

Developmental paths in the acquisition of the Japanese liquid: An Optimality-theoretic perspective*

Isao Ueda and Stuart Davis

Abstract

This study offers a unified account of the acquisition of the Japanese liquid. It is recognized that there are two possible paths children take to reach the fully developed system with respect to the acquisition of the liquid. We first provide detailed data for these two paths. These data are analyzed under Optimality Theory. We discuss that the acquisition of the liquid is explicated by positing a series of rerankings of three phonological constraints, and that the two different paths are nothing other than two different reranking processes. Finally, we suggest that our analysis sheds light upon other aspects related to the distribution of the liquid.

1. Introduction

Although Japanese has a relatively simple segmental inventory and most of the target sounds are acquired fairly early, there are some segments which are reported to be acquired relatively late. Amongst them is the liquid, which has often been a subject matter of phonological acquisition research (Umebayashi and Takagi 1965, Sakauchi 1967 and Murata 1970 *inter alios*).

At least two representative types or patterns are reported in the first language acquisition of the Japanese liquid. These two types are differentiated in that they exhibit different substitution patterns and that they take different "paths" in acquisition, which have never been analyzed in any unified way. Given this, we set up two goals for the present paper. First, we provide rather detailed descriptive data of these "paths" integrating our previous work

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(Ueda and Davis 1999, 2001a and b); we then examine the data from an Optimality-theoretic perspective with a discussion of some implications sprouting from the analysis. Overall, the present paper serves as a unified and finalized version of our earlier work.

2 Two developmental paths of the Japanese liquid

Japanese has only one liquid, which is /r/. It is labeled as a tap or a flap depending on the literature (Vance 1987). It exhibits a wide range of allophonic variation both contextually and within and across dialects and idelects. In acquisition /r/ most likely alternates with or is replaced by /d/. The featural difference between them is that /r/ is specified as [+sonorant], whereas /d/ is specified as [-sonorant] (Carr 1993).

Shown in (1) is one of the two representative types mentioned above (henceforth abbreviated as Type A). In the earliest stage of acquisition, target /r/ is misproduced as [d], while target /d/ is correctly produced as [d] in word-initial position (a and b). In word-medial or intervocalic position, however, target /r/ is correctly produced as [r], but target /d/ is misproduced as [r] (c and d). This type is characterized as a complementary distribution type, in which [d] and [r] behave like two allophones of a phoneme and appear in mutually exclusive environments. (We assume here the independently motivated Coda Condition in Japanese that prevents /r/ and /d/ from surfacing as a coda.)

(1) Type A (The earliest stage)

Word-initial position

(a)	Phonetic forms	Target forms	Gloss
	dappa	rappa	trumpet
	doosoku	roosoku	candle
	demon	remon	lemon
	disu	risu	squirrel

(Target /r/ is misproduced as [d])

(b)	Phonetic forms	Target forms	Gloss
	daruma	daruma	tumbler
	doobutsuwa	doobutsuwa	zoo
	denja	denja	tram car

(Target /d/ is correctly produced as [d])

Word-medial position

(c)	Phonetic forms	Target forms	Gloss
	paraʃuuto	paraʃuuto	parachute
	guroobu	guroobu	glove
	terebi	terebi	television
	sora	sora	sky

(Target /r/ is correctly produced as [r])

(d)	Phonetic forms	Target forms	Gloss
	dʒiɾooʃa	dʒidooʃa	automobile
	namira	namida	tear
	buɾoo	budoo	grape

(Target /d/ is misproduced as [r])

In the second type (henceforth abbreviated as Type B), target /r/ is replaced by [d] irrespective of the position in a word. Target /d/ is correctly produced everywhere.

(2) Type B (The earliest stage)

Word-initial position

(a)	Phonetic forms	Target forms	Gloss
	dappa	rappa	trumpet
	doosoku	roosoku	candle
	demon	remon	lemon
	disu	risu	squirrel

(Target /r/ is misproduced as [d])

(b)	Phonetic forms	Target forms	Gloss
	daruma	daruma	tumbler
	doobutsueŋ	doobutsueŋ	zoo
	denʃa	denʃa	tram car

(Target /d/ is correctly produced as [d])

Word-medial position

(c)	Phonetic forms	Target forms	Gloss
	padaʃuuto	paraʃuuto	parachute
	gudoobu	guroobu	glove
	tedebi	terebi	television
	soda	sora	sky

(Target /r/ is misproduced as [d])

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(d)	Phonetic forms	Target forms	Gloss
	dʒidooʃa	dʒidooʃa	automobile
	namida	namida	tear
	budoo	budoo	grape
	(Target /d/ is correctly produced as [d])		

3 *Developmental paths of Type A and B*

In this section we examine how Type A and B develop from their initial stages to the fully developed stage. The step-by-step development is schematically expressed in (3) and (4), where symbols (#_) and (V_V) denote word-initial and intervocalic positions respectively and (d-/d/) means target /d/ is produced as [d] and so forth. Let us observe the developmental path of Type A. In the earliest stage, as shown in (1), the children have only word-initial [d] and intervocalic [r] whether the target is /d/ or /r/ (3a). In the second stage word-initial [r] emerges as a free variant of [d]. This means the same word-initial target of the same lexical item is produced either as [d] or as [r]. On the other hand, intervocalically no [d] has been evident yet (3b). The third stage sees the word-initial phonemic split is completed; target /r/ is correctly produced. However, intervocalic target /d/ is still produced as [r] (3c). In the fourth stage [d] appears intervocalically in free variation with [r]. The target in the same lexical item is produced either as [d] or as [r] (3d). The fifth and final stage shows the completion of phonemic split both word-initially and intervocalically (3e).

(3) Developmental path of Type A

(a) First stage

#_: d-/d/, d-/r/ V_V: r-/d/, r-/r/

(b) Second stage

#_: d-/d/, d, r-/r/ V_V: r-/d/, r-/r/

(c) Third stage

#_: d-/d/, r-/r/ V_V: r-/d/, r-/r/

(d) Fourth stage

#_: d-/d/, r-/r/ V_V: d, r-/d/, r-/r/

(e) Fifth stage

#_: d-/d/, r-/r/ V_V: d-/d/, r-/r/

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Next, let us take a look at the developmental path of Type B in (4). In the earliest stage target /r/ is replaced by [d] irrespective of position in a word (4a). The target /r/ is produced as [r] or [d] intervocalically in the second stage, whereas target /r/ is still produced as [d] word-initially (4b). In the third stage the phonemic split is completed intervocalically, while target /r/ is still produced as [d] word-initially (4c). In the fourth stage target /r/ is produced as [r] or [d] word-initially. Again this is an instance of free variation (4d). Finally, phonemic split is completed word-initially too in the fifth stage as in (4e).

(4) Developmental path of Type B

(a) First stage

#_: d-/d/, d-/r/ V_V: d-/d/, d-/r/

(b) Second stage

#_: d-/d/, d-/r/ V_V: d-/d/, d, r-/r/

(c) Third stage

#_: d-/d/, d-/r/ V_V: d-/d/, r-/r/

(d) Fourth stage

#_: d-/d/, d, r-/r/ V_V: d-/d/, r-/r/

(e) Fifth and final stage

#_: d-/d/, r-/r/ V_V: d-/d/, r-/r/

In the next section, we see how these two different developmental paths are explained in a unified way under Optimality Theory.

4 Optimality-theoretic account

The development of Type A and Type B from their earliest stages through their fully developed stages are captured by positing the three markedness and faithfulness constraints below which demote or promote in a step-by-step fashion but taking different paths. Therefore these two types of acquisition are also characterized by the way these constraints are reranked along the paths they take.

- (5) Three relevant constraints
- (a) *Margin/r: "r" is avoided in margin (i.e. onset) position.
 - (b) Intervocalic weakening (IW): segments in intervocalic position are weakened.
 - (c) Feature faithfulness (FF): features which make up the input should be realized in the output.

The constraint (a) comes from Prince and Smolensky's (1993) margin hierarchy in which "r" is the most dispreferred (true) consonant in onset position. The preference for intervocalic weakening as reflected in (b) has been discussed by Kirchner (1998); we assume here [r] is a weakened version of [d]. The feature faithfulness constraint in (c) is part of the faithfulness family of constraints as originally developed in McCarthy and Prince (1995). Our claim is that the developmental realization of /d/ and /r/ is the result of the ranking of these three constraints whereby in both Type A and Type B the faithfulness constraint (c) is initially low-ranked. Type A and Type B result from different paths taken by the children which reflect a different change over time of the ranking of these three constraints.

First let us consider how these constraints are ranked in fully developed (adult) system. In the fully developed system, [r] surfaces in margin position and [d] is not weakened intervocalically. Thus FF is ranked highest as in (6).

- (6) Ranking for the fully developed (adult) system
FF >> *Margin/r, IW

In the following sections we examine how this fully developed ranking is achieved in Type A and B in their courses of development.

5 Constraint demotion/promotion in Type A

In this section we discuss how these three constraints are demoted (and promoted) in the course of development in Type A. Let us consider the initial ranking of Type A first. In the earliest stage the word-initial output is realized as [d] regardless of the target. The fact suggests that *Margin/r is higher ranked than FF. This ranking is formalized in the following tableaux. (We use [a] as representing all vowels throughout the discussion.)

- (7) Tableaux for word-initial /ra/ and /da/ in the initial stage
 a. /ra/ --- [da]

/ra/	IW	*Margin/r	FF
ra		*!	*
☞ da			*

- b. /da/ --- [da]

/ra/	IW	*Margin/r	FF
ra		*!	*
☞ da			*

The two tableaux (7a) and (7b) demonstrate that *Margin/r plays a crucial role in determining the output. The violation of FF matters relatively less. Thus *Margin/r is ranked higher than FF, resulting in the unfaithful output [da] for /ra/. Therefore the constraint ranking here is: *Margin/r >> FF, with IW being irrelevant in this case.

In the intervocalic position, the constraint IW is at work now, resulting in the targets /d/ and /r/ being both realized as [r]. This is formalized in the two tableaux (8a) and (8b).

- (8) Tableaux for word-medial /ara/ and /ada/ in the initial stage
 a. /ara/ --- [ara]

/ara/	IW	*Margin/r	FF
☞ ara		*	*
ada	*!	*	*

- b. /ada/ --- [ara]

/ara/	IW	*Margin/r	FF
☞ ara		*	*
ada	*!	*	*

Here we have the ranking: $IW \gg *Margin/r, FF$. The integration of the above two rankings results in the ranking in the initial stage of Type A in (9).

- (9) Initial ranking (Type A)
 $IW \gg *Margin/r \gg FF$

Let us move on to the second stage. In this stage word-initial [r] emerges as a free variant of [d]. This is explained by positing $*Margin/r$ being demoted (or FF promoted). Notice in (10a) neither [ra] nor [da] is an absolute winner over the other. The violation of $*Margin/r$ yields the surface [da] and the violation of FF yields [ra]. Note that this free variation reflects the lack of any decisive winner.

- (10) Tableaux for the second stage (Type A)

a. /ra/ --- [ra] or [da]

/ra/	IW	*Margin/r	FF
☞ ra		*	
☞ da			*

b. /da/ --- [da]

/da/	IW	*Margin/r	FF
ra		*	
☞ da			*

c. /ara/ --- [ara]

/ara/	IW	*Margin/r	FF
☞ ara		*	
ada	*!		*

d. /ada/ --- [ara]

/ara/	IW	*Margin/r	FF
☞ ara		*	*
ada	*!		

The ranking for this stage is in (11).

(11) Ranking for the second stage (Type A)

IW >> *Margin/r, FF

In the third stage word-initial targets are produced correctly due to *Margin/r being demoted once again. Let us see this in the tableaux (12) and the ranking in (13).

(12) Tableaux for the third stage (Type A)

a. /ra/ --- [ra]

/ra/	IW	FF	*Margin/r
☞ ra			*
da		*!	

b. /da/ --- [da]

/da/	IW	FF	*Margin/r
ra		*!	*
☞ da			

c. /ara/ --- [ara]

/ara/	IW	FF	*Margin/r
☞ ara			*
ada	*!	*	

d. /ada/ --- [ara]

/ada/	IW	FF	*Margin/r
☞ ara		*	*
ada	*!		

(13) Ranking for the third stage (Type A)

IW >> FF >> *Margin/r

The fourth stage is also a state of free variation: if FF is still outranked by IW, we get intervocalic [r] as in the third stage above. However, if FF is placed on the equal ranking to IW with the demotion of IW, we have intervocalic [d]. We assume that this is a transitional stage as in the following tableaux. Notice that in this case, the free variation occurs as a result of the ranking undetermined locally.

(14) Tableaux for the fourth stage (Type A)

a. /ra/ --- [ra]

/ra/	IW	FF	*Margin/r
☞ ra			*
da		*!	

b. /da/ --- [da]

/ra/	IW	FF	*Margin/r
ra		*!	*
☞ da			

c. /ara/ --- [ara]

/ara/	IW	FF	*Margin/r
☞ ara		*	*
ada	*!	*	

d. /ada/ --- [ada]

/ada/	IW	FF	*Margin/r
ara		*	*!
→ada	*		

We can see this local indeterminacy reflected in the ranking in (15).

- (15) Ranking for the fourth stage (Type A)
 IW >> FF >> *Margin/r or IW, FF >> *Margin/r

The fifth and final stage is the fully developed stage. The child has the same ranking as the adult system as in (6), which is repeated here as (16).

- (16) Ranking for the fifth (fully developed) stage (Type A)
 FF >> *Margin/r, IW

6 Constraint demotion/promotion in Type B

In this section we see how the three constraints are demoted (or promoted) in Type B, which triggers consequent changes in the phonological system. Let us begin with the initial stage in which all targets are realized as [d]. This is due to undominated *Margin/r; [r] never surfaces. Hence the ranking in (17).

- (17) Initial ranking (Type B)
 *Margin/r >> FF, IW

In the second stage the target /r/ is produced as [r] or [d] intervocally, whereas target /r/ is still produced as [d] word-initially. Again, this is a transitional stage between the first and the third stages. If the ranking is the same as that in the first stage, then the intervocalic target /r/ is produced as [d], while if IW is equally ranked to *Margin/r, it is produced as [r] which is shown in the following.

(18) Tableaux for the second stage (Type B)

a. /ra/ --- [da]

/ra/	*Margin/r	IW	FF
ra	*		
☞da			*

b. /da/ --- [da]

/ra/	*Margin/r	IW	FF
ra	*!		*
☞da			

c. /ara/ --- [ara]

/ara/	*Margin/r	IW	FF
☞ara	*!		
ada		*	*!

d. /ada/ --- [ada]

/ada/	*Margin/r	IW	FF
ara	*		*!
☞ada		*	

The ranking for the second stage is in the following.

(19) Ranking for the second stage (Type B)
 *Margin/r >> FF, IW or *Margin/r, IW >> FF

In the third stage, the fluctuant ranking is now fixed and the phonemic split is completed intervocalically, whose ranking is in (20).

(20) Ranking for the third stage (Type B)

*Margin/r, IW >> FF

In the fourth stage FF is promoted so that all three constraints are ranked equally, which results in word-initial /r/ being produced either as [d] or [r]. Notice in the following tableau (a) that there is no decisive winner, hence this free variation.

(21) Tableaux for the fourth stage (Type B)

a. /ra/ --- [da] or [ra]

/ra/	IW	*Margin/r	FF
ra		*	
da			*

b. /da/ --- [da]

/da/	IW	*Margin/r	FF
ra		*	*!
da			

c. /ara/ --- [ara]

/ada/	IW	*Margin/r	FF
ara		*	
ada	*		*!

d. /ada/ --- [ada]

/ada/	IW	*Margin/r	FF
ara		*	*!
ada	*		

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Thus the ranking for this stage is in (22).

(22) Ranking for the fourth stage (Type B)

*Margin/r, IW, FF

Finally the adult-like system is reached with the fully developed ranking, which is repeated in (23).

(23) Ranking for the fifth (fully developed) stage (Type B)

FF >> *Margin/r, IW

In what follows we summarize the two different paths we have been discussing.

(24) Summary of the constraint reranking processes in the two "paths"

a. Type A

1 IW >> *Margin/r >> FF

2 IW >> *Margin/r, FF

3 IW >> FF >> *Margin/r

4 IW >> FF >> *Margin/r or IW, FF >> *Margin/r

5 FF >> *Margin/r, IW

b. Type B

1 *Margin/r >> FF, IW

2 *Margin/r >> FF, IW or *Margin/r, IW >> FF

3 *Margin/r, IW >> FF

4 IW, *Margin/r, FF

5 FF >> *Margin/r, IW

7 Discussion

Given the constraint reranking processes shown in (24), the acquisition of Japanese /r/ is characterized as two dynamic processes wherein the relative ranking of the three constraints, IW, *Margin/r and FF exhibits a series of changes. In Type A, IW stays relatively high on the ranking compared with *Margin/r before it is outranked by FF; in Type B, on the contrary, it is *Margin/r that stays relatively high. The difference between the two paths is reduced to the two different constraint reranking processes.

In addition to this characterization, there are a few aspects we should pay heed to. First, the reranking of the constraints takes

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place step by step. It does not occur "by leaps and bounds." For example, given the demotion of a constraint Ca (or promotion of Cb) in the ranking: Ca >> Cb >> Cc at one stage, we can predict that the reranking takes place to yield a new ranking, for instance: Ca, Cb >> Cc in the next stage. Each transition in Type A and B follows this procedure. A 'radical' reranking like: Cb >> Cc >> Ca would not be expected. In this respect we can also predict how the grammar is restructured.

Second, surface free variation is either the result of a constraint unstable in ranking (the ranking is locally undetermined), or the result of equal ranking among the (relevant) constraints so that there is no decisive winner among the candidates.

Third, the intermediate stages of acquisition reveal some important aspects of Japanese phonology. We find an interesting parallelism in some Japanese dialects. Let us take a look at the distribution of [r] and [d] in Hachijo Island dialect and in Osaki dialect of Niigata..

(25) Distribution of [r] and [d] in Japanese dialects

a. Hachijo Island dialect (Kokuritsu Kokugo Kenkyusho 1950)

Hachijo Island	Standard Japanese	Gloss
danbo:	ranbo:	violence
dentogen	rentogen	X-ray
do:soku	ro:soku	candle
ɕjindʒi	rindʒi	extra
ɕzusu	rusu	absence

(The neutralization occurs only in word-initial position)

b. Osaki dialect of Niigata (Kato 1961)

Osaki	Standard Japanese	Gloss
koromo	kodomo	child
sore	sode	sleeve
so:ra	so:da	(it is) true
ɕjirɔ:ʃa	ɕjido:ʃa	automobile

(The neutralization occurs only in intervocalic position)

We notice that the distribution of [r] and [d] in Hachijo dialect is exactly the same as that in the third stage of Type B, in which *Margin/r is ranked higher than FF. Also, the distribution of [r] and [d] in Osaki dialect is exactly the same as that in the third stage of Type A, in which IW is ranked higher than FF. Sugito (1996) reports that dialects exhibiting the 'confusion' between [d] and [r] are scattered across Japan. This fact suggests that in the

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phonological system of Japanese, the ranking between IW, *Margin/r and FF tends to be unstable, which results in some dialects being different in the distribution of [d] and [r]. Moreover, some idiolectal variation has been observed and some generational differences have been noted. For instance, in both dialects (a) and (b), standardization is in progress; the younger people are speaking standard Japanese. This means *Margin/r and IW are being demoted in these dialects respectively. This is a further reflection of unstable ranking among the three constraints. The developmental paths we have been discussed show various distributions of [d] and [r], but they are nothing but some instantiations which result from the constraint rankings permitted within the limits of the grammar of Japanese; early misarticulation is not deviant nor "disordered" in this sense. Furthermore, if we turn to the languages of the world, we find languages in which [r] and [d] exhibit the same distribution. In Tagalog which has a flap "r", the distribution of [d] and [r] looks like the initial stage of Type A. See some examples from Tagalog in (26).

(26) Tagalog (Schachter and Otones 1972)

Phonetic forms	Gloss	Phonetic forms	Gloss
dalita	poverty	maralita	poor
dapat	should	narapat	proper
dining	hearing	makarinig	hear

We conclude this section by claiming that the distribution of [d] and [r] in child Japanese we have been discussing is not an isolated phenomenon but it is deeply associated with the distribution of [d] and [r] in general.

One final remark is in order. Thus far we have discussed the aspect of development in which acquisition takes place only by constraint reranking. In such acquisition, having acquired adult-like inputs is presupposed. However, there are some cases in which a child does not seem to have adult-like inputs. In a case like this the child has to learn adult-like inputs as well as adult-like constraint ranking. Usually the phonemic split occurs with a new sound gradually diffusing into lexicon; the child has to learn the target word by word, morpheme by morpheme. Our discussion does not hold for the case of this "lexical diffusion." In lexical diffusion, a target of a word may be correctly produced, but the same target of another word may be wrongly produced. On the other hand, in the free variation we have discussed, the target of the very same word is produced correctly or incorrectly (Ueda 1999). The acquisition by lexical diffusion has not been

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studied well and needs further research.

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Isao Ueda
Department of Area Studies, Osaka University of Foreign
Studies,
Japan
e-mail: uedais@osaka-gaidai.ac.jp

Stuart Davis
Department of Linguistics, Indiana University
United States of America
e-mail: davis@indiana.edu

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University and University of Colorado, Boulder.

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Author: Isao Ueda
Department of Area Studies, Osaka University
of Foreign Studies

Stuart Davis
Department of Linguistics, Indiana University

Postal Address: Isao Ueda
Department of Area Studies
Osaka University of Foreign Studies
8-1-1 Aomatani-higashi, Minoo-shi, Osaka-fu
562-8558
Japan

Stuart Davis
Department of Linguistics
Memorial Hall 322
1021 East Third Street
Indiana University
Bloomington, IN
47405
USA

E-mail: uedais@osaka-gaidai.ac.jp
davis@indiana.edu