Phonological representation of Chinese disyllabic words

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Introduction

Spoken words in spontaneous speech are often reduced, but not necessarily produced in any arbitrary form. This study explores whether there may exist a kind of invariability in surface forms, which is possibly associated with word-level processing in spoken word production and retrieval.

Coalescence of Chinese disyllables

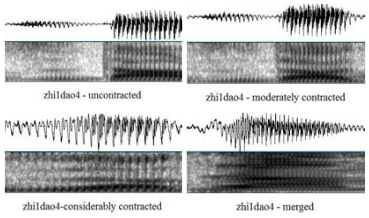
In ancient Chinese, a new/unknown character is transcribed by two already known characters, whose pronunciation has the onset from the first syllable and the rhyme from the second syllable. A similar coalescence mechanism can also be observed in some Chinese dialects, e.g., ki lai => kiai (to rise up) in Southern Min (Lien 1997).

Reduction of Chinese disyllabic words

- **Phonological rules** (coalescence, syllable merger)
  - Writing system (1) zhīhū 之乎 => zhū 諸
    之*pronoun*,乎*particle* => 諸"*all*", "*every*"
    (2) zhèyàngzi 這樣子"*this way*" =>jiàngzi 醬子)
  - Edge-in theory (Merger = S1-onset + S2-rhyme)
  - Sonority principle (Nuclei merging by sonority)
- **Phonetic reduction**
  - Gradient degrees in terms of acoustic features
- **Automatic speech recognition** (ASR)
  - Pronunciation variation modeling, dictionary
- **Mental representation of spoken words**
  - Categorical exemplar clouds

Syllable contraction in conversational speech: Four cases of reduced speech

zhīdào (to know) /tʂɯ.tau/ (Tseng *et al*. 2013)



Data

Taiwan Mandarin Conversational Corpus, 573K words

- Academic licenses are available via the Association for Computational Linguistics and Chinese Language Processing (ACLCLP)

- **Sinica MCDC8**: Eight hours of speech data annotated with interpausal unit boundary information (**IPU**), 123K syllables (Tseng 2019)

- Phone-aligned Chinese Conversational Speech Database: 3.5 hours of speech data with human-verified, signal-aligned phone boundary information; used as training data for the ILAS phone aligner

Taiwan Mandarin Conversational Corpus

	Mandarin Map Task Corpus (MMTC)	Mandarin Topic-oriented Conversation Corpus (MTTC)	Mandarin Conversational Dialogue Corpus (Sinica MCDC8 + MCDC22)
Speech type	Task-oriented	Topic-specific	Free conversation
Speaker	28F/24M	33F/25M	37F/23M
Recording	2002	2002	2001
Data	3 hrs. (29 dialogues)	10 hrs. (26 conversations)	30 hrs. (30 conversations)
Signal alignment	IPU/**word**/ syllable/phoneme	IPU/**word**/ syllable/phoneme	IPU/**word**/ syllable/phoneme

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Research motivation

Our hypothesis is that for Chinese disyllabic words, the coalescence form may also be a type of phonological representation, in addition to the canonical form. **Phonetic similarity scores** calculated on the basis of free phone recognition results and **word reduction type** (RT) determined by syllable contraction degrees were used to study gradient acoustic features and the derived phonological categories of disyllabic words in a Chinese conversational speech corpus.

Reduction types (RT)

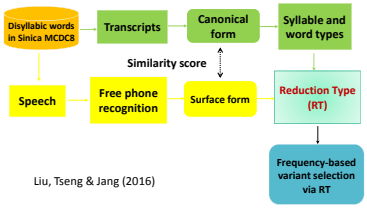
RTs are defined according to different degrees of syllable contraction observed in spontaneous speech: Canonical form type (**CAN**), marginal segment deletion type (**MSD**), nucleus merger type (**NUM**), and syllable merger type (**SYM**).

Constraints in RT derivation algorithm

More reduced ↑

RT	Word-internal syllable boundary	Segment omission	Nucleus length constraint	Cross-boundary segment preservation	*Xian zai* (now) /ejen.tsai/
SYM	-	Yes	<2	No	/ejai/
NUM	+/-	Yes	≥2	No	/ejenai/
MSD	+	Yes	≥2	Yes	/ejen.ai/
CAN	+	No	≥ 2	Yes	/ejen.tsai/

Deriving categorical RT



Liu, Tseng & Jang (2016)

"Typical" variants derived by means of RT

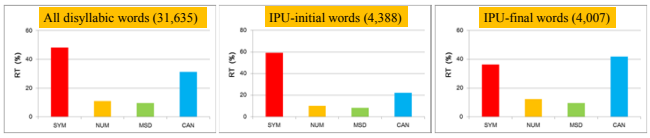
- 31,635 tokens of disyllabic words produced in the **Sinica MCDC8** were processed
- Typical variants of all disyllabic words were individually selected by signal-based scores and phonologically based algorithms, for which word-level variability and frequency effect are taken into consideration (Bybee 2001, Pierrehumbert 2001).
- Data-driven SYM forms may not always correspond to the phonologically predicted target forms (coalescence of two original syllables).

Majority RT and typical variants for disyllabic words that occur > 100 times in the Sinica MCDC8)

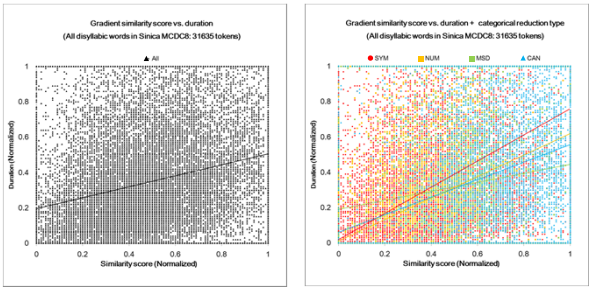
Word	Gloss	MCDC8 count	Canonical form	Majority RT	RT (%)	Typical variant
jiù shì	that is	1039	/tɕ j ou ʂ i/	SYM	50.82	/tɕ ɯ/
wǒ mén	we	878	/w o m ə n/	SYM	84.97	/ŋ/
rán hòu	then	733	/ʐ a n x ou/	SYM	79.81	/ʈ au/
juè dé	to feel	676	/tɕ ye t ə/	SYM	64.64	/tɕ ye/
yīn wèi	because	651	/i n w ei/	SYM	67.28	/ʐ ei/
méi yǒu	not/have not	571	/m ei j ou/	SYM	66.90	/m ə/
suǒ yǐ	so	479	/s w o i/	SYM	90.61	/ʦ ei/
kě shì	but	466	/kʰ ɔ ʂ i/	SYM	61.16	/kʰ ɯ/
qí shí	in fact	431	/tɕʰ i ʂ i/	SYM	54.06	/tɕʰ ɣ/
shí hòu	time	420	/ʂ i x ou/	SYM	83.10	/ʂ ou/
tā mén	they	415	/tʰ a m ə n/	SYM	83.37	/tʰ a ŋ/
xiàn zài	now	397	/ɕ j e n ʦ ai/	SYM	69.02	/ɕ j ai/
bǐ jiào	more	371	/p i tɕ j au/	SYM	63.34	/tɕ j au/
shén me	what	346	/ʂ ə n m o/	SYM	90.75	/ʂ ʂ/
zhè yàng	in this way	339	/ʈʂ ə j a ŋ/	SYM	87.02	/tɕ j a/
zhēn de	really	281	/ʈʂ ə n t ə/	SYM	64.77	/ʈʂ ə/
nà biān	there	269	/n a p j e n/	SYM	46.84	/n/
kě yǐ	can	260	/kʰ ɔ i/	SYM	85.00	/kʰ y/
hǎo xiàng	it seems	259	/x au ɕ j a ŋ/	SYM	57.53	/x a/
zhī dào	to know	234	/ʦ ɯ t au/	SYM	51.28	/ʦ au/
hěn duō	a lot	232	/x ə n t w o/	SYM	43.53	/ŋ t ou/
kě néng	possibly	223	/kʰ ɔ n ə ŋ/	SYM	84.75	/kʰ ə/
hái shi	still/or	218	/x ai ʂ ɯ/	CAN	47.71	/x ai ʂ i/
yì xiē	some	202	/i ɕ j e/	CAN	62.87	/i ɕ j e/
bù huì	will not	199	/p u x w ei/	SYM	64.32	/p w ei/
ér qiě	however	194	/ɚ tɕʰ j e/	CAN	59.28	/ɚ ɕ ye/
xué xiào	school	172	/ɕ ye ɕ j au/	SYM	55.81	/ɕ j au/
yīng gāi	should	168	/i ŋ k ai/	SYM	41.07	/n ə/
zì jǐ	-self	168	/ʦ i tɕ i/	SYM	62.50	/ʦ i/
dōng xi	thing	149	/t o ŋ ɕ i/	MSD	41.61	/w ɕ i/
yǐ qián	before	147	/i tɕʰ j e n/	CAN	78.91	/i ɕ ye n/
rú guǒ	if	139	/ʐ ɥ k w o/	SYM	81.29	/w o/
nǐ mén	you (plural)	138	/n i m ə n/	SYM	85.51	/n/
dàn shì	but	137	/t a n ʂ ɯ/	SYM	44.53	/t ə/
lǐ miàn	inside	126	/l i m j e n/	CAN	60.32	/i m e/
zěn mó	how	124	/ʦ ə n m o/	SYM	91.13	/ʦ ŋ/
gōng sī	company	121	/k o ŋ s i/	MSD	46.28	/k u ʂ i/
yǐ jīng	already	117	/i tɕ i ŋ/	SYM	49.57	/i/
yí yàng	the same	115	/i j a ŋ/	CAN	54.78	/i j a/
rén jiā	people	112	/ʐ ə n tɕ j a/	SYM	51.79	/n j ai/
dà gài	probably	108	/t a k ai/	SYM	62.96	/t ai/
dà jiā	everyone	100	/t a tɕ j a/	SYM	72.00	/t a/

(Modified from the results presented in Liu, Tseng & Jang 2016)

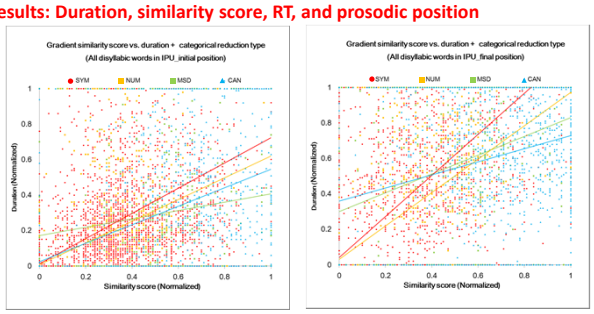
Results: RT distribution (Sinica MCDC8)



Results: Duration and similarity score (gradient) vs. RT (categorical)

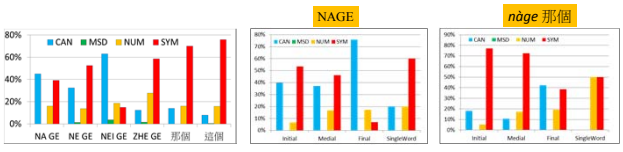


Results: Duration, similarity score, RT, and prosodic position



RT of disyllabic demonstratives (word category, discourse function, RT, prosodic position)

- 3% of tokens in the Sinica MCDC8 are demonstratives: Lexical and filler uses
  - **Lexical use** of demonstratives:
    Distal: *that* 那 *nà*/na/, *nè*/nə/, *nèi*/nei/
    Proximal: *this* 這 *zhè*/tʂə/, *zhèi*/tʂei/
    } w/o 個 *ge* (a classifier for general use)
  - **Demonstrative fillers**: NA (NE/NEI), NAGE (NEGE/NEIGE), ZHEGE (ZHEIGE)



Observations

- **CAN and SYM are both preferred**.
- In general, the larger the similarity score is, the longer the duration is.
- RT corresponds to the similarity score by reduction degree and duration.
- For words in the IPU-initial position, SYM is preferred and produced with a short duration, while those in the final position, both of CAN and SYM are preferred: Cues for **boundary effects** in conversational speech (initial shortening and final lengthening).
- Phonological representation of disyllabic words may be conditioned by **production frequency** as well as by the associated **prosodic positions**.
- **Uses of demonstratives differ in terms of RT distribution pattern (discourse function?)**

Implications

The more reduced a word is, the more difficult to recognize it? Not necessarily.

A word recognition experiment was conducted by Lee (2018), using CAN, MSD, and SYM disyllabic stimuli whose surface form was derived by the Edge-in theory (Chung 1997), the Sonority Principle (Hsu 2003), and the Discriminative Trace Principle (Tseng 2005) for high- and low-frequency words selected from the Sinica MCDC8. **CAN and SYM were statistically more quickly recognized than MSD irrespective of production frequency.**

Conclusion: The extreme case of phonetic reduction of Chinese disyllabic words (**SYM**) that resembles the coalescence form may possibly be a categorical type of spoken word variant that is phonologically represented in the mental lexicon.