CONTRASTIVE HIERARCHY ANALYSIS OF THE MANDARIN VOWEL SYSTEM[*]

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1. Introduction

The notion of contrast has been a central part of linguistic theory (Jakobson 1941, Jakobson and Lotz 1949, Trubetzkoy 1969, Dresher 2015). Many phonological theories seek to account for whether or not two sounds are contrastive in a given language. At this point, Dresher's contrastive hierarchy theory provides great insights to identify contrastive sounds in a given language. More specifically, Dresher (2009, 2015, 2018) identifies two important components of phonological feature specifications: The successive division algorithm (SDA) and the Activity Principle. Under Dresher's contrastive hierarchy theory, features should be specified by establishing a language-specific feature hierarchy. Establishing this hierarchy (a procedure for specifying contrasts) is based on the Successive Division Algorithm (SDA), which will be introduced later. The selection of the features is determined by examining the phonological processes in a given language, which is called the Activity Principle by Dresher (2009). Those concepts have helped to successfully identity a unique set of contrastive features in many languages, such as Manchu (Zhang 1996), Ngizim (Mackenzie 2013), Laurentian French (Hall 2016), Xunke Oroqen (Dresher 2018), and Korean (Kwon 2019).

Using Dresher's theory, the aim of the present study is to conduct a contrastive hierarchy analysis of Mandarin vowels by examining the phonological processes in Mandarin vowel systems, with consideration of feature propagation as proposed by Piggott (1992) and Hall (2016). I will begin with a brief description of Dresher's contrastive hierarchy theory and the Activity principle, with examples from Burstynsky (1968) and Hall (2016). Then, feature propagation (Hall 2016) will be discussed. Next, the Mandarin vowel system is introduced. By examining phonological processes in the Mandarin vowel system, I will illustrate why the [±high], [±front], [±low], and [±round] features are chosen for the hierarchy and argue for the following ranking: [±high] > [±front] > [±low] > [±round].

2. The contrastive hierarchy theory

2.1 The contrastive hierarchy theory and SDA

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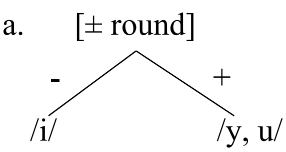
Dresher (2009) provides an empirical and theoretical foundation for the theory of contrastive hierarchy: features are specified by establishing a language-specific feature hierarchy by applying what Dresher calls the successive division algorithm (SDA), the procedure for specifying contrasts. In this model, in the first step, segments do not have feature specifications and there are no differences among those segments, as shown in the example below.

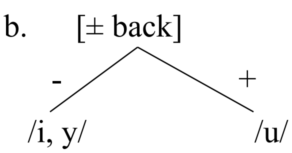
(1) /i, y, u/

Then, a distinctive feature is selected to divide segments into two sets: a group of segments with the positive value for this feature and a group of segments with the negative value for the feature. In the example, in order to divide three high vowels /i, y, u/, two possible binary features are needed: [±round] and [±back]. We could choose either [±round] or [±back] to first divide the segments into two sets. This will result in two possible rankings, as in (2).

(2) a.

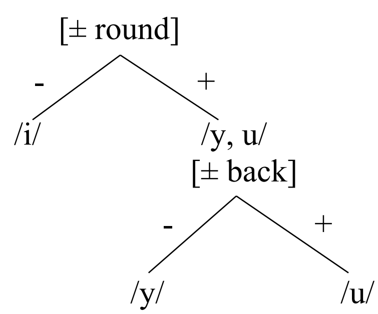


b.

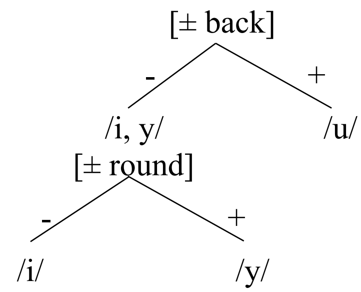


After that, an additional feature will be selected in each feature specification and thus further divide the segments into subsets. This procedure will apply in turn until each phoneme is uniquely and correctly specified. In the example, if [±round] is selected first, [±back] will then be chosen to further divide /y, u/ into subsets. If [±back] is selected first, [±round] will then be chosen to uniquely specify /i, y/. There are two possible hierarchies, as given below.

(3) a. [± round] > [± back]



b. [± back] > [± round]



The SDA, according to Hall (2007), is also an acquisition algorithm that describes how a language learner builds phonological representations by creating phonemic distinctions and using features to mark them. Dresher's Successive Division Algorithm is given below.

(4) Successive Division Algorithm

a. Begin with no feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.

b. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.

c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

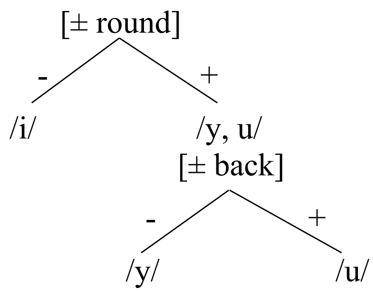
As shown above, there are two possible hierarchical organizations of features. Two questions raised here are: how we can tell which is the correct analysis? How do we determine which features are contrastive (i.e., are specified) and therefore selected for ranking, and which ones are redundant (i.e., not represented phonologically)? Here, the Activity Principle comes to play a role.

2.2 The choice of contrastive features: The Activity Principle and Phonotactic distribution

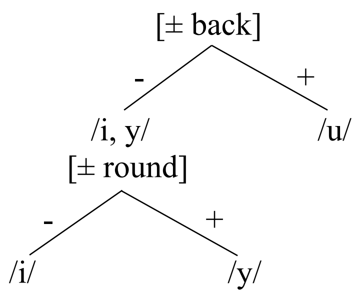
Whether or not a given feature is specified in a given language is determined by examining the phonological processes in that language. This approach to select features is named the Activity Principle by Dresher (2016). It is designed to identify the contrastive features that are relevant to the phonological computation (Dresher 2016). For instance, if a feature, such as [±voice] triggers a phonological process, such as a voicing assimilation rule (e.g., English plural allophone /z/ -> /s/ /_[-voice]), then the feature is active and therefore the [±voice] feature should be included in the feature hierarchy.

Let's take a look at one example. Referring back to two possible hierarchies in section 2.1, let's assume that three high vowels /i, y, u/ are Laurentian French high vowels that are specified by two binary features [± round] and [± back]. This will give us two possible hierarchies.

(5) a. [± round] > [± back]



b. [± back] > [± round]



(Burstynsky 1968: 11)

In order to determine which ranking is correct, the relevant phonological process of assibilation is taken into account: The high front vowels /i/ and /y/ trigger assibilation of coronal stops such that /d/ and /t/ become sibilant consonants before /i/ and /y/, as shown below in (6-7).

(6) Assibilation of /t/ and /d/ before /i/ and /y/

a. *j'ai dit* [ʒedzi]
b. *du pain* [dzypɛ]
c. *petit* [p(ə)tsi]
d. *t ˆetu* [tɛtsy] (Burstynsky 1968: 13)

(7) Phonological rule: Assibilation

$$\begin{bmatrix}\text{+coronal}\\ \text{-sonorant}\end{bmatrix} \text{-> [+strident] /\_} \begin{bmatrix}\text{-consonantal}\\ \text{-back}\\ \text{+high}\end{bmatrix}$$

(Hall 2016: 3)

As shown in (6-7), [±back] is a phonologically active feature because [-back] triggers the phonological process: /d/ and /t/ become sibilant consonants only before the segments /i/ and /y/ which are specified with [-back] (i.e., not before /u/). The evidence from the phonological activity here shows that /i/ and /y/ must have an active phonological feature [±back], so [±back] should be ranked above /i, y/ to make sure they are specified with [-back][1]. What we can conclude based on my analysis is that for French high vowels, [±back] should be active, and [±back] should be chosen first to specify /i, y/ in the contrastive hierarchy. Let us return then to the two possible representations of the vowel inventory in (5). The order in (5a) will predict the wrong alternations: /i/ cannot trigger assibilation because it is not specified with [-back]. This will predict incorrect surface forms, such as *[pətit]. Therefore, (5b) is the correct ranking in Laurentian French high vowels.

Although according to the activity principle, phonologically active features must be a contrastive feature selected for a hierarchy, determining contrastive features is in fact more complex than this. All active features are contrastive but not all contrastive features are active. There are several diagnostics used in identifying contrastive features. Here, I adopt Dresher's (2009) summary of diagnostics from previous scholars (Trubetzkoy 1939, Jakobson 1962). I only discuss phonotactic distribution related to my analysis.

In one of the diagnostics, Dresher (2003) mentions that X participates in a set of other phonemes, with respect to phonotactic distribution, where F is required to differentiate X from other phonemes. To be more specific, a feature value to be considered contrastive for a given phoneme "if there is another phoneme in the language that is identical except for that feature" (Dresher 2003: 48). For example, in English, the feature [±voice] will be contrastive for /p, t, k/ with a group of other phonemes /b, d, g/ because they are alike in place and manner of articulation, so they can only be distinguished from them by [±voice].

Now we have looked at how contrastive features might be selected. Let us turn to in what order they might be selected.

2.3 The order of contrastive features: the scope relation

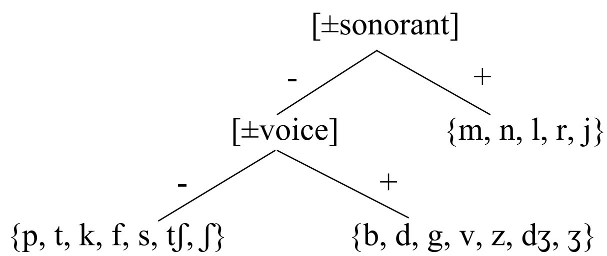
As mentioned earlier, once the features are selected based on examining phonological processes in a given language, they must be ranked hierarchically following the SDA. There are several approaches to consider how those features are ordered.

Before going further to discuss ordering features, the term *scope* needs to be defined. In the contrastive hierarchy, Dresher (2009) uses the term *scope* to refer to the relation between features on different layers, or a feature and an inventory downwards in a feature hierarchy. In this way, *wider scope* used by Dresher (2009) simply means that a feature is in a dominant position in a hierarchical position. Hall (2016) uses the term *higher scope* to refer to a feature ranked higher in a feature hierarchy. The scope relation stipulates that the feature ranked higher has dominance to influence the contrastive specification of the inventory downwards. For instance, as can be seen in the tree in (8) below, [±sonorant] is ranked higher than [±voice], so once segments are specified for [±sonorant], this

[1] Here, we would actually need another phonological process to show why [±round] is selected. I will leave it aside here.

determines whether or not they will be specified for [±voice]. In particular, within the [+sonorant] sub inventories, there is no contrast to be marked by [±voice], and so sonorants are unspecified for voicing: as given in (8), sonorants, such as /m/, /n/, /l/, /r/, and /j/, do not receive [+voice]. With the [-sonorant], [±voice] is contrastive and assigned to all obstruents, categorizing them into two subsets. This clearly shows that sub inventories are marked with different features because they inherit[2] or influence activities from the feature ranked hierarchically. In relation to the use of the term scope, in (8), [±sonorant] is structurally higher in the tree than [±voice] and thus is said to have wider scope than [±voice].

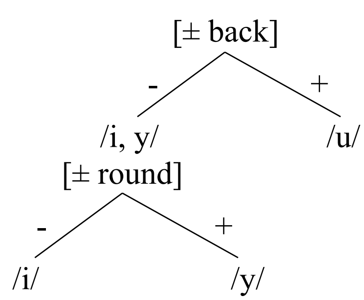
(8)



There are three statements proposed by Hall (2016) to illustrate the order of contrastive features and their scope relations. Here, I only discuss one of them, which is related to my analysis: If a feature, is phonologically active on a given segment, then that feature must be specified on the given segment or segments and ranked above the segments to specify that segment (Hall 2016).

Referring back to the case of the Laurentian French high vowels in (5b), repeated here as (9), if a feature, such as [-back], is phonologically active on the given segments /i, y/, then [-back] must be specified on /i, y/ and have scope over them.

(9) [± back] > [± round]



2.4 Feature propagation (Piggott 1992, Hall 2016)

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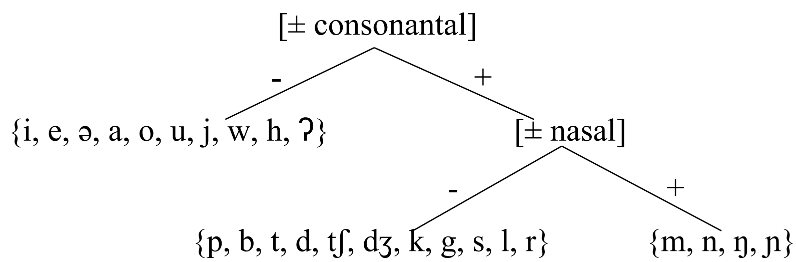
[2] Inheritance here means that [sonorant] sounds aren't [+voice] and [+ voice] sounds are [-sonorant] because their feature specification is influenced by the feature ranked hierarchically.

Piggott (1992) and Hall (2016) propose the idea of feature propagation. It simply means that a feature that is contrastively specified on one segment may spread its contrastive feature to other segments on which it was not underlyingly specified.

An example given by Hall (2016) is Malay nasal harmony where the rightward spread of [+nasal] from nasal stops to [-consonantal] segments (vowels, glides, and glottals) until it is blocked by a [+consonantal] segment. To make it more explicit, let's look at the partial contrastive hierarchy for Malay first, as in (10).

(10) Partial contrastive hierarchy for Malay: [± consonantal] > [± nasal]

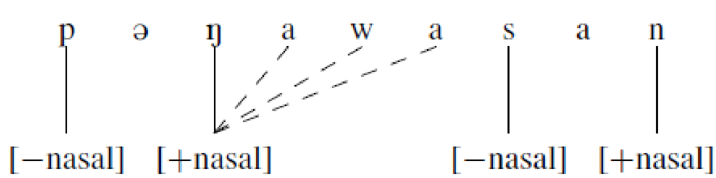


(Hall 2016: 5)

As shown above, in Malay, [+consonantal] is ranked higher than [+nasal], which means that [-consonantal] segments do not have a contrastive feature [+nasal]. Malay shows a harmony from nasal stops [+nasal] that targets vowels, laryngeals and glides ([-consonantal]) (Onn 1976). Liquids and obstruents ([-nasal]) block harmony. In other words, we can say that segments with no contrastive specification for [+nasal] are potential targets of harmony, while segments specified for [±nasal] are potential triggers and blockers: [+nasal] is the trigger while [-nasal] is the blocker.

According to feature propagation, as in (11), [+nasal] is able to spread from a segment on which it is contrastive, in this case /ŋ/, to one on which it is not, /a/, and continues to spread rightward until it is blocked by a contrastively [+consonantal, -nasal] segment, here /s/:

(11) Deriving by spreading



(Hall 2016: 5)

I will build on those theories and principles to present a contrastive hierarchy analysis of Mandarin vowels.

3. Mandarin vowels

3.1 Mandarin Standard Chinese (MSC)

The term ‘Chinese’ has been widely and broadly used to refer to languages spoken in China. Linguistically speaking, Chinese refers to the seven languages spoken within China, including Wu, Xiang, Gan, Hakka, Min, Yue, and Mandarin (Zhou 1999). Some linguists refer to those languages as the Chinese dialects (Lin 2001). From the traditional approach, the various versions of the Chinese language have always been regarded as dialects of the same language, including Mandarin (as the Northern Dialect), Yue (Cantonese), Min, Kejia (Hakka), and Wu (Shanghainese) (Lin 2001). Those dialects are differentiated among one another predominantly phonologically (Lin 2001). Mandarin as the Northern Dialect has been officially accepted as Putonghua, literally the common language in China. Mandarin is also called Mandarin Standard Chinese (MSC) or Standard Chinese (SC) (Wiese 1997, Duanmu 2007). The present study looks into Mandarin Standard Chinese (MSC). I will refer to MSC as Mandarin.

3.2 Vowel system in Mandarin

There are many different analyses of the phonology of Mandarin vowels. The traditional view is that Mandarin has six underlying vowels, from which all surface forms are derived. Some alternate theories propose five phonemes (Hockett 1947, Cheng 1966, Cheng 1973, Wiese 1997). Table 1 presents the Mandarin vowels under consideration as phonemes. The high vowels /i/, /y/, and /u/ and the low vowel /a/ are uncontroversial. The main problem in the description of the Mandarin vowel system lies in the treatment of mid vowels, as can be seen below.

Table 1. Vowels in Chinese

Front	Central	Back	
i, y		u	High
e	ə	ɤ/o	Mid
	a		Low

As Bender (1988) stated, many scholars define the vowel system based on Pinyin, However, Pinyin is not a true phonology of Mandarin. The traditional Pinyin approach to Mandarin vowels posits six underlying vowels: three high vowels and three non-high vowels /i, y, u, e, a, o/. Hockett (1947) is the first one to question this approach and review the phonemes of Mandarin based on an examination of vowel features. His vowel inventory consists of the vowels /i, y, u, e, a/. Based on investigating phonological processes in Mandarin, Cheng (1966) proposes that it is necessary to have only one underlying mid vowel phoneme: [ə]. All the surface forms could be seen as allophonic variations of that form. His vowel system includes /i, y, u, ə, a/. More recently, in line with Cheng (1966), numerous scholars acknowledge that there are five vowel phonemes /i/ /y/ /ə/ /a/ /u/ in Mandarin by looking at the predictability of the phonological processes affecting the mid vowel (Wiese 1997, Lin 2001, Duanmu 2007), such as the fronting rule that /ə/ → /e/ before front vowels. The present study adopts the analysis that the vowel phonemes in Mandarin are /i/ /y/ /ə/ /a/ /u/ for several reasons given below.

There are debates about the mid vowel /ə/ as an underlying vowel in Mandarin because schwa, the mid vowel [ə], is considered as a phonetic segment that is absent as an underlying vowel in many languages, such as English (Flynn 2012). However, the status of schwa could be disputed for Mandarin because other studies have shown that schwa /ə/ is underlyingly a central vowel in some languages, such as Manchu (Zhang 1996, Van Oostendorp 1998).

There is evidence to support /ə/ as a phoneme in Mandarin. According to Cheng (1973) and Duanmu (2007), /ə/ is an underlying form in Mandarin. The illustration is presented below.

Table 2. Mandarin mid vowels (Duanmu 2007: 51)

Mid vowels	Contexts
[e]	[ei], [je], [ɥe] [ɥye]
[o]	[ou], [wo]
[ə]	Elsewhere, both in open or close syllables, such as [fən], [fəŋ] and [kə]

As in Table 2, [e] occurs before /i/, such as [fei] ‘fly’, and it also occurs in open syllables following /j/, /ɥ/ and /y/, such as [je] ‘leaf’, [ɥe] ‘cut’, and [ɥye] ‘lack’; [o] occurs before /u/ or in open syllables only coming after labials, such as [wo] ‘I’. However, /ə/ occurs in multiple contexts: it occurs before /-n, -ŋ/ in closed syllables, such as [fən] ‘pink’ and [fəŋ] ‘wind’. /ə/ also occurs in open syllables, such as /kə/ ‘class’. According to Duanmu (2007), [e] and [o] do not occur before/-n, -ŋ/ in closed syllables: there are no examples in Mandarin, such as *[fen] and *[fon] or *[feŋ] and *[foŋ].

Considering the distribution of the mid vowels, [e] and [o] are predictable from the phonological context in which they occur: [e] occurs next to a front vowel or glide, [o] occurs next to [u] or [w]. On the other hand, [ə] is unpredictable, and it occurs in more contexts, so [ə] must be the underlying form, and [e] and [o] are its allophones (Cheng 1973, Duanmu 2007).

Let’s return to the Mandarin vowel system. In the Mandarin vowel system, there are five underlying phonemes /i/ /y/ /ə/ /a/ /u/ (Duanmu 2007), as in Table 3: Three high vowels /i, y, u/, one mid vowel /ə/, and one low vowel /a/. Next, it is important to consider how to specify those vowels with contrastive features.

Table 3. Mandarin vowels

Front	Central	Back	
i, y		u	High
	ə		Mid
	a		Low

4. Contrastive hierarchy analysis of Mandarin vowels

According to the activity principle, the selection of contrastive features is based on which features are active in the phonological processes in a given language. In Mandarin, there are four phonological processes which will guide our analysis of the contrastive hierarchy: frontness assimilation in the mid vowel /ə/; frontness assimilation in the low vowel /a/; backness assimilation in the mid vowel; and glide formation in the high vowels /i, y, u/.

4.1 Phonological processes in Mandarin vowels

In the Mandarin vowel system, the mid vowel /ə/ assimilates to the two front vowels /i/ and /y/. As shown below, /ə/ becomes [e] when adjacent to /i/ and /y/. It is important to note that in Mandarin, /ə/ does not occur after a front vowel /i/ or before a front vowel /y/. There is no example, such as *[fiə] or *[xəy].

(12) Frontness assimilation in the mid vowel

UF (underlying)	SF (surface)	Gloss
f**əi**	f**ei**	fly
ɥ**yə**	ɥ**ye**	lack

The mid vowel /ə/ also assimilates to a neighboring vowel if the adjacent vowel is a back vowel /u/. As can be seen below, /ə/ becomes [o] before /u/.

(13) Backness assimilation in the mid vowel

UF	SF	Gloss
əu	g**ou**	dog

Moreover, in Mandarin, the three glides [j, ɥ, w] are derived from the underlying high vowels /i, y, u/ when these vowels occur in the onset with an adjacent vowel (Lin 2001, Duanmu 2007). In this process, /i/ becomes [j], /u/ becomes [w], and /y/ becomes [ɥ] when coming before a vowel.

(14) Glide formation rule

UF	SF	Gloss
yan	ɥæn	money
ian	jæn	salt
uo	wə	hold

Furthermore, [j, ɥ, w] also trigger the same phonological processes as the high vowels /i, y, u/ do because they are allophones of the high vowels. For example, [j, ɥ] trigger frontness assimilation in the mid vowel, while [w] triggers backness assimilation in the mid vowel (Duanmu 2007).

(15) Frontness assimilation and backness assimilation triggered by [j, ɥ, w]

UF	**SF**	**Gloss**
j**ə**	j**e**	street
ɥ**ə**	ɥ**e**	cut
w**ə**	w**o**	I

In Mandarin, frontness assimilation also takes place in the low vowel: [a] becomes [æ] before [j] and [ɥ], such as [jæn] and [ɥæn] not *[jan], *[ɥan], as given below.

(16) Frontness assimilation in the low vowel

UF	**SF**	**Gloss**
y**a**n	ɥ**æ**n	money
i**a**n	j**æ**n	salt

The following table presents a summary of triggers and phonological processes in Mandarin vowels.

Table 4. The summary of triggers and phonological processes in Mandarin vowels.

Triggers	Phonological processes
/i, y/ front vowels	Frontness assimilation in /ə/
/u/ round vowel	Backness assimilation in /ə/
/i, y, u/ high vowels	High vowels become glide in the onset
[j] and [ɥ] (allophones of /i/ and /y/)	Frontness assimilation in /a/
[j, ɥ, w] glides	Frontness and backness assimilation in /ə/

The illustration of those processes is important because it shows how contrastive features are selected. Next, let's look at how to select contrastive features based on those phonological processes.

4.2 The selection and ranking of contrastive features

In the contrastive hierarchy, the selection of contrastive features is determined by examining the phonological processes (Dresher 2009) and phonotactic distribution in a given language (Hall 2016). Based on the processes given previously, it seems that there are two features that must be selected:

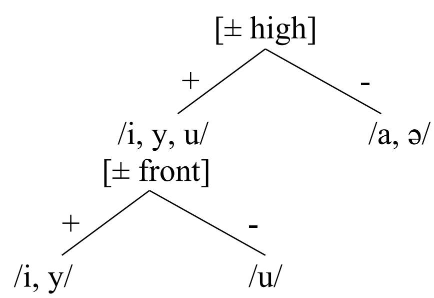
[±front][3] is selected because it triggers frontness assimilation in the mid vowel /ə/; it also triggers backness assimilation in the mid vowel /ə/, so [±front] is a phonologically active feature in the mid vowel. /ə/ assimilates to [+front] when adjacent to /i/ or /y/. As shown in (12-13), /ə/ becomes [e] before or after /i/ and /y/. Also, /ə/ assimilates to [-front] when adjacent to /u/ (/ə/ becomes [o] before /u/).

[±high] is selected for the contrastive hierarchy because in Mandarin, the three glides [j, ɥ, w] are derived from the underlying high vowels /i y u/ when these vowels occur in the onset with an adjacent vowel, which means that [±high] should be used to identify the three high vowels as targets.

In relation to ranking features, as Hall (2016) stipulates, if a feature is phonologically active on given segments, it must be ranked higher and specified for those segments. [±high] is a phonologically active feature, which means that [±high] should be specified for /i, y, u/ to make sure they are properly identified as targets: only high vowels become glides in the onset. [+front] should be specified on /i, y, u/ because /i/ and /y/ trigger frontness assimilation, and /u/ triggers backness assimilation, so [±front] needs to be ranked higher than /i, y, u/. To meet the two conditions, [±high] is first selected to specify /i, y, u/ for [+high] and /a/ and /ə/ are specified for [-high]. Then, /i, y, u/ are assigned with [±front]: /i, y/ are specified with [+front]; /u/ is specified for [-front], as can be seen in the following.

(17) The ranking of [±high] and [±front]

[±high] > [±front]

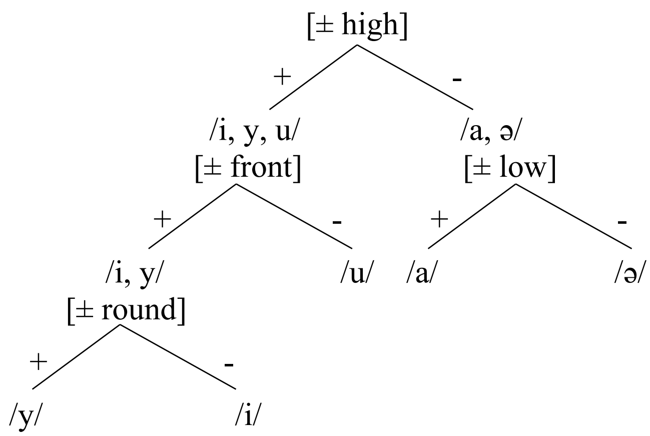


As Dresher (2009) mentioned, in the contrastive hierarchy each phoneme needs to be uniquely specified. In order to further divide /i/ from /y/, [±round] is selected because it is the only feature to distinguish /i/ from /y/. [±low] is selected to distinguish /a/ and /ə/. [±round] and [±low] are phonologically inactive features here because they do not trigger any processes in Mandarin. The contrastive hierarchy of Mandarin is shown below.

[3] I have chosen [front] rather than [back] as the contrastive feature because Wiese (1997) makes use of [±front], [±labial], [±low] to specify the Mandarin vowels. As Wiese mentioned, [±front] is used in addition to [±back] because assimilation leads to vowels which are [+front] and not just [-back]. Also, making use of [±front] has the advantage of describing /a/ as being [-front]. This seems more correct than saying that it is [+back] because /a/ does not trigger any phonological processes involving [±back] in Mandarin. For example, if /a/ is specified with [+back], it should trigger backness assimilation as /u/. However, backness assimilation is only triggered by /u/ in Mandarin.

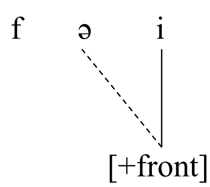
(18) The contrastive hierarchy of Mandarin

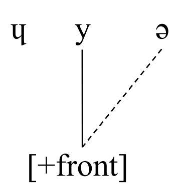
[±high] > [±front] > [±low] > [±round]

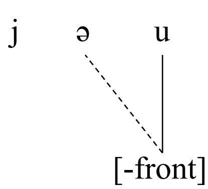


Referring back to feature propagation mentioned in section 2.4, a feature that is contrastively specified on one segment may spread to other segments on which it was not underlyingly specified (Hall 2016). In Mandarin, /ə/ and /a/ are crucially not specified with [±front]. They will receive [±front] feature through feature propagation: The front vowels /i, y/ propagate [+front] to the mid vowel /ə/ which is unspecified for [+front]. /ə/ receives [+front] and becomes [e], as in (19a-b). A back vowel /u/ spreads [-front] to /ə/ which is unspecified for [-front], so that the mid vowel /ə/ receives [-front] and becomes [o].

(19) Feature propagation

a.


b.


c.


5. Conclusion and remaining questions

In conclusion, the preceding sections have introduced the contrastive hierarchy theory and the activity principle proposed by Dresher (2009), with some detailed illustrations in terms of the selection of contrastive features and the scope relations in the contrastive hierarchy. With the use of binary features, the present study demonstrates that the feature hierarchy in the Mandarin vowel system can be represented with the contrastive hierarchy theory and the activity principle. More specifically, the hierarchical organization of features in Mandarin vowels is [±high] > [±front] > [±low] > [±round] as this ranking explains the phonological processes and natural classes in Mandarin.

As Cowper and Hall (2019) postulate, it is expected that the order of acquisition corresponds to hierarchical scope, which implies that features ordered higher in the tree would be acquired first by children. Following this approach, Bohn (2018) has conducted a study investigating the acquisition of stressed vowels in Brazilian Portuguese by 3 monolingual children, using the SDA as a phonological model. His findings suggest that although children' learning paths vary, their learning paths follow a hierarchical developmental path. Hierarchical scope also raises the question of how learners might reorganize their feature hierarchy when acquiring a new feature in L2 or L3. It would be interesting to see whether there are distinctions between the acquisition of phonologically active and inactive features and between features ranked high and features ranked low in L2 or L3. More importantly, if a feature is ranked in a high position in one language but low in another language, how will learners reorganize their feature hierarchy in order to acquire a such feature, such as re-ranking their feature hierarchy, and what the evidence would be to tell them that they need to reorganize. Those are some possible questions that could be investigated in future studies.

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