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Perception of Native English Reduced Forms in Chinese Learners: Its Role in Listening Comprehension and Its Phonological Correlates

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Previous research has shown that learners of English as a second language have difficulties in understanding connected speech spoken by native English speakers. This study examines the role of the perception of reduced forms (e.g., contraction, elision, assimilation) of English words in connected speech comprehension and the phonological skills underpinning reduced forms perception. Sixty Chinese-speaking undergraduate students were tested with a battery of listening and phonological tasks in English. Results of regression analyses show that receptive vocabulary and perception of reduced forms contributed unique variance to listening comprehension for native English. Moreover, results further show that part-word recognition in a speech gating task and receptive vocabulary predicted perception of reduced forms via a direct pathway, whereas phonemic awareness and phonological memory predicted perception of

reduced forms via an indirect pathway (through part-word recognition). These results have implications for the phonological skills that are fundamental to the acquisition of reduced pronunciation variants and the importance of systematic training of reduced forms perception in second language education.
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Given the prevalent use of Internet and other media such as paid TV channels, exposure to native spoken English today is not bound by learners' geographical location. Thus, ability to comprehend native English is important in non-English-dominant countries. To date, even though current teaching methodology emphasizes the use of authentic English materials in learning English as a second language (ESL) inside the classroom, learners often find themselves unable to comprehend the language when they experience the real use of the language outside the classroom (Ito, 2006). Such listening difficulties persist even after prolonged listening exposure to native English speech (J. D. Brown & Kondo-Brown, 2006), causing anxiety around second language (L2) learning and low motivation among underperforming listeners (Mills, Pajares, & Herron, 2006).

L2 Listening Comprehension Difficulties Attributed to Reduced Forms

Previous studies on L2 listening difficulties have paid only scant attention to the perception of reduced forms such as those shown in Table 1 (J. D. Brown & Kondo-Brown, 2006). In a handful of studies (e.g., Henrichsen, 1984), native English speakers as well as high-level and low-level ESL learners were tested for their comprehension of English sentences with and without reduced forms. Advanced ESL learners performed in line with native English speakers when the English sentences did not contain any reduced forms. However, the performance of ESL learners became significantly worse than that of native speakers when the English sentences contained various types of reduced forms. Such results reveal the distinct role of perception of reduced forms in ESL listening. As some ESL learners go on to become English teachers, we risk presenting students with poor models if we do not train perception of reduced forms. As shown in Shockey's (2003) study, none of the 16 native speakers of Hong Kong Cantonese who became teachers of English was able to comprehend the whole sentence "the screen play didn't resemble the book at all"

TABLE 1
The Nine Reduced Forms in English Appearing in the Reduced Forms Dictation Test

	Reduced Forms	Description	Examples
1	contraction	A type of elision (see below) that appears in written forms and involves fixed grammatical patterns	would not (/wʊd nɔt/) → wouldn’t (/wʊdnt/)
2	juncture	Two or more words being linked and pronounced as one	catch air (/kætʃ ɛə/) → (/kætʃɛə/)
3	elision	Deletion of sounds	left behind (/lɛft bɪhaɪnd/) → (/lɛfbɪhaɪn/)
4	vowel weakening	Vowels in unstressed syllables being weakened and reduced to weaker vowels, e.g. a schwa (/ə/)	of (/ɔv/) → (/əv/)
5	assimilation	A sound changes so that it becomes more similar to neighboring sounds	takes them (/teɪks ðəm/) → (/teɪks̺əm/)
6	intrusion	A sound (e.g. /ɹ/) being inserted to facilitate the smooth flow of speech	idea of (/aɪdɪə ɔv/) → (/aɪdɪəɹəv/)
7	flapping	/t/ and /d/ occurring between vowels and followed by an unstressed vowel being pronounced as flaps in American English	eater(/itɚ/) → (/iɾɚ/)
8	glottalization	/t/ being replaced by a glottal stop	certain (/sɚtən/) → (/sɚʔn/)
9	palatalization	Triggered by a following consonant /j/, the consonants /s/, /t/ and /d/ come to be articulated in a position closer to the palate as /ʃ/, /tʃ/ and /dʒ/	this year (/ðɪs jiə/) → (/ðɪʃɪə/)

spoken by a native speaker of English (p. 121). To avoid a vicious cycle of poor comprehension of reduced forms, we need to better understand the role of reduced forms perception in L2 listening comprehension.

In this study, we hypothesized that L2 listening comprehension difficulties were the result of the difference between canonical form and reduced forms of words. When a native language is spoken in casual speech, speakers tend to maximize the ease of articulation and follow a principle of economy of effort (Ladefoged, 2000). As a result, in connected speech, the difference between segments is reduced to a minimum, increasing the chance of causing listening comprehension difficulties for listeners. The negative impact of such reduction on listening comprehension is evident in both native and nonnative speakers (e.g., Ernestus, Baayen, & Schreuder, 2002; Tuinman, Mitterer, & Cutler, 2012). Moreover, this reduction phenomenon is not limited to European languages but is also commonly observed in non-European languages (see Ernestus & Warner, 2011, for review). In English, for example, when *might rain* and *my train* are pronounced in casual speech at a conversational rate by a native English speaker, ESL learners can easily mix up the two phrases. In fact, the phonemic representations of *might rain* and *my train* are almost identical and they differ only in acoustic cues that indicate the word boundary. This linguistic phenomenon is called *juncture* and is an instance of a family of reduced forms (Mok, Setter, & Low, 2011). Other major reduced forms are illustrated in Table 1.

Phonological Representation Hypothesis: The Influence of Quality of Listeners' Phonological Representations on the Acquisition of Reduced Forms

By definition, phonological representations hold speech sound information and abstract phonological features of spoken words in our long-term memory system, forming the basis of access to word meanings. Fully specified phonological representations contain more detailed, distinct, and smaller-sized chunks of phonological information (e.g., Anthony et al., 2010; Fowler, 1991) which facilitate learners' listening skills. The more fine-grained the phonological representations, the better the learner's ability to access segments of these representations (Elbro, 1998).

Based on three contemporary theoretical views that position the ways the pronunciation variants are learned at the mental representational level, we postulated the phonological underpinnings of reduced forms perception. These three views are *pure abstractionist*, *pure exemplar*, and *hybrid*, with the last incorporating the other two views (see Ernestus, 2014, for details). The pure abstractionist view suggests that the mental lexicon contains each word in the form of one abstract representation (e.g., a sequence of phonemes). Speakers-unique acoustic features (indexical information) are normalized and prelexical representations are generated for lexical access to full-word representations by phonetic implementation rules. In contrast, the exemplar view contends that the mental lexicon contains representations of all different tokens of words the language users have ever encountered in either production or perception of speech, which are exemplars containing detailed acoustic information (e.g., Goldinger, 1998) or even the context in which the tokens occur (Hawkins, 2003). The hybrid view takes a middle position and suggests the presence of both abstract representations and exemplars in the mental lexicon. We propose that the ability to form high-quality phonological representations is crucial for storing reduced forms in the mental lexicon and learning abstract phonological rules.

The Proximal-Distal Dimension of the Phonological Representation Hypothesis

Among the multiple markers of phonological representations, many are not unique to reduced forms perception but have been shown to serve other language processing tasks such as word reading and picture naming (Sutherland & Gillon, 2005; Swan & Goswami, 1997); thus, it is important to identify skills that are more specific to reduced forms perception (proximal factors) and that are less relevant (distal factors). We identified phonological skills likely to be relevant to reduced forms perception by referring to its nature, that is, processing of continuous, fast, reduced, and unfamiliar speech for meaning. Five markers—spoken word discrimination, part-word recognition, phoneme awareness, receptive vocabulary, and phonological memory, which have been shown to be good indicators of phonological representations (Swan & Goswami, 1997)—were hypothesized to be particularly important for successful perception of reduced forms.

Using regression analysis, the composition of phonological representations specific to reduced forms perception will be revealed. Although some phonological skills may still exert strong influences on reduced forms acquisition during adolescence and show significant and linear regression effects detectable in our undergraduate sample, other phonological skills might develop earlier and then serve as a basis for subsequent development of other skills (Werker & Yeung, 2005) that may contribute to reduced forms perception. For instance, it has been argued that speech perception has an effect on reading via its impact on phonological awareness (e.g., Boets et al., 2011); in this example, we would regard phonological awareness as a *proximal* influence on reading and speech perception as a *distal* factor (see Bishop, Nation, & Patterson, 2014, for a discussion).

In the context of this study, it is possible that phonological skills specific to reduced forms acquisition develop over time and the respective phonological representations are constantly changing with listening experiences. Hence, different phonological skills might play different roles in the course of development. Therefore, we use mediation analysis to identify proximal skills, which are those that play a direct role in individual variations in reduced forms perception; distal skills, which are those that play an indirect role; and mediators, which are those that link the proximal and distal skills. In testing our phonological representation hypothesis, we focus on both the significance and directness of the relationships between the five phonological skills and reduced forms perception. The results will further our understanding of phonological development with regard to reduced forms acquisition.

Five Postulated Phonological Skills

Spoken word discrimination. First, facility in discriminating and categorizing speech sounds in English is likely to be important in bottom-up word identification. For second language learners, those who can differentiate similar-sounding phonemes (i.e., minimal pairs) have superior word recognition in an L2. This is especially true for learners whose native phonetic system does not contain some of the phonemes of the target nonnative language (e.g., the English phoneme /θ/ is absent in Chinese and therefore Chinese learners are faced with difficulties when word discrimination involves this phoneme, for instance, /s-θ/ contrast in canonical or reduced forms; C. Brown, 2000). Yet mere mastery of phoneme discrimination is insufficient for connected speech comprehension. As shown in J. D. Brown and Hilferty's (1986) training study of Chinese graduate students, the group who received lessons on the linguistic properties of fluent speech outperformed those who received practice in English minimal pair discrimination (e.g., /sɪp/ and /zɪp/, a pair of words including a voiceless and a voiced alveolar fricative, respectively). The result shows that while phoneme discrimination is significant for connected speech perception, other skills have additional contributions to the performance on connected speech perception.

Part-word recognition. The nature of phonological information stored with lexical representations is key to rapid lexical access. When words in running speech are reduced, some of the acoustic-phonetic information available for lexical access is lost and the incomplete acoustic signal may activate many potential lexical items and therefore confuse the listener. It has been shown that more skillful listeners are capable of making use of relatively fewer acoustic-phonetic signals and making more accurate prediction in the face of competing lexicons (Luce, 1986). Such ability is commonly measured by the *speech gating task* (Grosjean, 1980; Hughes & Reed, 2011). In this task, listeners are presented with a stretch of speech divided into segments of increasing length and are asked to predict how the stimulus would continue after each segment (Thorpe & Fernald, 2006). As both the speech gating task and reduced forms perception demand the skills of identifying words using partial acoustic-phonetic signals, we predicted that part-word recognition, as measured by the gating task, would play an important role in the perception of reduced forms.

Phonemic awareness. This involves metacognitive awareness of the phonemic structure of a language. Awareness of larger phonological units such as rime begins to develop in childhood (Goswami & Bryant, 1990). With time and practice, the unit size of phonological awareness becomes smaller and the skills of manipulating phonemes become more advanced. Individuals with good phonemic awareness have more detailed phonological representations, which might be an advantage for the recovery of phonemes that were reduced in running speech. Moreover, phonemic awareness is linked bidirectionally with phoneme discrimination (C. Brown, 2000). Enhanced discrimination of phonemic contrasts in isolated words can foster the awareness of phonological units at the metalinguistic level (Goswami, Gerson, & Astruc, 2010). In addition, as phonemic awareness is found to be a prominent skill for reading acquisition, it might indirectly promote listening comprehension through its effect on ESL learners who rely on subtitles to compensate for listening difficulties experienced when watching movies or TV programs. With more than one possible role played by phonemic awareness, studying the role of phonemic awareness in perception of reduced forms in ESL learners is deemed important.

Vocabulary knowledge. There is ample evidence that continuous speech recognition involves top-down influences from vocabulary knowledge, which makes it possible to predict upcoming words (e.g., Norris, McQueen, Cutler, & Butterfield, 1997). In accordance with this, vocabulary knowledge is one of the core skills that explain listening comprehension competence (Andringa, Olsthoorn, van Beuningen, Schoonen, & Hulstijn, 2012; Mecarrty, 2000; Vandergrift, Goh, Mareschal, & Tafaghodtari, 2006). Vocabulary is important for semantic processing of speech streams, and activation of vocabulary knowledge during listening can provide useful contextual cues for spoken word recognition (e.g., Bonk, 2000). Furthermore, according to the lexical restructuring model, an expanding vocabulary size prompts more specified phonological representations (Metsala & Walley, 1998). Given these multiple roles of receptive vocabulary, we hypothesized that it is an important skill for the comprehension of connected speech.

Phonological memory. As shown in infant studies, the ability to hold a longer stream of speech supports the learning of transition probabilities and prelexical cues that signal word boundaries (Christophe, Dupoux, Bertoncini, & Mehler, 1994). Phonological memory is also strongly associated with the acquisition of L2 vocabulary knowledge (Papagno & Vallar, 1995; Service & Kohonen, 1995). In this regard, phonological memory might be expected to have an indirect, distal effect on comprehension, via its influence on vocabulary learning. In addition, we speculated that good phonological memory could have a proximal influence on reduced forms comprehension insofar as it indexes storage of the stream of speech for online lexical processing. Successful L2 listening comprehension requires accurate decoding of spoken words and good retention of aurally presented information (Tsui & Fullilove, 1998). This skill is especially crucial for connected speech because comprehension of reduced forms may require contextual cues from one or more utterances before and/or after the target spoken word (Cheung, 1996; Harrington & Sawyer, 1992; McDonald, 2008). When words are very much reduced as in connected speech, multiple lexical candidates are simultaneously activated and compete with one another (Broersma & Cutler, 2011; McQueen, 2005). A longer span of phonological memory retains more information during online spoken word recognition and provides a larger buffer for the lexical competition before an optimal solution is obtained. L2 listeners require an even longer phonological memory span if more irrelevant competitors are activated during perception of casual speech (Cutler, Mitterer, Brouwer, & Tuinman, 2010). Therefore, we hypothesized that phonological memory plays an important role in the acquisition and perception of reduced forms.

RESEARCH QUESTIONS

In this study, we examined the linkages among various phonological skills thought to underlie the perception of English reduced forms in Chinese undergraduate ESL learners. Specifically, we asked, does reduced forms perception predict listening comprehension? If so, to what extent? Second, which aspect(s) of phonological representations best predicts the ability to perceive reduced forms? As well as testing the relative importance of each phonological skill, we tested both the direct and indirect effects of phonological skills on reduced forms comprehension. The testing of indirect effect was designed to examine whether some skills play a more proximal role in contrast to other skills that exert their influences on reduced forms perception via a mediator.

METHODOLOGY

Participants

The analyses presented in this study were based on a sample of 60 Chinese-speaking undergraduate students with a mean age of 20 years and 11 months (*SD* = 3 months) and a male-to-female ratio of 7:13. The participants were recruited from four universities in Hong Kong through announcements on university intranets and mass emails. These students were majoring in the fields of arts, science, social science, engineering, and business. Universities in Hong Kong adopt English as the main medium of instruction.

Hong Kong students start learning English as a compulsory subject at the age of 3 years when they enter kindergarten Level 1. Generally speaking, Hong Kong students have intermediate- to high-level English proficiency as indicated by a mean band score of 6.3 on the International English Language Testing System (IELTS; IELTS Partners, 2012) achieved by academic candidates. Student participants in the study were of mixed English abilities. Information about their English abilities was obtained by acquiring their grades in Use of English in the Hong Kong Advanced Level Examination (HKALE). Based on a study in search of the equivalency between the grade levels on the HKALE and the IELTS band scores (Hong Kong Examinations and Assessment Authority, 2015), our participants' listening performances fell between the approximate IELTS band scores 5.4 and 8.3, with a mean of 6.5.

Procedure

Participants were asked to read an information sheet and sign a consent form to indicate their consent to participate in the research. The testing was conducted in a research laboratory or a reserved classroom in three universities. All audio materials were played from a laptop computer and were delivered through Audio-technica ATH-SJ11 headphones. The testing session lasted for 1.5 to 2 hours with intermittent breaks. Each participant received an HKD 50 book coupon as remuneration.

Except for recordings used in the general listening test, which were adopted directly from commercially available sources, all speech tokens were recorded in a soundproof environment with a high-quality recorder, Roland R-09HR, digitalized at a sample rate of 44.1 Hz with a 16-bit amplitude resolution.

The majority of audio stimuli were presented with a British accent (Received Pronunciation; RP). British English is the major variety of English taught to Hong Kong Chinese in their primary and secondary school curriculums. Speech stimuli spoken in General American (GA) English were prepared so as to include reduced forms that are not common in a British accent. The RP talker had been living in England for 37 years (Bristol, Birmingham: 17 years; London: 20 years) and the GA talker had been living in the United States for 28 years (Texas: 1 year; Hawaii: 1 year; Arkansas: 1 year; Florida: 15 years; Washington, D.C.: 10 years). The speech production speed of the RP speaker and the GA speaker were approximately 186 syllables per minute (spm) and 222 spm, respectively. All recorded materials were processed using Audacity (version 2.0.2; Audacity Team, 2012) for noise reduction. We did a pilot testing and verified that the materials could be comprehended by native English speakers. The speech tokens produced had enough degree of reduction and could well represent various types of our designated reduced forms.

Measures

Given that connected speech comprehension in second language learners required sustained attention, we tried to minimize the administration time. The data we obtained follow the standard response format specified in the standardized tests' manuals or tests commonly used by researchers. In order to measure multiple phonological skills, we did not run the whole test but selected items that had optimal difficulty level and discriminative power, indicated in a pilot test of a group of 10 Chinese learners of English. The internal reliabilities as indicated by Cronbach's alphas are presented in Table 2. Moderate to high internal reliabilities were obtained for all measures. The tasks chosen had minimal demand of English spelling ability, and the degree of accent was not part of the scoring criteria.

General listening comprehension test. This task assessed general English listening comprehension skills of the participants, who were asked to listen to four sections of naturally occurring conversation and

TABLE 2
Descriptive Statistics of All the Measures (n = 60)

Task and maximum score	Mean (*SD*)	Internal reliability (Cronbach's alpha)
1. General listening comprehension (max = 21)	12.81 (3.13)	.61
2. Reduced forms dictation (max = 39)	23.73 (4.93)	.78
3. Minimal pairs discrimination (max = 80)	48.33 (7.37)	.72
4. Speech gating (max = 31)	10.31 (1.84)	.71
5. Phonemic awareness (max = 17)	8.15 (3.73)	.81
6. Receptive vocabulary (max = 15)	6.63 (2.13)	.62
7. Nonword repetition (max = 108)	61.83 (10.73)	.61

BBC/CNN news reports delivered in fluent English by native speakers at an approximate average speed of 280 spm. The listening materials and part of the questions were adopted from a list of commercially available English listening training materials (Berwick, Hardy-Gould, Southern, Thorne, & Wallwork, 2008; Y. H. Chan, 2003; Collins, 2007; Qin, 2003). In this task, students were instructed to answer a set of multiple-choice questions evaluating their understanding of the materials. There were 21 questions in total.

Reduced forms dictation test. This test's format was adapted from Henrichsen's (1984) sandhi-variation exercise. It measured whether the listeners could identify English words in their reduced forms. Participants were required to complete a dictation test consisting of 33 sentences embedded with reduced forms. The sentences presented in this task contain representatives of nine types of reduced forms: contraction, juncture, elision, vowel weakening, assimilation, intrusion, flapping, glottalization, and palatalization (see Table 1). These sentences were adapted from a selection of teaching materials and studies on connected speech (Bond, 1999; Henrichsen, 1984; Hewings, 2007; Ito, 2006; Matsuzawa, 2006; Mok et al., 2011; Shockey, 2003; Wang, 2005). Certain reduced forms that were not commonly found in British English speech (e.g., flapping) were recorded in a General American accent. They comprised eight target sentences.

In this task, students were instructed to listen to speech segments presented in a random order. Then they were asked to type the whole sentence on the computer. Students were allowed to listen to the sentence repeatedly up to three times. Scoring was based on the correct dictation of certain target features instead of the whole sentence. Omissions were counted as errors. Given that six sentences contained two target segments, the total score of this test was 39.

Minimal pairs discrimination task. This task assessed the ability of discriminating monosyllabic English words that differed only in one phoneme: either the initial consonant, the final consonant, or the vowel. The stimuli were adopted from A. Y. Chan (2010) and Marks (2007). Participants were given four trials of practice before the experimental trials. Stimuli were presented and responses were recorded via E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). On each trial, a word pair was presented to the participants, who were asked to identify whether the two words were the same or different by pressing a key (J for different, F for the same) on the keyboard. For pairs of identical word, the two words were spoken by different speakers so that the speech tokens were not acoustically the same. There were 80 trials in total. The phonemic differences between 40 word pairs lay in their vowels, and that between the other 40 pairs lay in their consonants.

Speech gating task. This task assessed part-word recognition, that is, the amount of acoustic-phonetic information students need for accurate recognition of an English word (Walley, Michela, & Wood, 1995). On each trial, participants were asked to listen to an initial segment (a gate) of a word in canonical form and write down their guess of the word on a record sheet. If the participant could not guess the word correctly, segments of the same word with increasing duration were presented until a correct response was given. The duration of the first gate of each word was 100 ms. Subsequent gates were incremented by 50 ms each so that the gates for each word were the word's initial 100 ms, 150 ms, 200 ms, and so forth. Because words are not homogeneous in length, the number of gates for each word was uneven. Scores of the gating task are reported as percentage of the whole word length required to identify the target words correctly. This scoring method was adapted with modification from A. M. Y. Wong, Kidd, Ho, and Au (2010). There were 31 trials in total.

Phonemic awareness test. This test was adopted from the Comprehensive Test of Phonological Processing (CTTOP; Wagner, Torgesen, & Rashotte, 1999). It assessed the participants' ability to identify and manipulate phonemes in English words. Four subtests covering different aspects of phonemic awareness (elision, segmentation, blending, and reversal) were administered. The whole test section consisted of 5 practice trials and 17 experimental trials. The elision test required students to pronounce a word with a certain sound in it omitted. The segmentation test required participants to break words into phonemes. In the blending test, students were asked to combine several separate sounds and pronounce them all together as a word or nonword. In the phoneme reversal test, participants were presented with a series of nonwords. They were asked to produce a real word by reversing the order of phonemes in a nonword. All test items were arranged in an easy to difficult order. There was one practice trial before each of the subtests. Each correct response was scored as 1.

Vocabulary test. Participants' vocabulary knowledge was assessed by selected items of the Mill Hill Vocabulary Scale (MHVS) from the Raven's Vocabulary Scales (Raven, Raven, & Court, 1998). Based on results of the pilot test, we selected 15 items that could discriminate the English vocabulary knowledge of ESL undergraduates well. On each trial, there was a group of six words. Participants were asked to identify the word that was synonymous with a target word. Each correct choice of word was scored as 1.

Phonological memory test. Phonological memory for English sounds was assessed by the nonword repetition subtest of the Comprehensive Test of Phonological Processing (CTTOP; Wagner et al., 1999). In this task, audio recordings of 18 nonwords were presented to the participants, who were required to repeat each nonword as accurately as they could. There were two practice items before the testing began. The nonword items were placed in an easy to difficult order. A partial scoring method was adopted to increase the sensitivity of the measure. One mark was given for each syllable and an additional mark for each two consecutive syllables correctly pronounced. However, one mark was deducted for each redundant syllable. The maximum score was 108.

ANALYSES AND RESULTS

The descriptive statistics of the participants' performances are presented in Table 2. The results show no ceiling and floor effect, a pattern that shows satisfactory difficulty level and discrimination power of the measures for studying individual variations in L2 listening comprehension in our Chinese undergraduate sample.

In the subsequent statistical analyses, we identified the roles of various phonological skills in the two main outcome variables: general listening comprehension and reduced forms dictation. Before running the regression analyses, we examined the correlations between general listening comprehension, reduced forms perception, and the phonological variables by performing a set of zero-order correlations (Table 3). The results show that general listening comprehension and reduced forms dictation were positively correlated with all the phonological measures (rs = .26 to .63, ps < .05). As suggested by Tabachnick and Fidell (2001), it was not necessary to correct for multicollinearity for correlations less than .70. The first question to be

TABLE 3
Pearson Correlations Among the Hypothesized Variables

	1	2	3	4	5	6	7
1. General listening comprehension	–						
2. Reduced forms dictation	.63**	–					
3. Receptive vocabulary	.50**	.47**	–				
4. Minimal pairs discrimination	.32*	.26*	.21	–			
5. Speech gating	.41**	.58**	.37**	.19	–		
6. Nonword repetition	.44**	.38**	.14	.07	.35**	–	
7. Phonemic awareness	.38**	.48**	.30*	.18	.40**	.45**	–

Note. *$p < .05$, **$p < .01$.

addressed is whether reduced forms perception and quality of phonological representations predict native English listening comprehension. For the identification of skills important for general listening comprehension, multiple regressions were computed (Table 4). When all the independent variables were included in the same equation, only reduced forms dictation ($\beta_{\text{standardized}} = .40$, $t[53] = 2.99$, $p < .01$) and receptive vocabulary ($\beta_{\text{standardized}} = .26$, $t[53] = 2.36$, $p < .05$) significantly predicted general listening comprehension.

The other research question is: Which aspect(s) of phonological representations best predicts the ability of comprehending reduced forms? Another multiple regression was computed to examine the predictors of reduced forms dictation. When all the variables were entered into the equation, only receptive vocabulary ($\beta_{\text{standardized}} = .24$, $t[54] = 2.24$, $p < .05$) and part-word recognition ($\beta_{\text{standardized}} = .34$, $t[54] = 2.98$, $p < .01$) significantly predicted performance in reduced forms dictation.

Upon the identification of significant predictors of general listening comprehension and reduced forms dictation, we conducted hierarchical regression analyses for further comparison of predictive power between the two significant predictors. In Models 1 and 2 predicting the outcomes of general listening comprehension, we entered the variables in three steps (Table 5). In Step 1, we entered minimal pairs discrimination, phonemic awareness, nonword repetition, and part-word recognition to detect the additional variances explained by reduced forms dictation and receptive vocabulary. In Model 1, we entered reduced forms dictation and receptive vocabulary in Steps 2 and 3, respectively. The order of Steps 2 and 3 was reversed in Model 2. The results show that Models 1 and 2 explained a total of 52% of variances in general listening comprehension. Reduced forms dictation and receptive vocabulary contributed unique variances of 5% and 8%, respectively, to listening comprehension, showing that each of them were unique predictors.

TABLE 4
Multiple Regressions Predicting General Listening Comprehension and Reduced Forms Dictation of Native English Among Chinese Second Language Learners of English

Predicting general listening comprehension, $R^2 = .52$			
	Independent variables	Standardized beta	*t*
1.	Reduced forms dictation	.40	2.99**
2.	Receptive vocabulary	.26	2.36*
3.	Minimal pairs discrimination	.15	1.50
4.	Speech gating	.00	0.18
5.	Nonword repetition	.26	2.34
6.	Phonemic awareness	.03	0.21
Predicting reduced forms dictation, $R^2 = .48$			
	Independent variables	Standardized beta	*t*
1.	Receptive vocabulary	.24	2.24*
2.	Minimal pairs discrimination	.10	0.98
3.	Speech gating	.34	2.98**
4.	Nonword repetition	.13	1.19
5.	Phonemic awareness	.19	1.63

Note. $*p < .05$, $**p < .01$.

In Models 3 and 4, we examined predictors of reduced form dictation (Table 5). In Step 1 of both Models 3 and 4, we entered minimal pairs discrimination, phonological memory, and phonemic awareness for detecting the additional variances explained by part-word recognition and receptive vocabulary. In Model 3, part-word recognition and receptive vocabulary were entered in Steps 2 and 3, respectively. The order of the two variables was reversed in Model 4. The two models explained a total of 43% and 48% variances, respectively, in reduced forms dictation. When entered into the last step of the regression equation, receptive vocabulary and part-word recognition contributed 4% and 9% unique variances, respectively, to reduced forms dictation, implying their significant roles in predicting the skill.

Testing for Distal Versus Proximal Effects

In addition to testing the relative importance of each phonological skill, we tested whether some skills could be indirectly related to reduced forms dictation. As shown above, part-word recognition and receptive vocabulary were two significant direct predictors of reduced forms dictation and therefore they were treated as mediators for subsequent analyses. The indirect effects analysis was conducted using Preacher and Hayes's (2008) INDIRECT macro operated on SPSS platform. The significance of the estimations was evaluated using both the Normal Theory test (also known as the Sobel test) and the

TABLE 5
Hierarchical Regressions Predicting General Listening Comprehension of Native English Among Chinese Second Language Learners of English

Predicting general listening comprehension Step	Independent variable	Beta	R^2	$R^2\ \Delta$	$F\Delta$
Model 1					
1.	Phonological variables[a]	–	.33	–	7.03**
2.	Reduced forms dictation	.48**	.47	.14	13.66**
3.	Receptive vocabulary	.25*	.52	.05	5.58*
Model 2					
1.	Phonological variables[a]	–	.33	–	7.03**
2.	Receptive vocabulary	.35**	.44	.11	9.97**
3.	Reduced forms dictation	.39**	.52	.08	8.96**
Predicting reduced forms dictation **Step**	**Independent variable**	**Beta**	**R^2**	**$R^2\ \Delta$**	**$F\Delta$**
Model 3					
1.	Phonological variables[b]	–	.29	–	7.96**
2.	Speech gating	.41**	.39	.10	13.15**
3.	Receptive vocabulary	.25*	.43	.04	5.01*
Model 4					
1.	Phonological variables[b]	–	.29	–	7.96**
2.	Receptive vocabulary	.33**	.39	.10	8.95**
3.	Speech gating	.34**	.48	.09	8.88**

Note. *$p < .05$, **$p < .01$.
[a]Minimal pairs discrimination, speech gating, nonword repetition, and phonemic awareness.
[b]Minimal pairs discrimination, nonword repetition, and phonemic awareness.

bootstrapping method. The Sobel test required the assumption of normality to be met. However, this assumption might not be realistic for testing indirect effects (Hayes, 2009; Preacher & Hayes, 2008). We reported results of the two tests so that we could judge their consistency.

We constructed three separate mediation models for treating minimal pairs discrimination, phonemic awareness, and nonword repetition as independent variables and tested each of their indirect influences on reduced forms dictation via part-word recognition and receptive vocabulary (Table 6). In Model 5, both Sobel and bootstrapping tests of indirect effects pointed to the same result, which was that minimal pairs discrimination did not influence reduced forms dictation in an indirect manner. For phonemic awareness (Model 6), a significant total effect was recorded showing that this skill explained variances in reduced forms dictation in an indirect way via part-word recognition, $p < .05$ by the Normal Theory test; 95% confidence interval (CI) [.06, .60] by the bootstrapping method. Similar results were obtained for nonword repetition, indicating a significant total indirect

TABLE 6
Mediation of the Effect of Three Phonological Variables on Reduced Forms Dictation Through Speech Gating and Receptive Vocabulary

Models	Mediators	Normal theory tests for indirect effects		Indirect effects of IV on DV through proposed mediators	Bootstrapping results for indirect effect[a] 95% CI	
		SE	*Z*	Point estimates	Lower	Upper
Model 5: Minimal pairs discrimination as IV						
	Total effect	.07	1.82	.09	−.03	.23
	Speech gating	.05	1.46	.06	−.02	.20
	Receptive vocabulary	.03	1.42	.04	−.00	.13
Model 6: Phonemic awareness as IV						
	Total effect	.11	2.95**	.30	.14	.65
	Speech gating	.11	2.44*	.21	.06	.60
	Receptive vocabulary	.06	1.67	.10	.01	.24
Model 7: Nonword repetition as IV						
	Total effect	.05	2.29*	.08	.01	.19
	Speech gating	.04	2.28*	.07	.01	.19
	Receptive vocabulary	.02	1.02	.02	−.01	.08

Note. *$p < .05$, **$p < .01$.
[a]Bias corrected and accelerated intervals using 1,000 bootstrap samples.

effect and specific mediating effect via part-word recognition, $p < .05$ by the Normal Theory test; 95% CI [.01, .19] by the bootstrapping method (Model 7). The statistical results are summarized pictorially in Figure 1.

DISCUSSION AND CONCLUSION

This study investigated the role of perception of native English reduced pronunciation variants in listening comprehension among Chinese ESL learners. Our results confirm that the ability to perceive phonologically reduced forms was a significant predictor of comprehension of native English connected speech among Chinese learners. Receptive vocabulary was also shown to be important for successful comprehension of English fluent speech by ESL learners. Under the framework of the phonological representations hypothesis, we further identified the phonological components that were critical to the reduced forms perception in terms of their relative importance and direct and/or indirect effects. Furthermore, receptive vocabulary and

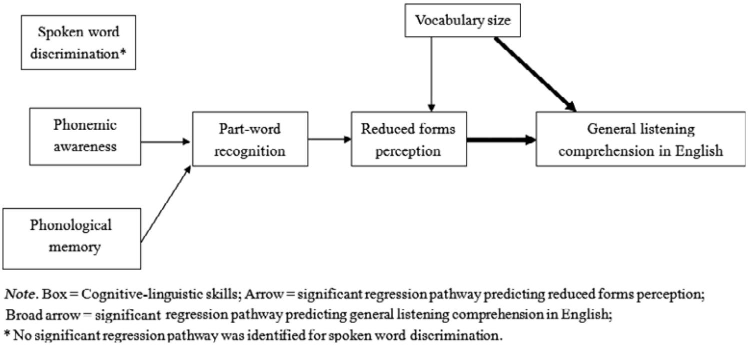

FIGURE 1. The box-and-arrow model of reduced forms perception constructed with reference to the results of the current study.

part-word recognition were found to be significant predictors of native English reduced forms perception.

As revealed in the regression analyses, both receptive vocabulary and part-word recognition were unique predictors of perception of reduced forms. This result implies that vocabulary and part-word recognition may work interdependently in supporting the comprehension and acquisition of reduced forms perception. The result is also consistent with a large body of studies that have highlighted the importance of both bottom-up and top-down processes for successful listening comprehension (e.g., Cutler & Norris, 1988; Norris et al., 1997; Trueswell, Tanenhaus, & Garnsey, 1994). The prominence of vocabulary knowledge and part-word recognition skills may lead us to speculate that the two skills play a part in both bottom-up and top-down processes in an interactive manner during online speech processing. On one hand, vocabulary knowledge provides a reservoir of knowledge for meaning access (Vandergrift, 2007). On the other hand, part-word recognition comes into play when lexical ambiguity in the connected speech is high (Tuinman et al., 2012). For the acquisition of reduced forms, the expansion of vocabulary size also results in a higher level of lexical differentiation (the lexical restructuring model; Metsala, 1997; Metsala & Walley, 1998), which better supports the translation of lexicons from canonical forms to reduced forms. Similarly, better part-word recognition performance implies the attainment of more advanced skills for recovering the acoustic-phonetic signals lost in reduced forms or more skillful application of reduced-forms-related-phonological rules. Further studies on these hypothesized interactive and acquisition processes are warranted.

One interesting result we obtained was that phonemic awareness and phonological memory significantly explained variance in reduced forms dictation through an indirect path via the mediator part-word recognition. In terms of distal-proximal factor dichotomy of speech processing (Bishop et al., 2014), part-word recognition and receptive vocabulary may be conceptualized as proximal factors and phonemic awareness and phonological memory as distal factors in the development of reduced forms perception. The discovery of two significant indirect pathways supports the idea of bootstrapping, whereby prerequisite skills promote the development of more advanced skills in successive stages of language development (Werker & Tees, 2005; Werker & Yeung, 2005; S. W. L. Wong, Chow, Ho, Waye, & Bishop, 2013). In our case, phonemic awareness and phonological memory bootstrap part-word recognition and receptive vocabulary, and in turn they further prompt the development of reduced forms perception. The actual bootstrapping effects among the above-mentioned variables are yet to be tested. Future studies using longitudinal or training designs are needed to further examine the development of phonological skills important for acquiring the representations of reduced forms.

What, then, are the implications for the three theoretical views that are concerned with the learning of connected speech perception (pure abstractionist, pure exemplar, and hybrid models)? Receptive vocabulary and part-word recognition performances are the best tasks for predicting reduced forms comprehension. Receptive vocabulary is important because, no matter which of the three mechanisms are more valid, top-down word knowledge can guide lexical access. As shown in our study, part-word recognition measured by the speech gating task also played a significant and proximal role in reduced forms dictation. We speculated that the influence of part-word recognition on reduced forms dictation may arise because the gating task tests ability to form phonetic implementation rules or a more advanced normalization procedure as suggested by the pure abstractionist model. Part-word recognition skill may be an index of ability to form segmented representations of stored exemplars, as contended by the pure exemplar models. Further studies are needed to distinguish these possibilities.

LIMITATIONS AND FUTURE DIRECTIONS

There are two major limitations in this study that could be addressed in future research. First, the study focused on the phonological aspect of speech perception and did not test other linguistic skills such as grammatical abilities. Furthermore, we did not consider the role of phonological output (motoric) representations, which could influence some of the skills tested here. Also, the phonological tasks used here were offline or time-free and did not require the listener to process the input rapidly in real time. The nonphonological aspects of these tasks might compensate for poor listening performances attributable to phonological deficits. Second, because of time limitations, we did not include all the items of some standardized psycholinguistic tests. Although the internal reliabilities for most of the tests were moderate, the inclusion of more items would further minimize measurement errors.

Pedagogical Implications

Our study delivers a clear message to educators that ability to perceive reduced pronunciation variants is important for L2 listening comprehension skills. The insights into the skills that contribute to the individual variations in reduced forms perception provided in this study can provide reference for the design of a detailed and comprehensive assessment of reduced forms related skills in L2 learners. As supported by the current study, students should be trained on the differences between words in canonical forms and in reduced forms. Teachers are advised to make use of authentic English audio in teaching so that students can make better use of relevant linguistic cues in running speech (Christophe et al., 1994).

In summary, our research has tested the phonological representation hypothesis in L2 connected speech perception and by doing so clarified the roles played by each of the phonological skills, showing that speech gating, receptive vocabulary, phonemic awareness, and phonological memory are prominent predictors of L2 reduced forms perception in either direct or indirect ways. These results have laid the ground for further investigation of the developmental trajectory of L2 connected speech perception and of the division of labor among the family of speech-linguistic predictors in relation to the development of L2 listening comprehension. Practically, we could consider developing a battery of tests for the assessment of native English reduced forms perception in L2 learners. These endeavors are crucial for intercultural communication and the lifelong learning of second languages.

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