spoke faster in ADS compared with IDS addressing 4- to 16-month-old children. In their study, articulation rate was measured at the utterance level instead of globally on the whole speech sample.

Despite the robust findings that IDS is slower than ADS in various languages, there is still conflicting evidence which shows that a slower speaking rate in IDS cannot be generalized to all languages. For example, Narayan and McDermott (2016) found that Sri Lankan Tamil IDS was not slower than ADS for any of the infant age groups under investigation (4 to 16 months). Also, Martin, Igarashi, Jincho, and Mazuka (2016) found that Japanese IDS addressed to toddlers (17- to 25-month-olds) was only slower than ADS at certain utterance positions. Their study focused on speech at the utterance-level and word-level, using mean mora duration as an indication of articulation rate. The results showed that IDS was slower than ADS only in phrase-final and utterance-final positions.

Thus, there is still no conclusive evidence that IDS is slower than ADS across all languages based on previous studies. Crucially, a cross-linguistic comparison of IDS speaking rate under the same experimental conditions is lacking. For these reasons, our first research question aims to examine whether IDS is slower than ADS in Dutch and Mandarin Chinese. As slower speaking rate is considered as a general prosodic property of IDS, we predict that both Dutch- and Mandarin-Chinese-speaking mothers would have a slower speaking rate in IDS compared with ADS.

Our second research question asks whether mothers slow down their speaking rate specifically when they introduce unfamiliar words to children in order to promote word learning. This question aims to explore the role of IDS speaking rate in lexical development.

The relationship between IDS speech rate and lexical development has been shown both concurrently and longitudinally. In a word recognition experiment, Song, Demuth, and Morgan (2010) manipulated speech rate in children's auditory input: half of the stimuli were presented in typical English IDS with a slow speech rate (1.94 syllables/s), while the other half had a faster speech rate (3.88 syllables/s) but preserved other prosodic aspects of IDS (such as higher pitch and larger pitch range). The results indicated that a slower speaking rate improved children's word recognition performance in comparison to faster speech. In a longitudinal study, Raneri (2015) showed that a slow speaking rate in IDS at seven months predicts larger expressive vocabulary at two years of age. Despite evidence from a word recognition study and the positive correlation between slow speaking rate and vocabulary size, it remains unknown to what extent speaking rate in natural IDS varies to specifically support lexical development.

Intuitively, slow speech is presumed to be clearer than fast speech, since phonetic contrasts are enlarged, providing more fine-grained linguistic information for language learners. However, as Bernstein-Ratner (1985, p. 262) noted, a global modification of speech rate does not necessarily mean longer segmental durations, since IDS may also have had more and longer pauses. It remains unclear whether articulation rate in IDS was consistently slower than in ADS. As Martin, Igarashi, Jincho, and Mazuka (2016) suggested, Japanese IDS was only slowed down in phrase- and utterance-final positions. Thus, the presumed facilitative effect of slow speaking rate on phonetic perception is unclear. Moreover, even if articulation rate in IDS is consistently slowed down, the phonetic properties of slow speech may not enhance phonetic contrasts. For example, VOT (Voice Onset Time), an acoustic feature that is crucial to distinguish voiceless and voiced consonants, is typically short in voiceless consonants, but long in voiced consonants. If VOT in IDS is shorter for voiceless consonants, but longer for voiced consonants, the contrasts between voiceless and voiced consonants are considered enlarged. However, McMurray, Kovack-Lesh, Goodwin, and McEchron (2013) found that VOTs were lengthened for both voiced and voiceless consonants in IDS, possibly due to the slow articulation rate. The CV ratio was the same in ADS and IDS, suggesting that VOTs were affected by the slower articulation rate in IDS, and therefore the changes did not necessarily support phonetic categorization.

Even if a slow speaking rate in IDS does not always promote phonetic acquisition, could it still be beneficial to word learning? In this paper, we try to gauge the potential effects of IDS speaking rate on language acquisition from the perspective of word learning. In adult speech, speakers usually slow down when they encounter less predictable words (Bell, Brenier, Gregory, Girand, and Jurafsky, 2009). During mother-child interaction, mothers are consistently faced with the need to use words that are unfamiliar to children. As unfamiliar words are usually less predictable compared with familiar words, it is possible that mothers take the familiarity of words into consideration and speak more slowly when they introduce unfamiliar words to their children compared with familiar words. Thus, our second research question aims at finding out whether speaking rate in IDS varies with the familiarity of words to the children. Specifically, we ask whether the speaking rate of utterances embedding unfamiliar words is slower than those including familiar words, and whether the realizations of unfamiliar words in IDS are slower than those of the same words in ADS. We predicted that (at the utterance level) mothers slow down for utterances containing unfamiliar words as well as (at word level) for unfamiliar words, but do not slow down for familiar words and for utterances embedding them.

To address these two research questions, we measured the speaking rate of IDS in a semi-spontaneous picture-book-telling task. This was done for the following reasons: the speech contexts in previous studies were often free mother-child interactions in the IDS conditions and spontaneous conversation in the ADS conditions. In spontaneous speech (elicited during “natural mother–child interaction”), the speech context varies according to the activity that is taking place. For this reason IDS may be more exaggerated compared with ADS in certain contexts, and less exaggerated in other contexts. Given this degree of variability, it is not clear whether the large differences between ADS and IDS reported for certain languages might actually have been due to the difference in settings and activities between the two conditions. In the current study, we minimized the effect of context by using the same semi-spontaneous picture-book-telling task in both conditions. Also, we used maximally similar materials for both Dutch and Mandarin Chinese to control the speech contexts in each language.

2. Methods

2.1. Participants

Twenty-five Dutch mother-child dyads (mean age = 18;13, age range = 18;00 – 18;29; girls N = 11) and twenty-one Chinese mother-child dyads (mean age = 18;15, age range = 17;21 – 18;27; girls N = 9) participated in the study. The Dutch mother-child dyads were recruited from the Utrecht Baby Lab database and were all monolingual Dutch native speakers. The Mandarin-Chinese dyads were recruited from kindergartens in Yichang, China. All the participant mothers spoke Mandarin Chinese (the official language in China) proficiently[1]. All children were typically developing. Mothers gave informed consent.

2.2. Materials

A picture book was designed to elicit a set of seven target words, including five unfamiliar words and two words familiar to 18-month-old children (Table 1). On each page, one word was shown on the left side, and the corresponding picture was on the right side. No other text was provided in addition to the target words. An additional six pages of pictures were used as fillers and to make the story coherent. Aside from the language used, the content of the Dutch and

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[1] All the participant mothers spoke Mandarin Chinese and a dialect (Southwest Mandarin). The participant children heard this dialect in their language community, but were exposed to Mandarin Chinese at home, at kindergarten, and in the national media. This type of bilingual language background is common for most people in China (Li and Lee, 2006).

Mandarin Chinese books were identical. The target words were all disyllabic nouns in both languages. The familiar words were selected from lists of common words in both Dutch and Chinese early vocabulary. Familiar words were listed in both the Dutch (N-CDI, Zink and Lejaegere, 2002) and Mandarin Chinese (M-CDI, Tardif, Fletcher, Liang, and Kaciroti, 2009) versions of MacArthur-Bates Communicative Development Inventories (CDI). The unfamiliar words were not listed in N-CDI or M-CDI. Selecting target words in such a way ensured that the default familiarity of the words applied to most of the participants. However, due to individual differences in vocabulary knowledge, the actual familiarity of the target words might vary among children. To examine whether each child was familiar with the target words or not, mothers filled out a word checklist after the experiment to determine whether the child understood the target words. This information was coded as Familiarity (Familiar/Unfamiliar) for data analyses.

Table 1. Overview of Stimuli

Dutch	Chinese (Pinyin)	English transcription	Default Familiarity
opa	yé ye	‘grandpa’	Familiar
appel	píng guǒ	‘apple’	Familiar
eland	mí lù	‘moose’	Unfamiliar
bever	hé lí	‘beaver’	Unfamiliar
walnoot	hé tao	‘walnut’	Unfamiliar
kasteel	chéng bǎo	‘castle’	Unfamiliar
pompoen	nán guā	‘pumpkin’	Unfamiliar

2.3. Procedure

Mandarin-Chinese participants were tested in a quiet room at a kindergarten, and Dutch participants were tested in a quiet room in the Utrecht Baby Lab. The procedure was identical for both language groups. Before the experiment, mothers were given a few minutes to familiarize themselves with the book. In the IDS condition, the child sat on his or her mother’s lap, and the mother was instructed to tell the story to her child the way she usually would at home. The mothers were specifically told they could use any sentences; the only requirement was to include the words on each page. In the ADS condition, the mothers were instructed to tell the story to the experimenter (female, a native speaker of Dutch or Mandarin Chinese), and to take into account the fact that she was a college student. The order of the two conditions was counterbalanced across participants. A ZOOM H1 recorder (with 16-bit resolution and a sampling rate of 44.1 kHz) was used to make audio recordings. Each experimental session took about 15–20 minutes. All families received a book as a gift after the experiment.

3. Results

Two sets of measurements were taken. First, we measured the speech rate and articulation rate over the entire story automatically using a Praat script (de Jong and Wempe, 2009). Second, we manually counted the numbers of syllables for the utterances containing target words (target utterances) and measured the articulation rate at the utterance level.

3.1. Overall measurements

As in Narayan and McDermott (2016), a Praat script (de Jong and Wempe, 2009) was used to measure speech rate and articulation rate automatically over the entire recordings. This script detects silent pauses and syllable nuclei in speech. Before running the script, we cleared the extraneous noise from the original recordings. This included any sounds that were not part of telling the picture book, for example the child's voice, the mother comforting the child, etc. To do so, a native speaker listened through the recordings and was trained to mark the noises and utterances that were irrelevant to the picture book in TextGrids. After cutting out the noises, we ran the Praat script to calculate the speaking rate of each recording. In total, 93 minutes of Dutch recordings (ADS: total = 34.32 min; mean = 82.38s; range = 36.6s – 187.6s; IDS: total = 58.29 min; mean = 139.9s; range = 76.4s – 236.1s) and 103 minutes of Mandarin Chinese recordings (ADS: total = 36.48 min mean =104.23s; range = 34s – 241.3s; IDS: total = 67.1 min; mean = 149.3; range = 78.4s – 746.6s) were analyzed. The script automatically generated speech rate and articulation rate for each recording (Table 2).

Table 2: Measurements and formulas for overall automatic measurements

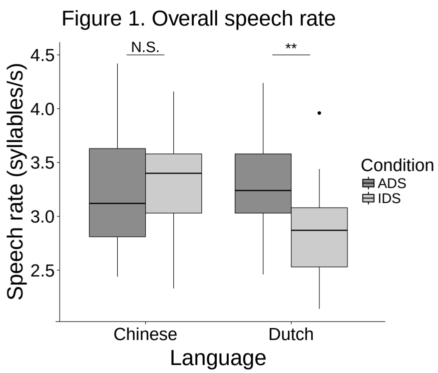
Measurements	Formulas
Speech rate (syllables/second)	Total number of syllables / Total duration
Articulation rate (syllables/second)	Total number of syllables / (Total duration - total pause duration)

Paired-sample t-tests were conducted using the t.test( ) function in the R environment (R development Core Team, 2008) to compare speech rate and articulation rate between ADS and IDS in Dutch and Mandarin Chinese, respectively[2]. For Dutch, there was a significant difference ($t(24) = 6.054$, $p < 0.001$) in speech rate between ADS ($M = 3.325$, $SD = 0.426$) and IDS conditions ($M = 2.844$, $SD = 0.456$) (Figure 1). There was also a significant difference ($t(24) = 3.579$, $p = 0.001$) in articulation rate between ADS ($M = 4.105$, $SD = 0.401$) and IDS conditions ($M = 3.698$, $SD = 0.681$) (Figure 2). These results suggest

[2] An example of the R codes is:
t.test(speech_rate_nl$speech_rate.ADS, speech_rate_nl$speech_rate.IDS, paired = TRUE)

that both speech rate and articulation rate were slower in Dutch IDS compared to ADS.

However, for Chinese, there was no difference (t(20) = -0.606, p = 0.551) in speech rate between the ADS condition (M = 3.253, SD = 0.540) and IDS condition (M = 3.320, SD = 0.499) (Figure 1). There was also no significant difference (t(20) = 1.386, p = 0.181) in articulation rate between ADS (M = 4.605, SD = 0.537) and IDS (M = 4.440, SD = 0.515) (Figure 2). These results suggest that Chinese IDS was not slowed down, regardless of whether pauses were included in calculating speaking rate.



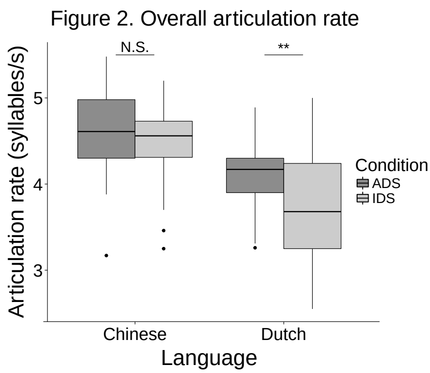


Figure 1. Box plots of speech rate for ADS and IDS in Dutch and Mandarin Chinese[3]

Figure 2. Box plots of articulation rate for ADS and IDS in Dutch and Mandarin Chinese

3.2. Measurements on the target utterances

For the next part of our measurements, we focused on the target words and the target utterances, i.e. the utterances containing the target words. Both target words and target utterances were annotated and extracted from the recordings for analysis using Praat (Boersma and Weenink, 2015). The utterances were annotated according to the definition of Analysis of Speech Units (ASU) (Foster, Tonkyn, and Wigglesworth, 2000). An AS-unit is “a single speaker’s utterance consisting of an independent clause, or a subclausal unit, together with any subordinate clause(s) associated with either.” (Foster, Tonkyn, and Wigglesworth, 2000, p. 365). Silent pauses mostly occurred between utterances, and sometimes within utterances. The durations of silent pauses were subtracted from the utterance durations when calculating the articulation rate of utterances. Native speakers of Dutch and Mandarin Chinese transcribed all utterances. Then, a native speaker counted the number of syllables in each utterance manually. In total, 639 Dutch utterances and 714 Chinese utterances were included for further

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[3] The box plots in our paper show the first and third quantiles, medians, and outliers (included in analysis).

analysis. The familiarity of the target words was coded according to mothers' reports. In total, there were 225 familiar utterances in Dutch and 490 familiar utterances in Chinese. We split each utterance into two parts: the target word and the rest of the utterance (Table 3). We also excluded short utterances under 5 syllables, in order to obtain reliable measures of articulation rate. As all target words were disyllabic, we measured word duration as an indication for the articulation rate: longer target word duration indicates a slower articulation rate. The mean target word durations and the mean articulation rates are given in Table 4.

Table 3. Measurements on target utterances and formulas

Measurements on target words and utterances	**Formulas**
Target word duration	Time ending – Time beginning
Articulation rate of the rest of the utterance (syllables/s)	(Number of syllables – 2[4])/ (utterance duration – target word duration – silent pause duration)

Table 4. Mean target word duration and mean articulation rate in Dutch and Mandarin Chinese, standard deviation in brackets

Language	**Familiarity**	**Condition**	**Target word duration**	**Articulation rate of the rest of the utterance**
Dutch	Familiar	ADS	0.377(0.126)	5.165(1.301)
		IDS	0.429(0.149)	5.338(1.363)
	Unfamiliar	ADS	0.483(0.137)	5.718(1.281)
		IDS	0.552(0.170)	5.304(1.477)
Mandarin Chinese	Familiar	ADS	0.495(0.215)	4.945(1.106)
		IDS	0.517(0.229)	4.941(1.448)
	Unfamiliar	ADS	0.547(0.206)	4.708(1.083)
		IDS	0.568(0.241)	5.059(1.468)

To assess the extent articulation rate of the target utterances differed between ADS and IDS, we used linear mixed-effects models for each language. In the models, we included fixed factors of Condition (ADS/IDS) and Familiarity (Familiar/Unfamiliar) as dependent measures: target word duration and articulation rate of the rest of the utterance, with Participant Number as a random factor, and allowing for random slopes for Condition and Familiarity (Barr, Levy, Scheepers, and Tily, 2013).

We used the lme4 package (Bates, Maechler, Bolker, and Walker, 2015) in the R environment (R development Core Team, 2008) for all data analyses. For each dependent measure, we took the backward elimination approach, starting

[4] Because all target words were disyllabic.

with a model that included all fixed effects plus the random factor, and all interactions between them (the most complex model)[5] (Bates, Kliegl, Vasishth, and Baayen, 2015a). Then, we used the 'step' function in the lmerTest package (Bates, Maechler, Bolker, and Walker, 2014, p. 15) to reduce the models by eliminating non-significant factors or interactions. When we arrived at an interaction of the fixed effects Condition and Familiarity in the final models, we split the data by Familiarity and built further models for each condition.

For Dutch target word duration (Figure 3), the final model (Table 5) showed that there was a main effect of Condition on utterance duration, suggesting that both familiar and unfamiliar were longer in IDS than ADS. These results can be interpreted by the prosodic marking of contextually new words in both ADS and IDS (Chafe, 1976, Fisher and Tokura, 1995). As each target word appeared on a new page in the picture book, the target words were contextually new regardless of their familiarity.

The final model for Dutch articulation rate excluding target words (Table 6) showed that there was a significant interaction of Condition and Familiarity ($p = 0.015$). To further examine the effects of Condition on utterance articulation rate, we split the data by Familiarity (Figure 4). The models showed a significant main effect of Condition for Unfamiliar ($\beta = -0.416$, $SE = 0.157$, $t = -2.646$, $p < 0.001$), but not for Familiar ($\beta = 0.211$, $SE = 0.183$, $t = 1.154$, $p = 0.25$) utterances. The results indicated that the articulation rate of the utterances surrounding unfamiliar words was slower in IDS compared to ADS, but utterances surrounding familiar words were not slower in IDS compared to ADS.

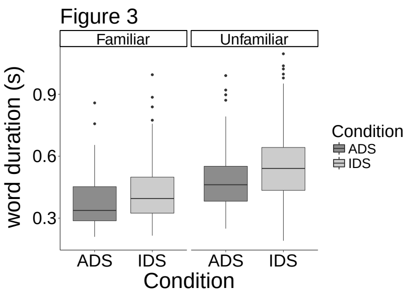
Table 5. Final model for Dutch target word duration

Parameters	***Estimate***	***SE***	***t-value***	***p***
	Fixed factors			
(Intercept)	0.367	0.015	23.918	<0.001***
Condition (IDS)	0.065	0.115	5.548	<0.001***
Familiarity(Unfamiliar)	0.125			
	Random factors			
	Variance	***SD***		
Participant(Intercept)	0.002	0.049		
Residual	0.021	0.143		

[5] An example of the R codes is: lmer(articulation_rate ~ Condition * Familiarity + (1 + Condition + Familiarity | Participant))

Table 6. Final model for Dutch articulation rate of the rest of utterance

Parameters	*Estimate*	*SE*	*t-value*	*p*
	Fixed factors			
(Intercept)	5.194	0.177	29.400	<0.001***
Condition (IDS)	0.188	0.187	1.001	0.317
Familiarity (Unfamiliar)	0.496	0.169	2.943	0.003**
Condition(IDS):Familiarity (Unfamiliar)	-0.570	0.233	-2.450	0.015*
	Random factors			
	Variance	***SD***		
Participant (Intercept)	0.313	0.559		
Residual	1.581	1.257		



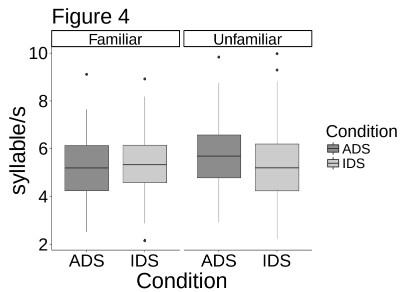


Figure 3. Box plots of word duration for ADS and IDS in Dutch
Figure 4. Box plots of articulation rate excluding target words for ADS and IDS in Dutch

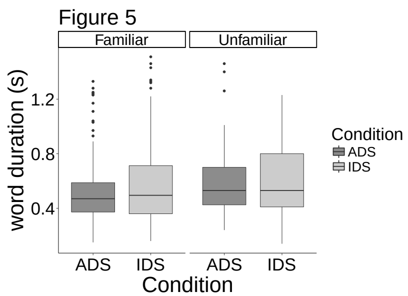
To summarize, the Dutch results indicate that Dutch mothers slowed down their utterances when they encountered unfamiliar words but not familiar words in IDS. Furthermore, they lengthened both familiar and unfamiliar words in IDS compared to ADS. However, for the Chinese group (Figure 5 and Figure 6) there was no difference between ADS and IDS in word duration ($\beta = 0.045$, SE = 0.027, t = 1.665, p = 0.111) between the two conditions (Table 7), and there was no significant difference in articulation rate of the surrounding utterances excluding target words ($\beta = 0.076$, SE = 0.107, t = 0.712, p = 0.477) (Table 8).

Table 7. Final model for Chinese target word duration

Parameters	*Estimate*	*SE*	*t-value*	*p*
	Fixed factors			
(Intercept)	0.540	0.028	19.213	<0.001
Condition (IDS)	0.045	0.027	1.665	0.111
	Random factors			
	Variance	***SD***		
Participant(Intercept)	0.012	0.011		
Condition (IDS)	0.009	0.092		
Residual	0.052	0.229		

Table 8. Final model for Chinese articulation rate of the rest of utterance

Parameters	***Estimate***	***SE***	***t-value***	***p***
	Fixed factors			
(Intercept)	4.910	0.124	39.491	<0.001***
Condition (IDS)	0.073	0.107	0.687	0.492
Familiarity (Unfamiliar)	-0.054	0.127	-0.427	0.670
	Random factors			
	Variance	***SD***		
Participant (Intercept)	0.141	0.376		
Residual	1.587	1.260		



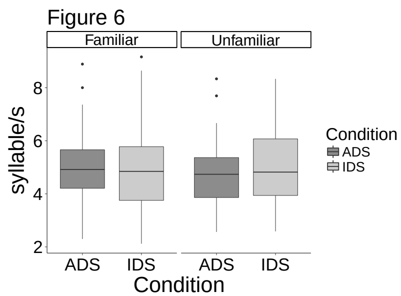


Figure 5. Box plots of word duration for ADS and IDS in Mandarin Chinese
Figure 6. Box plots of articulation rate excluding target words for ADS and IDS in Mandarin Chinese

4. Discussion and conclusions

Despite the common assumption that IDS is generally slower than ADS, our results suggest that IDS is not always slower than ADS when mothers address 18-month-old children. Two types of evidence support this conclusion. First, IDS is not necessarily slower than ADS across languages. Dutch IDS, as expected, was found to be slower than ADS, inclusive or exclusive of silent pauses. Our Dutch results are in accordance with previous findings on English, German, Cantonese, Korean, and Tagalog. However, Mandarin Chinese IDS is not slower than ADS with respect to either speech rate or articulation rate, both at the global level and utterance level. These results are consistent with previous findings on Japanese and Sri Lankan Tamil. Second, IDS is also not consistently slower than ADS within the same language. Even in Dutch, where IDS is generally slower than ADS, mothers only slow down utterances embedding words unfamiliar to children.

Our results show cross-linguistic differences in IDS speaking rate. A natural question that arises is why Chinese IDS is, unexpectedly, not slower than Chinese ADS. One possible explanation is the age of infants under investigation. General prosodic modifications in IDS are known to change in accordance with the child's stage of language development (Kitamura, Thanavishuth, Burnham, and Luksaneeyanawin, 2001; Stern, Spieker, Barnett, and MacKain, 1983). In general, IDS becomes more ADS-like as children grow older. For example, Narayan and McDermott (2016) showed that the articulation rate of Tagalog and Korean IDS increased from 4 months onwards and was already similar to ADS as the children reached 15-16 months. As our participants were 18-month-old children, it is possible that Mandarin Chinese IDS addressed to younger children is slower than ADS, but the speaking rate is already ADS-like when children are 18 months of age. It would be interesting to see the developmental trajectory of speaking rate in IDS from birth until 18 months old. Future research on cross-linguistic comparisons should also examine how and why this trajectory might vary across languages.

Our results are the first to show that Dutch mothers use a slower articulation rate to highlight unfamiliar words when addressing children. This suggests that Dutch mothers are sensitive to whether their child knows a word or not, and that they use speaking rate to highlight unfamiliar words, which may potentially facilitate their child's word learning. As IDS facilitates word learning (Ma, Golinkoff, Houston, and Hirsh-Pasek, 2011), it would be interesting to know whether it is specifically this property of a slower speech rate that contributes to the facilitating effects. Our study did not take children's lexical development into consideration. Since previous research has shown that a slow speaking rate in American English IDS at 7 months of age predicts vocabulary size at two years (Raneri, 2015), a useful future direction would be to examine whether this predictive relation exists for Dutch and Chinese as well.

In addition to affecting speech rate, IDS modifications also include higher pitch, a larger pitch range, and greater pitch variation (Fernald and Simon, 1984; Fernald et al., 1989). Our results showed that mothers vary their articulation rate to highlight unfamiliar words, and hence, a future direction for study would be to investigate whether other prosodic modifications also differ between familiar and unfamiliar words in IDS.

In conclusion, our results suggest that cross-linguistically, IDS is not always slower than ADS. Language-specific properties exist: Dutch mothers generally slowed down in IDS in comparison with ADS, while Chinese mothers did not slow down in IDS. Furthermore, our results provide evidence for the potential linguistic function of IDS. Dutch mothers slowed down utterances surrounding unfamiliar words in IDS, but did not slow down utterances surrounding familiar words. This targeted speech rate pattern may function to facilitate word learning. However, unlike Dutch mothers, Chinese mothers did not slow down even when talking about unfamiliar words. Future analyses should be carried out to explore the relation between the speaking rate in maternal input and children's language outcomes in Dutch and Mandarin Chinese, aiming at further exploration of the role of IDS in language acquisition.

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