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*Moraic reversal and realisation: analysis of a Japanese language game**

Daiho Kitaoka
University of Ottawa and University of Nottingham Ningbo China

Sara Mackenzie
Memorial University of Newfoundland

This paper provides a description and an Optimality Theory analysis of the Japanese language game sakasa kotoba. This analysis contributes to the phonological study of language games, as sakasa kotoba constitutes a novel language game type: total mora reversal. In addition, our analysis contributes to the study of Japanese phonology, by providing evidence (i) for the mora, (ii) on the internal structure of the syllable in Japanese and (iii) on the representation of moras occurring in complex syllables, namely coda nasals, geminates and long vowels. The patterning of these moras suggests that the game manipulates intermediate representations, rather than underlying or surface forms. We propose a formal analysis within the framework of Stratal OT. The analysis uses a game-specific constraint to motivate reversal, with other aspects of game form shape determined through the interaction of markedness and faithfulness constraints.

1 Introduction

This paper provides a description and analysis of the Japanese language game SAKASA KOTOBA 'reverse language'. This analysis contributes to the phonological study of language games, as sakasa kotoba has previously received only a brief and incomplete description in the literature (Smith 1980) and constitutes a novel language game type, namely total mora reversal.

* E-mail: DAIHO.KITAOKA@NOTTINGHAM.EDU.CN, SJMACKENZIE@MUN.CA.
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The analysis also contributes to the study of Japanese phonology, by providing evidence (i) for the mora, (ii) on the internal structure of the syllable and (iii) on the representation of coda nasals, geminates and long vowels.

The study of language games has provided a significant source of evidence regarding theories of phonological representations (Bagemihl 1989, 1995, Vaux 2011). As illustrated in studies of language game typologies by Bagemihl (1989, 1995), language games involve systematic manipulation of linguistic structure. Language game operations include affixation, reversal and replacement processes, which resemble those found in regular non-game phonologies. Parallels between language game operations and phonological processes in natural languages mean that language game studies provide relevant sources of evidence for theories of phonological operations and representations, particularly with respect to the representation and manipulation of prosodic constituents such as syllables (e.g. Davis & Hammond 1995), timing units (e.g. Bagemihl 1989), feet (e.g. Tateishi 1989), moras (e.g. Tateishi 1989, Katada 1990) and tonal melodies (e.g. Hombert 1986). Like work on other Japanese language games (e.g. Tateishi 1989, Katada 1990), the present study shows that the patterning of sakasa kotoba can be accounted for by making reference to the mora as a constituent.

The patterning of sakasa kotoba further suggests that structures manipulated by reversal correspond neither to underlying representations nor to regular Japanese surface forms. Rather, the language game operation takes as its input an intermediate representation. Evidence for intermediate representations comes from the patterning of geminates, long vowels and coda nasals, as well as from the interaction of sakasa kotoba with other phonological processes. This pattern is compatible with a variety of frameworks that make use of intermediate representations, including rule-based approaches. We provide a formal analysis within the framework of Stratal Optimality Theory (e.g. Kiparsky 2000, Bermúdez-Otero 2003, Rubach 2003). In our proposal, the input to the game is the output of an OT evaluation consistent with the lexical level. The architecture of Stratal OT allows for the manipulation of intermediate forms while deriving the phonological shape of game forms through the interaction of markedness and faithfulness constraints.

The structure of the paper is as follows. §2 provides relevant background on Japanese prosodic structure. §3 introduces sakasa kotoba, including a description of the speakers and elicitation materials used in this study (§3.1), a summary of the basic sakasa kotoba pattern (§3.2) and a presentation of variation found between speakers in cases where the reversal operation results in marked structures (§3.3). §4 considers the relationship between phonological representations manipulated by the game and the conventions of Japanese orthography. §5 presents the constraint ranking used to account for the reversing operation in forms that contain only simple CV syllables, and §6 shows how this analysis can be extended to forms that contain geminates, long vowels and moraic nasals. §7 provides arguments for intermediate representations and proposes a stratal OT

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analysis which integrates the constraint rankings proposed in these sections. In §8, we suggest formal approaches to some of the variation found between speakers. §9 provides additional evidence for intermediate representations by examining the interaction of sakasa kotoba with phonological processes such as rendaku and high vowel devoicing. §10 concludes.

2 Background on Japanese prosodic structure

Both traditional studies and contemporary linguistic analyses make reference to the mora as a prosodic unit of Japanese (e.g. McCawley 1968). Evidence for the mora is found in studies of phonological processes, poetic metre, orthography and speech errors (e.g. Kubozono 1989, Labrune 2012). A simple mora consists of a vowel, optionally preceded by a consonant. The words in (1) consist of sequences of simple moras.[1]

(1) /sa.ku.ra/ [sakura] 'cherry blossom'
/ka.o.ri/ [kaori] 'fragrance'

In addition to (C)V moras, Japanese has what are traditionally referred to as 'special' moras: N, Q and R (e.g. Vance 1987). (2a) shows forms with the special mora N, realised as a word-final or preconsonantal nasal, the forms in (2b) contain Q, realised as the first half of a geminate consonant, and those in (2c) have R, realised as vowel length.

(2) a.	/ho.N/	[hoɴ]	'book'	/ka.N.ki/	[kaŋki]	'ventilation'
b.	/o.ka.Q.pa/	[okappa]	'bobbed hair'	/ki.Q.te/	[kitte]	'stamp'
c.	/si.R.to/	[ʃiito]	'sheet'	/ka.R.do/	[kaado]	'card'

The relevance of the syllable in Japanese phonology is a matter of debate, with some claiming that no reference to syllable structure is necessary (e.g. Labrune 2012), while others argue that the syllable is needed to account for pitch accent, loanword truncation and restrictions on superheavy syllables (McCawley 1968, Kubozono 1999, Kawahara 2012). Any analysis of Japanese phonology requires some mechanism to account for the difference in status and distribution between simple CV moras and the special moras N, Q and R. We will assume the syllable is a prosodic constituent of Japanese, and that restrictions on the realisation and distribution of special moras follow from their place within syllable structure. Given these assumptions, each of the simple moras shown in (1) constitutes a syllable, whereas the forms in (2) contain complex syllables consisting of a simple CV mora followed by N (a), Q (b) or R (c).

[1] Boundaries between moras are indicated with '.'. Throughout the paper, transcriptions for underlying forms largely follow the conventions of Kunreisiki romanisation. However, /y/ in the Kunreisiki rules is transcribed as /j/ here (e.g. /sya/ in the Kunreisiki rule is transcribed as /sja/), and surface [ʧa] is transcribed as /tja/, whereas the Kunreisiki rule uses /cha/.

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3 Sakasa kotoba

3.1 Data

Sakasa kotoba is a Japanese reversing game, played by the first author in childhood. A word in sakasa kotoba is derived by reversing moras, as seen in (3).

(3)

Regular form	*Game form*	
sakura	rakusa	'cherry blossom'
todoroki	kirodoto	'roar'
iou	uoi	'sulphur'

Aside from a brief description in Smith (1980), sakasa kotoba has not been considered in the descriptive or theoretical literature on language games.[2] Although Smith (1980) presents only six game forms, there is considerable variation in his examples; two are unambiguous examples of moraic reversal (no alternate pronunciations are provided) (4a), two are presented as having two variants, one consistent with moraic reversal and the other consistent with syllabic reversal (4b), and two are examples of syllabic reversal (4c).

(4)

	Regular form	*Game form*	
a.	taira	raita	(name)
	kappu	pukka	'cup'
b.	riŋgo	gonri ~ goriN	'apple'
	ginza	zaŋgi ~ zagiN	(name)
c.	bjoobu	bubjoo	'screen'
	tiizu	zutii	'cheese'

In addition to the relative absence of linguistic literature on sakasa kotoba, we also did not find any sources on its prevalence in Japanese culture. To our knowledge, and in contrast to zuuja-go, a game widely used among jazz musicians (Itô *et al.* 1996), social functions of the game have not been reported. For the first author, the game was purely an enjoyable form of childhood word play. Anecdotally, both a speaker who transcribed the data and one of the participants in the study reported here initially said that they were unfamiliar with sakasa kotoba, but after hearing the elicitation materials reported that they had in fact played a game like it in childhood. It is possible that something similar to sakasa kotoba is widespread, but not always known by this name. Further exploration of these issues is beyond the scope of this paper.

In our study, we elicited data from six Japanese speakers, three who reported that they had learned the game in childhood, two who were

[2] Smith (1980) cites Martin (1974) as the source of the sakasa kotoba data presented in his thesis. There is no Martin (1974) listed in Smith's references, and we believe that the intended citation is Martin (1975). Unfortunately, no page numbers are provided in Smith and we were unable to find any reference to sakasa kotoba in Martin (1975).

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familiar with the name of the game but did not remember playing it, and one who originally stated he had not played the game but after elicitation said that he had played a game of this type. Speakers participating in the study were given verbal instructions that included two sakasa kotoba examples formed from words containing only CV syllables. 64 Japanese words were presented to each speaker, with the order of presentation being consistent across speakers.

For each example, the word was first presented to participants in a carrier sentence, intended to illustrate its meaning, and then pronounced in isolation. Speakers provided game forms after hearing the word in isolation. Elicitation was conducted orally. For one speaker, the first author read the elicitation materials directly to the participant. The other five speakers were presented with recordings of the first author embedded in a PowerPoint presentation. Each slide was accompanied by the recorded carrier sentence and isolation form for one example. Slides did not contain any written instructions or written forms of any items. The only information on the slides was the example number and the total number of examples included (e.g. '1 of 64').

Elicited data were transcribed impressionistically by the first author. In order to verify some cases of ambiguity, a second transcriber provided representations for all the data, without seeing the first author's transcriptions. For most forms, the transcriptions were in agreement, although there were some discrepancies, mostly involving transcriptions of the moraic nasal. In some items, the first author transcribed a uvular nasal and the second transcriber used a nasalised version of the preceding vowel or showed the nasal as assimilating to the place of articulation of a following segment. There were also some cases where the first transcriber perceived a glottal stop before a liquid or glide which was shown as geminated by the second transcriber. The differences between transcriptions in these cases are not crucial for our analysis. Unless otherwise noted, forms in the paper are given as transcribed by the first author. The full set of transcriptions from the two transcribers is available in the online supplementary materials.[3] Due to researcher error, not all items were recorded for two of the speakers. As a result, responses are reported from all six speakers for items 1–32 in the supplementary materials, but for items 33–41 only from five speakers, and for items 42–64 only from four.

As is commonly the case in language games (see e.g. Nevins & Vaux 2003, Vaux 2011), variation is found between speakers for some forms. For many examples, however, there was uniformity in the responses from all participants. In the following discussion, when game forms are presented without discussion of variation, all speakers behaved alike in their production for those examples.

3.2 The basic pattern

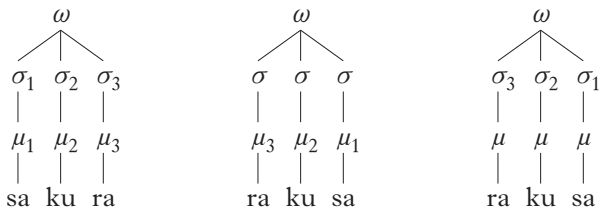
The basic pattern of sakasa kotoba is illustrated in the elicited forms in (3) above. In these examples, the mora that is final in the regular form is initial

[3] Available at https://doi.org/10.1017/S095267572100004X.

in the game form. The mora in second position in the regular form is in penultimate position in the game form, and so on. Sakasa kotoba forms also undergo alterations in pitch accent; this is not indicated in the transcriptions. Pitch accent in the elicited data varies amongst speakers and items. For some speakers, game forms have initial accent, regardless of the accent pattern of the base form. Other speakers have unaccented game forms, or show variation between items. Some speakers produced game forms slowly, mora by mora, without a clear accent pattern for the word as a whole. Although some of this variation may follow from differences in the game itself, the native dialect of participants was not controlled in the study (pitch accent patterns vary considerably across Japanese dialects). The description and analysis below will focus on segmental aspects of game structure.

The data in (3) contain only simple moras. The sakasa kotoba forms of these words are compatible with an analysis in terms of either of moraic or syllabic reversal, as illustrated in (5).

(5) *Regular form* *Moraic reversal* *Syllabic reversal*



Unlike the preceding examples, the forms in (6) contain the special moras N, Q and R. Reversal of moras and syllables will yield different results for these forms; the elicited game forms in (6) demonstrate that moras are the units reversed in the game. (Broad transcriptions of both regular Japanese forms and game forms are shown in / /.[4])

(6)	*Regular form*		*Game form*		
a.	/ki.N.ho.si/ ‘to be a giant-killer’	[kimboʃi]	/si.bo.N.ki/	[ʃiboŋki][5]	*[ʃibokiŋ]
b.	/ki.Q.te/ ‘stamp’	[kitte]	/te.Q.ki/	[tekki]	*[tekit]
c.	/do.to.R.ru/ (name)	[dotooru]	/ru.R.to.do/	[ruutodo][6]	*[rutoodo]

[4] Forms shown between / / here are not intended as underlying representations in the sense of stored forms that are inputs to the phonological grammar. Both game forms and regular language forms have the same underlying representations. Details of how underlying representations map to game forms are provided in the analysis in §5–§8.

[5] This form also shows the effect of the compound voicing process known as rendaku. The interaction of rendaku and sakasa kotoba is discussed in §9.

[6] There was one case of variation in example (6c). Speaker 1 altered the voicing in one consonant in the reversed form, producing [ruudodu].

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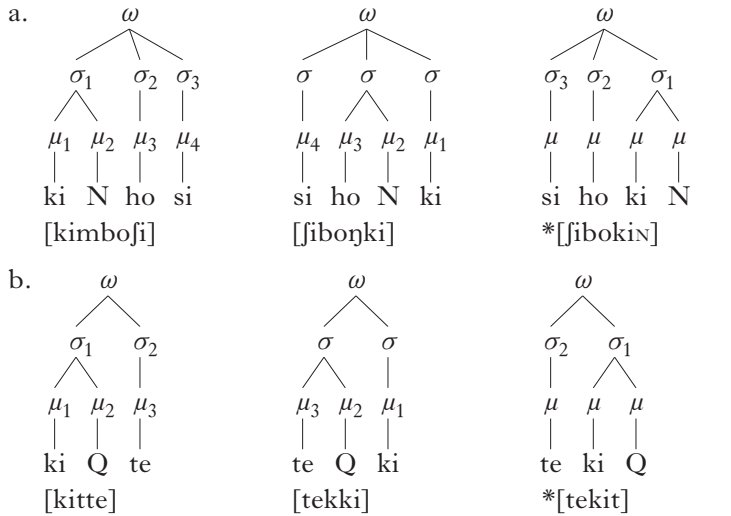
Contrary to the data reported in Smith (1980), none of the speakers in this study produced syllabic reversals for the forms in (6), although some instances of syllabic reversal were produced for more complex forms. These are considered in following sections.

Representations of the reversals in (6a, b) are given in (7).

(7)



The starred examples in (7) show the unattested game forms that would be expected if syllables were the units referred to by the game. The actual game forms are inconsistent with reversing games attested in other languages in which either segments (8a) or syllables (8b) are the units referred to in the reversing operation, and also differ from 'false reversals', in which timing relations are maintained while the segmental material of syllables is reversed, as in (8c) (data from Bagemihl 1989).

(8)

	Regular form	*Game form*	
a.	*Segmental reversal in Javanese*		
	dolanan	nanalod	'to play around'
	boʧah	haʧob	'boy'
b.	*Syllabic reversal in Tagalog*		
	paŋit	ŋitpa	'ugly'
	kapatid	tidpaka	'sibling'
c.	*False reversal in Luganda*		
	kutegeeza	zageteeku	'to inform'
	kubajja	jabakku	'to work in wood'

The Luganda game forms in (8c) have been used to argue for a timing tier, in which the length and arrangement of consonants and vowels are represented separately from segmental features (Clements 1986). These forms

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resemble the syllabic reversals of Tagalog in (8b), but differ in that the timing structure of the word remains unaltered in the game form. In the second form in (8c), the regular form consists of three syllables, with the third consonant, /j/, being a geminate. The game form shows syllabic reversal, but with gemination remaining as a property of the third consonant, now /k/. This can be contrasted with the sakasa kotoba form shown in (9).[7]

(9) *Regular form* *Game form*
kogitte teggiko 'cheque'

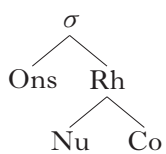
As in the Luganda example, the regular Japanese form has three syllables, with a geminate consonant straddling syllables 2 and 3. When the Japanese form undergoes reversal, however, the location of consonant length also changes. This follows from the analysis proposed here, in which moras are the units which undergo reversal.

For these examples, game forms can be created from regular Japanese forms through total moraic reversal, as in (10).

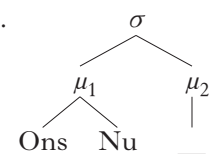
(10) $\mu_1 \mu_2 \ldots \mu_n \rightarrow \mu_n \mu_{n-1} \ldots \mu_2 \mu_1$

The patterning of game forms provides evidence against the widely assumed syllable structure in (11a). Instead, the operation of sakasa kotoba is consistent with Kubozono's (1989) model of the syllable in Japanese in (11b).

(11) a.



b.



A language like English is analysed as having a syllable structure as in (11a), in which a nucleus and following consonant form a constituent, the rhyme. One or more consonants preceding the nucleus also form a constituent, the onset. For Japanese, we assume the syllable structure in (11b). In this model, the syllable consists of one or two moras, with the first mora containing a vowel and an optional preceding consonant, and the second mora restricted to the set of special moras, N, Q and R. The definition of the mora in this structure is equivalent to that proposed in Hyman (1985), but contrary to the moraic theory of Hayes (1989), in which the onset consonant is directly adjoined to the syllable node. In this structure, a consonant and a following vowel form a constituent, a mora, which does not correspond to either the rhyme or the onset in (11a). This is the constituent that is reversed

[7] Five of the speakers gave the game form shown in (9). One speaker gave [tekkogi] as the game form for /kogiQte/ [kogitte]. This variant is not consistent with syllabic reversal (*[tegitko], *[tegikko]) or false reversal, and does not reflect any more general pattern for this speaker. We interpreted this particular variant as an error.

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in sakasa kotoba. The syllable structure in (11b) is also adopted in Katada's (1990) analysis of shiritori, a different Japanese language game.

The data summarised in this section show that the general pattern of sakasa kotoba can be characterised as total moraic reversal. Sakasa kotoba thus differs from other reversing games discussed in the language game literature involving processes such as segmental reversals, syllabic reversals and false reversals.

3.3 Marked structures and variability

In the core Japanese lexicon, the distribution of the special moras is severely restricted. In native, or Yamato, vocabulary, N must occur word-finally or before a homorganic consonant, Q must precede a voiceless obstruent and R must follow a vowel.[8] Forms obeying these restrictions, and their sakasa kotoba counterparts, were illustrated in (6). (6a) contains the moraic nasal N, which precedes a homorganic stop in the surface form of both the regular form and its sakasa kotoba version. In (6b), the special mora Q precedes a voiceless obstruent in both the regular Japanese form and in the reversed form. (6c) contains the vowel-length mora R immediately following a vowel in both the regular form and the game form. For these examples, the elicited game forms were the same for all speakers.

Speakers also behaved alike for some forms in which reversal leads to marked, but not unattested sequences. In Yamato Japanese, only voiceless obstruents can be geminated. (Geminate voiced obstruents do not occur in the core Japanese lexicon, but are attested in loanwords such as [beddo] 'bed'.) Sakasa kotoba may result in forms where Q precedes voiced obstruents, in which case the voiced obstruents undergo gemination, as in (12).

(12) *Regular form* *Game form*
/ba.Q.ko/ [bakko] /ko.Q.ba/ [kobba] 'infest'

For most speakers, the requirement that moras be reversed in game forms is rigidly adhered to, even when this results in structures not typically permitted in Japanese. These cases nonetheless give rise to variation, largely in the phonetic realisation of the special moras N and Q. For some patterns, we find significant differences in game forms between speakers, including cases in which reversal is judged to be impossible. These patterns of variation are summarised in the following subsections.

3.3.1 *Variation in the realisation of* N *and* Q. In forms in which reversal results in the moraic nasal occurring before a continuant segment, we find variation in the realisation of the nasal. Variants include the uvular nasal, as well as instances in which the nasal assimilates to the place of articulation of a following consonant. Representative examples are shown in (13).

[8] As noted in previous literature (e.g. Poser 1990, Labrune 2012), some exceptional forms contain sequences of special moras, as in /roNdoNQko/ [rondoŋkko] 'Londoner'.

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(13)	*Regular form*		*Game form*	
a.	/ra.N.ti/ 'lunch'	[ranʧi]	/ti.N.ra/	[ʧiɴra] (S1–5) [ʧinra] (S6)
b.	/za.N.ge/ 'repent'	[zaŋge]	/ge.N.za/	[geɴza] (S2–6) [genza] (S1)
c.	/wa.N.ha.ku/ 'naughty'	[wampaku]	/ku.pa.N.wa/	[kupaɴwa] (S3, 5) [kupampa] (S1–2)[9]

In examples (13a, b), most of the speakers produced a game form in which the moraic nasal was realised as uvular.[10] For each of these examples, however, one of the speakers (not the same speaker across examples) produced an alveolar nasal, showing evidence of assimilation to a following consonant. In (13c), two speakers produced a uvular nasal, and two others produced a form in which the moraic nasal assimilated in place to the following consonant. In these cases, assimilation was also accompanied by strengthening of the following glide, resulting in [kupampa]. These examples show variation in the phonetic realisation of the nasal in game forms, but with consistency across speakers in the basic pattern of reversal.

Similar variation is found in the realisation of Q in cases where reversal results in its occurrence before a sonorant. When such a sequence is required by the game, either the sonorant consonant following Q is geminated or Q is realised as a glottal stop, as illustrated in (14).[11]

(14)	*Regular form*		*Game form*		
a.	/ju.Q.ke/	[jukke]	/ke.Q.ju/	[kejju] (S1, 3) [keʔju] (S4–6)	(Korean dish)
b.	/ra.Q.ka/	[rakka]	/ka.Q.ra/	[kaʔra]	'falling'

As is the case with voiced geminates in general, geminate sonorants also occur within the peripheral vocabulary of Japanese in interjections, onomatopoeia and recent loanwords, as in [arraa ~ aʔraa] 'Allah'. As in the game forms, these forms also are subject to variation, with both geminate sonorants and glottal stops attested.

These cases of variation in N and Q are within the range of variation found in the realisation of these moras in other contexts in Japanese.

[9] Speaker 4's game form for this item was not clearly recorded, and Speaker 6 produced a game form in which the moraic nasal was deleted and reversal was incomplete, resulting in [kuwapa]. We do not provide analysis of these variations, which we attribute to the fact that this was the first item, and speakers were getting used to the task.

[10] We do not distinguish between the uvular nasal and placeless or more approximant realisations in the transcription. As noted in §3.1, the second transcriber used a nasalised vowel instead of [ɴ] for some of these forms, consistent with descriptions which state that an approximant is a typical realisation of the moraic nasal before continuants (e.g. Yoshida 2003, Vance 2008).

[11] Although these forms were perceived as varying between speakers by the first author, the second transcriber used a geminate consonant for all speakers for these examples.

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3.3.2 *Word-initial* N. For other forms, moraic reversal results in a clear violation of phonotactic restrictions. In words ending in a moraic nasal, reversal results in game forms with N in word-initial position, a structure that is ill-formed in Japanese. Nonetheless, most speakers consistently performed moraic reversal for these examples. The quality of the resulting word-initial nasal showed some variation between speakers, analogously to the cases discussed in the preceding section. The most significant variation in these examples is that one speaker, Speaker 3, consistently stated that game forms are not possible in this case. Whereas other variation discussed so far can be interpreted as variation in the phonetic realisation of a special mora, with no significant variation in the reversing operation itself, this pattern shows that for one speaker, the reversing operation cannot be carried out if it would result in a word-initial moraic nasal.

The patterns illustrated in (15) are representative of the eleven elicited forms that have a word-final N in Japanese. For both of these items, Speaker 3 stated that a game form could not be produced, and the other speakers produced game forms with moraic reversal and word-initial N.[12]

(15)	*Regular form*		*Game form*		
a.	/ke.ge.N/	[kegeɴ]	/N.ge.ke/	[ɴ̩geke] (S1–2, 5) [ŋ̩geke] (S6) *impossible* (S3)	‘suspicious’
b.	/ma.N/	[maɴ]	/N.ma/	[ɴ̩ma] (S1–2, 4) [m̩ma] (S5–6) *impossible* (S3)	‘ten thousand’

For some items, there was also variation in the place of articulation of the initial nasal. Although there are no additional regular patterns in the data for these items, there are cases where additional variants were produced, including some where a speaker reversed syllables rather than moras. One such example is shown in (16).

(16)	*Regular form*		*Game form*	
	/sju.N.zju.N/ ‘hesitation’	[ʃuɴʤuɴ]	/N.zju.N.sju/	[ɴ̩ʤuɴʃu] (S5) [m̩ʤumʃu] (S4) [ɴ̩ʤunʃu] (S6)
			/zju.N.sju.N/	[ʤunʃuɴ] (S1) *impossible* (S2, 3)

The Japanese form in (16), /sju.N.zju.N/, contains both a word-final and a word-internal moraic nasal. Three speakers performed moraic reversal for this form, with variation in the place of the nasal. Two speakers stated that

[12] Speaker 3 was not recorded for example (15a), due to a recording error. The elicitation materials contain seven forms with word-final N that were recorded for this speaker. The speaker stated that the game was impossible for all seven. We include the ungrammatical response as one of the possible variants for this item because of this speaker’s consistent pattern across similar items.

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a game form for this item was not possible. For one of those, Speaker 3, this reflects a systematic rejection of all game forms that would require an initial moraic nasal. Speaker 2, however, produced game forms for all other such items. One speaker, Speaker 1, produced [ʤunʃuɴ] as the game form. This form is consistent with syllabic reversal. This speaker did not generally treat the game as syllabic reversal, and consistently produced game forms with moraic reversals for the patterns discussed above.[13] This example suggests that this speaker may have used syllabic reversal as an alternative strategy when moraic reversal would result in a particularly marked structure.

Outside of game forms, word-initial N is barred within the core Japanese lexicon, including both Yamato and Sino-Japanese forms. Word-initial moraic nasals do occur within Japanese, but only in recent loanwords, as in [ɴ̩ʤamena ~ n̩ʤamena] 'N'Djamena (foreign name)'. Loanwords of this shape are rare.

3.3.3 *Word-initial* R. As with N, moraic reversal may result in R occurring in initial position. Word-initial R is not found outside of game forms. In these cases, we find substantial variation in game forms across speakers. Three examples with this structure were included in the elicitation materials, two of which are shown in (17).

(17)

	Regular form		*Game forms*	
a.	/ki.R/ 'key'	[kii]	/R.ki/	[iki] (S1, S2, S5)[14]
			/N.ki/	[ɴ̩ki] (S6)
				impossible (S3)
b.	/ga.ri.ba.R/ 'Gulliver'	[garibaa]	/R.ba.ri.ga/	[abariga] (S5)
			/N.ba.ri.ga/	[ɴ̩bariga] (S6)
			/ba.ri.ga/	[bariga] (S2)
			/baR.ri.ga/	[baariba] (S1)
				impossible (S3)

For the examples in (17), we find three distinct patterns. For (17a), most speakers produced word-initial R as a vowel with the same features as the vowel in the following syllable. Given that an R occurring in word-initial position after reversal will always be followed by the vowel that preceded it in the regular Japanese form, the R in such cases can be described either as assimilating to the vowel in the following syllable or as a vowel maintaining surface properties present in the regular language form. These descriptions will be equivalent in all such cases.[15] Speaker 3 stated that a game form is impossible for this example. This is consistent with this speaker's pattern for forms in which moraic reversal would require

[13] However, this speaker did produce syllabic reversals for some other complex forms discussed below.

[14] Speakers 1 and 2 initially produced an unreversed form, [kii], for this item, followed by the game form given here.

[15] In §8, we argue that the initial R acquires feature specifications through assimilation to the vowel in the following syllable.

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an initial N. An interesting variant was produced by Speaker 6, who realised the initial mora as a nasal rather than as a vocalic mora.

We find the same patterns for (17b), /ga.ri.ba.R/, but with additional variation. This form is more complex than (a), consisting of four moras rather than two. Speakers 3, 5 and 6 treated these two items alike, respectively judging reversal to be impossible, realising R as a vowel identical to that in the following syllable and substituting the moraic nasal for R. In addition to these patterns, we find two additional variants. Speaker 2 produced [bariga], in which the R mora in the Japanese form is omitted, while Speaker 1 produced [baariba], a form that resembles syllabic reversal and includes a change from [g] to [b].

One additional form containing word-final R was elicited. Responses to this item, (18), differed substantially from those to (17).

(18)	*Regular form*		*Game form*		
	/to.R/	[too]	/R.to/	[oto] (S1, 4)	'ten'
				[uto] (S2–3, 5–6)	

Two speakers produced [oto] as the game form for /to.R/ in (18). This is consistent with moraic reversal and realisation of initial R as a vowel that assimilates to the vowel in the following syllable, as seen in the other items containing word-final R. Four speakers produced [uto] as the game form. There are two possible analyses of the source of the initial [u] in the game forms for these speakers. One possibility is that this is a default vowel which is the realisation of the underspecified mora R when no preceding segment is available to provide feature values. Alternatively, this game form could be argued to provide evidence that these speakers analysed the Japanese form [too] as resulting from assimilation of a final /u/ to a preceding /o/, a common assimilation pattern in the language.[16] If this is the case, the underlying representation of [too] for these speakers is /tou/ rather than /toR/. The game form is a straightforward moraic reversal of a representation that precedes the application of assimilation. One point of support for this interpretation is that Speaker 3 was among those who gave [uto] as the sakasa kotoba form for this word. This speaker consistently gave 'impossible' as a response to other forms with word-final N or R. The fact that this speaker provided [uto] as the game form for [too] suggests that he analysed the surface form as resulting from assimilation rather than from the interpretation of the vowel-length mora R.

3.3.4 *Intervocalic* N *and* Q. Unlike R and N, the geminating mora, Q, does not typically occur word-finally in Japanese.[17] Hence, word-initial Q is never required by the reversing operation of sakasa kotoba.

[16] Examples of sakasa kotoba forms of words with assimilation are discussed in §3.3.6.

[17] Although Q does not occur word-finally in the Japanese lexicon, according to Vance (1987), a glottal stop can occur finally in interjections.

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Nonetheless, reversal does result in forms where Q occurs in environments that are not normally permitted. When a regular Japanese form contains a geminate preceded by a vowel-initial mora, reversal results in intervocalic Q. Similarly, reversal of forms in which N is preceded by a simple V mora results in intervocalic N. These moras are typically dependent on a following consonant to determine place features, in the case of N, or all features, in the case of Q. The three items in (19) contain such sequences.

(19)	*Regular form*		*Game form*		
a.	/a.Q.ka/	[akka]	/ka.Q.a/	[kaʔa] (S1, 6) [kaʔʔa] (S2, 5)	'deterioration'
b.	/u.N.ti/	[untʃi]	/ti.N.u/	[tʃiɲ̩u] (S2–5) [tʃiŋu] (S1, 6)	'poop'
c.	/a.N.ki/	[aŋki]	/ki.N.a/	[kiɲ̩a] (S2–4) [kiŋa] (S1, 6) [kiŋŋa] (S5)	'memorise'

The forms in (19) show moraic reversal of these cases for all speakers, with variation in the place of the moraic nasal and variation in the length and syllabification of both the nasal and the glottal stop. The variation shown is based on the first author's impressionistic judgement. However, these are also cases where there were differences between the forms given by transcribers. The second transcriber did not show gemination for any of the examples in (19).

3.3.5 *Sequences of special moras.* Up to this point, items discussed include Japanese words that can result in phonotactically marked sequences when subject to reversal. The regular Japanese forms themselves, however, do not contain marked sequences. The elicitation materials also included three forms containing sequences of adjacent special moras. Although special moras are typically restricted in their distribution, as discussed above, sequences of special moras do occur in some loanwords (20a), onomatopoeia (20b) and emphatics (20c).[18]

(20)	*Regular form*		*Game form*		
a.	/ro.R.N/	[roon]	/N.R.ro/	[ɲ̩nro] (S1–2) [ɲ̩ɴ̩ro] (S4–6) *impossible* (S3)	'loan'
b.	/si.R.N.to/	[ʃiinto]	/to.N.R.si/	[tonnʃi] (S1–2) [tonɲ̩ʃi] (S5–6)	'in silence'
c.	/ho.N.Q.to/	[hontto]	/to.N.ho/ /to.Q.ho/ /N.to.ho/	[tonho] (S1, 3–5) [tohho] (S2) [ɲ̩otoho] (S6)	'very'

[18] Transcriber 2 did not distinguish between different syllabifications for the items discussed in (20a, b), but transcribed the uvular nasal as long for all speakers.

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(20a, b) contain a sequence of the vowel-length mora R and the moraic nasal N. Strict moraic reversal of these forms will result in a /N.R/ sequence. All speakers who produced game forms for these examples performed moraic reversal and interpreted the resulting N as a uvular nasal, with the following R lengthening the nasal for all speakers. Speaker 3 judged the game to be impossible for (20a), consistent with his response to other forms in which moraic reversal would result in a word-initial N.

Example (20c), /hoNQto/, contains the moraic nasal before the geminating mora Q. The form was produced as [hontto] in the elicitation materials. Moraic reversal of this form would result in /toQNho/. None of the speakers produced a form consistent with this representation. Speakers 1, 3, 4 and 5 gave [toɴho] as the game form, showing no evidence of the geminating mora being retained in the game form. Speaker 2 produced [tohho], with gemination but without the moraic nasal, while Speaker 6 had [ɴotoho], which is not consistent with either syllabic or moraic reversal, and contains an additional vowel, not present in the regular Japanese form.

3.3.6 *Reversal and vowel assimilation.* In addition to forms with underlying R, the elicitation materials also included forms with long vowels resulting from assimilation. Japanese has an optional process of vowel assimilation targeting /ou/ and /ei/ sequences. The output of assimilation is a long mid vowel, as in /kouki/ [kooki ~ kouki] 'second half'. For most items of this type, speakers produced sakasa kotoba forms which did not show any effects of vowel assimilation, despite the fact that the assimilated form is what was presented during elicitation. Relevant items are given in (21).

(21)

Regular form		*Game form*	
/kouki/	[kooki]	[kiuko]	'second half'
/ikou/	[ikoo]	[ukoi][19]	'transition'
/keikaku/	[keekaku]	[kukaike]	'plan'
/haisou/	[haisoo]	[usoiha]	'delivery'

Other items including assimilated vowels showed variation between speakers. Reversed forms with an unassimilated vowel, which was universally supplied for the items in (21), continue to be the most common variants. For example, four speakers performed moraic reversal without any effects of vowel assimilation for (22a). Speaker 1, however, produced [ʃijoobi], consistent with syllabic reversal.[20] This pattern is seen with

[19] For [ikoo], one speaker gave [ukohi] as the game form, with an epenthesised [h]. With this exception, not directly relevant to the issue at hand, all speakers behaved alike for the items in (21).

[20] Speaker 3 gave [ʃijoubi], which is not consistent with either moraic or syllabic reversal.

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other items. Speaker 1 gave forms with syllabic, rather than moraic, reversal for examples (22b, c), and Speaker 6 also gave a form consistent with syllabic reversal for (22b).

(22)	*Regular form*		*Game form*	
a.	/bijousi/	[bijooʃi]	[ʃiujobi] (S2, 4–6) [ʃijoobi] (S1) [ʃijoubi] (S3)	'hairdresser'
b.	/batou/	[batoo]	[utoba] (S2–5) [tooba] (S1, 6)	'verbal abuse'
c.	/koukou/	[kookoo]	[ukouko] (S2–6) [kookoo] (S1)	'high school'

For (23), [tooja], we find another pattern. Again, most speakers performed moraic reversal without assimilation, giving [jauto]. Speakers 1 and 6, however, gave [jaato] as the reversed form. [jaato] is not a syllabic reversal, which would give [jatoo], nor is it a direct moraic reversal of the surface form, as in [jaoto]. Instead, [jaato] appears to be a reversal which treats the assimilated vowel of the Japanese word as the vowel-length mora R. [jaato] would be the expected game form of [toRja].

(23)	*Regular form*		*Game form*	
a.	/touja/	[tooja]	[jauto] (S2–5)	'cultivation'
b.	/toRja/	[tooja]	[jaato] (S1, 6)	

The pattern of variation in these forms reveals differences in speakers' treatment of long vowels arising from assimilation as compared to long vowels arising from R. Speaker 3 found reversal to be impossible for all forms with word-final R, but readily produced sakasa kotoba forms for words ending in long vowels resulting from assimilation. Like most participants, Speaker 3's game forms did not show effects of assimilation for these items.[21]

The data discussed in this section show that, in cases where reversal results in forms that violate phonotactic restrictions, we find variation between speakers. Much of this variation concerns the phonetic realisation of special moras, such as variation in the place of articulation of the moraic nasal. Unlike other participants, Speaker 3 judged game forms to be impossible for examples where reversal would result in a word-initial special mora. Other substantial variation was found in the case of Speaker 1, who produced syllabic reversals for some forms in which moraic reversal would result in initial N or R, as well as for some forms containing vowels that undergo assimilation.

[21] The possible influence of orthographic representations on this pattern is discussed in §4.

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4 Orthographic influence

Before proceeding to a formal analysis of sakasa kotoba, we briefly address the issue of orthographic influence on the game. Japanese orthography uses a combination of three types of characters, hiragana, katakana and kanji. In both hiragana and katakana, each character corresponds to a mora (with the exception of complex onsets, as discussed below). It could therefore be argued that the reversing operation of sakasa kotoba is not phonological, but orthographic; the pronunciation of a reversed series of written characters. Previous work has shown an influence of orthography on Japanese language game patterns, as in Itô *et al.*'s (1996) study of zuuja-go, as well as on some phonological processes (Kawahara 2018). Based on the data collected here, we demonstrate that, although some speakers' forms show some influence of orthography, sakasa kotoba nonetheless involves phonological operations, and cannot be reduced to the manipulation of written characters.

Participants in the study were not exposed to written forms during the elicitation process, and the materials included several words that are commonly written with kanji, characters that represent morphemes, not moras. Of course, these facts do not preclude the possibility that participants construct orthographic representations in the course of the sakasa kotoba reversing operation. For many words, reversal of orthographic characters and reversal of moras are equivalent. This does not provide evidence for or against the influence of orthography in the game, but reflects the importance of the mora in Japanese phonology and the close relationship between orthographic and phonological systems. However, there are some cases where orthographic and moraic representations diverge. In such cases we find variation between speakers. Some of the sakasa kotoba variants in our data show evidence of orthographic influence, while others provide evidence that reversal operates on phonological, not orthographic, representations.

Words containing assimilated vowels provide one type of case in which moraic and orthographic representations differ. For example, some reversals of the form [tooja], shown in (24), written as とうや and discussed in §3.3.6 above, are consistent with orthography having an influence on the game. The pronunciation faithful to the orthography, [touja], includes the sequence [ou]. Although this is a possible pronunciation, assimilation is common between vowels in this context, resulting in [tooja], the pronunciation used in the elicitation materials. (24a) shows the orthographic form of the word, accompanied by a transcription representing the conventional pronunciations of the written characters in isolation. These are followed by a transcription showing moraic boundaries for the unassimilated underlying form. (b) shows inferred reversed forms of (a) which reference orthographic characters, underlying moras or surface moras. In (c), we provide the actual sakasa kotoba variants elicited in the study.

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(24)		*orthographic*		*moraic* (UR)	*moraic* (SR)
a.	*Regular form*	とうや	/to.u.ja/	/to.u.ja/	[tooja]
b.	*Reversal*	やうと	/ja.u.to/	/ja.u.to/	[jaoto]
c.	*Game form* [jauto] (S2–5), [jaato] (S1, 6)				

As we saw in §3.3.6, four speakers provided [jauto] as the reversed form. The unassimilated form referenced in this variant is a possible pronunciation, and a hypothesised phonological representation. This reversal is also consistent with the written form, and these speakers may have been referencing an orthographic representation when performing reversal. Two speakers, however, provided reversals that are not consistent with an orthographic representation. While no speaker provided the game form based on the surface representation, namely [jaoto], two speakers gave [jaato]. In §9, we propose that such forms are based on a putative intermediate representation, [toRja], formed as a step in the assimilation process. This shows that the intermediate representation manipulated by these speakers is phonological rather than orthographic.

The sakasa kotoba variants in (24c) show that, in forms with vowel assimilation, some speakers produce reversals which are consistent with an orthographic representation but inconsistent with a reversal of the moras present in the surface form in the elicitation materials. However, the unassimilated reversals consistent with the orthography are also consistent with the proposed phonological representation of these items. These forms therefore do not provide conclusive evidence that orthographic representations are manipulated by speakers.

Other forms which display a divergence between orthographic and phonological representations include those with complex onsets.[22] In these cases, the orthography is not isomorphic with any plausible phonological representation. The offglide of a complex onset is written with a character representing /Ci/ accompanied by a small や /ja/, ゆ /ju/ or よ /jo/. For instance, /rjo/ is orthographically comprised of り /ri/ and a small よ /jo/.[23] These character sequences represent one mora, just like single characters like ち /ti/, り /ri/ or し /si/, since the complex onset does not contribute to syllable weight. In sakasa kotoba forms, this sequence is mostly manipulated as a unit in the game, maintaining the original linear order of characters rather than reversing them. Illustrative examples are provided in (25). Unlike the example in (24), the sequence of moras that form the conventional pronunciation of the orthography is not equivalent to the underlying moraic representation.

[22] There is debate about whether /Cj/ sequences should be analysed as complex onsets or as palatalised consonants (e.g. Nogita 2016, Hirayama & Vance 2018). Because neither palatalised consonants nor complex onsets are moraic, these distinctions are not crucial for the issues considered here.

[23] This is in contrast to sequences like りよ /rijo/, with big よ, which are comprised of two moras.

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(25)

		orthographic		*moraic*	
a.	*Regular form*	もうりょう	/mo.u.ri.jo.u/	/mo.u.rjo.u/	(UR)
				[moorjoo]	(SR)
	Reversal	うょりうも	/u.jo.ri.u.mo/	/u.rjo.u.mo/	(UR)
				[orjoomo]	(SR)
	Game form				
	[ujoriumo] (S1), [urjoumo] (S5–6), [urjorjou] (S4), *impossible* (S2–3)				
b.	*Regular form*	しゅつらん	/si.ju.tu.ra.N/	/sju.tu.ra.N/	(UR)
				[ʃutsuraɴ]	(SR)
	Reversal	んらつゅし	/N.ra.tu.ju.si/	/N.ra.tu.sju/	(UR)
				[ɴ̩ratsuʃu]	(SR)
	Game form				
	[ɴ̩ratsu] (S1), [ɴ̩ratsujuʃi] (S2), [ɴ̩ratsuʃu] (S5–6), *impossible* (S3)				

For the word [moorjoo] in (25a), written as もうりょう, two speakers provided a game form [urjoumo], in which the complex onset, [rjo], forms a unit. These productions are consistent with moraic, but not orthographic, reversal. However, Speaker 1 provided the form [ujoriumo], in which /rjo/ in the Japanese form is divided into /ri/ and /jo/. Reversal in this case does not operate on moras, syllables or any other phonological units. Instead, orthographic characters are the reversed units. This pattern is not systematic, however. For the example in (25b), two speakers gave [ɴ̩ratsuʃu] for [ʃutsuraɴ] /sjuturaN/. This game form treats palatalisation and the following vowel as a unit, and is consistent with moraic, but not orthographic, reversal. One speaker gave [ɴ̩ratsujuʃi] as the game form. This is consistent with reversal of the written characters しゅつらん. No speakers, on the other hand, employed the orthographic pattern in their reversal of [ʃuɴʤuɴ] しゅんじゅん, which contains two complex onset sequences.[24] Neither onset sequence was divided in the game forms provided by four speakers, including Speaker 1, who showed evidence of orthographic reversal in [ujoriumo].[25]

These examples show that for some speakers, orthography plays a significant role in sakasa kotoba for some items.[26] However, the orthographic

[24] Discussion of all variants produced for this item is provided in the previous section in reference to example (16).

[25] Speakers 2 and 3 judged reversal to be impossible for [ʃuɴʤuɴ] and [moorjoo], and Speaker 3 also stated that reversal is impossible for [ʃutsuraɴ]. This is a consistent pattern for Speaker 3 for words that end in a final special mora, and is occasionally shown by other speakers.

[26] Data from preliterate child speakers would be a valuable source of evidence on this issue. In the course of the review process, an anonymous reviewer generously provided data elicited from a five-year-old. Of the eight forms provided, some showed moraic reversal (e.g. [katta] → [takka]) and others showed syllabic reversal (e.g. [honto] → [tohon]). Further study of children's sakasa kotoba forms may provide insight into the role of orthography in game patterning.

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pattern is not consistent among words or among speakers. In many cases, similarities between the reversal of phonological constituents and the reversal of orthographic characters are expected, given the relationship between orthographic and phonological representations. However, the existence of forms such as [urjoumo] as the reversal of the form written もうりょう or [jaato] as the reversal of the form written とうや demonstrate that orthographic representations cannot be the sole basis of reversal for all speakers. In cases where speakers do make reference to orthography, a reversed sequence of written characters is not sufficient to determine how phonotactically marked sequences created by the game are repaired or how special moras are realised in contexts not seen in regular Japanese forms (phonological or orthographic). An account of these aspects of game patterning is provided in following sections.

5 OT analysis

The characterisation of sakasa kotoba as total moraic reversal provides an accurate description of the language game operation. It does not, however, tell us how the reversing operation is carried out in the grammar. In this section, we provide an OT analysis of sakasa kotoba. We use a game-specific constraint to trigger reversal, with other aspects of game forms determined by the ranking of faithfulness and markedness constraints. Following Itô *et al.*'s (1996) analysis of zuuja-go, we use the constraint CROSS-ANCHOR(μ) in (26a) to motivate the reversal observed between the game form and its regular correspondent. CROSS-ANCHOR(μ) requires a mora at the left edge of the input to be realised at the right edge of the output. The relative ranking of two faithfulness constraints, CONTIGUITY(μ) in (b) and LINEARITY(μ) in (c), determines the shape of game forms.

(26) a. CROSS-ANCHOR(μ)
For any mora x that is at the left edge in the input, x is at the right edge in the output.

b. CONTIGUITY(μ)
Moras adjacent in the input must be adjacent in the output.

c. LINEARITY(μ)
If mora x precedes mora y in the input, x precedes y in the output.

In a game with total reversal, elements that are adjacent in the input are adjacent in the output. In sakasa kotoba, CONTIGUITY, which maintains adjacency relations between input and output elements, is ranked above LINEARITY, which maintains precedence relations. This ranking results in total reversal of the relevant constituents, in this case moras, as illustrated in (27). See Itô *et al.* (1996) and Borowsky & Avery (2009) for use of LINEARITY and CONTIGUITY constraints in game analyses.

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(27) /to.do.ro.ki/ [todoroki] → /ki.ro.do.to/ [kirodoto]

/todoroki/	CONTIGUITY	CROSS-ANCHOR	LINEARITY
a. todoroki		*!	
☞ b. kirodoto			******
c. dorokito	*!		***

In (27), the faithful candidate, (a), fails to satisfy the game-specific constraint CROSS-ANCHOR and is eliminated. Candidate (c) satisfies CROSS-ANCHOR by moving the initial mora, [to], to final position. Patterns of this type are common in language games, as in Pig Latin, where a word-initial onset is moved to the end of a word (Vaux 2011). This operation leads to a violation of CONTIGUITY, as the moras [to] and [do], which are adjacent in the input, are not adjacent in the output. CONTIGUITY is ranked high in sakasa kotoba, and candidate (c) is eliminated. The optimal candidate in (b) satisfies CONTIGUITY through total reversal. All moras that are adjacent in the input are adjacent in the output. Their order is reversed, leading to rampant violation of LINEARITY. LINEARITY is ranked low, however, leaving candidate (b) as optimal.

6 Reversal of special moras

Evidence that moras are the relevant units manipulated by the game is provided by the behaviour of the special moras, N, Q and R. Whereas other moras have boundaries that coincide with syllable boundaries, special moras do not. Ranking CONTIGUITY and CROSS-ANCHOR above LINEARITY triggers total moraic reversal in game forms with special moras, exactly as in forms that contain only V and CV moras. (28a, b) show the evaluations of form containing the moraic nasal N and the vowel-length mora R respectively.[27]

(28) a. /ki.N.ho.si/ [kimboʃi] → /si.bo.N.ki/ [ʃiboŋki]

/kiNhosi/	CONTIGUITY	CROSS-ANCHOR	LINEARITY
i. kiNboʃi		*!	
☞ ii. ʃiboNki			******
iii. ʃibokiN	*!		***

b. /do.to.R.ru/ [dotooru] → /ru.R.to.do/ [ruutodo]

/dotoRru/	CONTIGUITY	CROSS-ANCHOR	LINEARITY
i. dotoRru		*!	
☞ ii. ruRtodo			******
iii. rutoRdo	*!		***

[27] Tableaux do not provide analyses for rendaku or palatalisation. Only candidates which show the effects of these processes are considered in the evaluation.

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The sakasa kotoba evaluation of /ki.N.ho.si/ and /do.to.R.ru/ is exactly parallel to that of a form containing only simple moras. In both tableaux, the faithful candidates are eliminated, due to violation of the game-specific constraint CROSS-ANCHOR. The winning candidates show total moraic reversal, thus satisfying CONTIGUITY. The candidates in (a.iii) and (b.iii) exhibit syllabic, rather than moraic, reversal, leading to fatal violations of CONTIGUITY. In the syllabically reversed candidate in (28a.iii), for example, the mora /N/ and the mora /bo/, which are adjacent in the input, are separated by /ki/, thus violating CONTIGUITY.

The tableaux in (28) do not show features for the special moras or account for how those moras are realised. In the regular Japanese form in (28a), N is realised as a labial nasal, homorganic with the following [b]. The game form, however, has a velar nasal as the realisation of N, which now precedes [k]. In (28b), R in the regular form has the features of the preceding [o]. In the game form, R is realised with the features of the vowel which precedes it after the reversing operation takes place, namely [u].

To account for the realisation of the special moras, we propose that the special moras have the featurally underspecified representations in (29). Similar proposals regarding the representation of special moras can be found in Labrune (2012).

(29)

N	Q	R
μ	μ	μ
$\begin{bmatrix}+\text{cons}\\+\text{nas}\end{bmatrix}$	[+cons]	[−cons]

The patterning of special moras in sakasa kotoba provides evidence in support of the representations in (29). As illustrated in the case of /dotoRru/ and /kiNhosi/ above, the featural realisation of special moras in game forms depends on the adjacent segments in the reversed forms, not the features present in the regular Japanese forms. This follows if the representations manipulated by reversal are underspecified, as in (29), rather than being fully specified surface segments.

In OT, the principle of Richness of the Base requires that inputs be free, without any language-specific restrictions. Consistent with this, the underspecified representations in (29) are possible input forms, but fully specified inputs must also be considered. The proposed underspecification of special moras does not follow from restrictions on the input, but rather is enforced in output representations by markedness constraints. Specifically, we analyse the representation of special moras in regular Japanese forms as resulting from the constraint in (30), adapted from Itô's (1989) CODACONDITION.

(30) MORA$_2$CONDITION

* $\mu]_\sigma$
|
[PLACE]

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This constraint is violated by any place features exclusively associated with μ_2 position in the syllable structure in (11b) above. In this model, the syllable consists of an obligatory μ_1 and an optional μ_2. Itô's (1989) CODACONDITION prohibits place specifications in coda position. According to the standard model of syllable structure in (11a), in which the syllable consists of an onset, nucleus and coda, the nasal and geminate moras, N and Q, would be syllabified as codas and be subject to CODACONDITION. However, the vowel-length mora R does not occur in coda position in any model of syllable structure. Hence, the feature specification of R would not be affected by the CODACONDITION constraint. In contrast, MORA$_2$CONDITION prohibits place and vowel quality features on the special mora R, just as it restricts place features of N and Q. In regular Japanese forms, all special moras occur in μ_2 position. As in the interpretation of CODACONDITION, multiply-linked features may be realised in μ_2 position without violating the constraint if they are also associated with a segment in μ_1 position. This allows homorganic nasals, geminates and long vowels to escape violation of the constraint when they result from multiple linking.

In both regular Japanese forms and game forms, the underspecified representations in (29) are enforced by MORA$_2$CONDITION. This is illustrated in (31), which shows a hypothetical input for the form [kimboʃi], with a fully specified labial nasal in μ_2 position.

(31)

/kimhosi/	MORA$_2$COND	MAX(μ)	MAX[F]
a. kimboʃi	*!		
☞ b. kiNboʃi			*
c. kiboʃi		*!	

The faithful candidate, with its fully specified nasal in μ_2 position, violates MORA$_2$CONDITION, and is eliminated. The optimal candidate in (b) contains a mora unspecified for place, equivalent to the representation of the special moras in (29). The place feature present in input /m/ is absent from the output, resulting in violation of low-ranked MAX[F]. In candidate (c), the nasal is deleted, leading to a fatal violation of MAX(μ).

The fully specified nasal in the input to (31) shows that the proposed constraint ranking is capable of enforcing underspecified representations of output forms, regardless of the degree of specification in the input. While Richness of the Base demands that both fully specified and underspecified inputs be permitted, the principle of Lexicon Optimisation (Prince & Smolensky 1993), which requires inputs to resemble outputs, would result in an underspecified representation of the special moras in the input forms as well. Special moras are, of course, realised with place features, with N surfacing as a labial nasal in [kimboʃi] and as a velar nasal in the reversed form, [ʃiboŋki]. We propose that the place features of N and Q are determined through multiple association with a

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following consonant in μ_1 position, similar to analyses of Japanese syllable structure using CODACONDITION (e.g. Itô & Mester 1993). Multiple linking violates *LINK in (32a) (Itô *et al*. 1995), but this is outranked by HAVEPLACE in (b), which requires all segments to be specified for place (Padgett 1995).

(32) a. *LINK
Assign a violation mark for every feature that is linked to more than one segment.
b. HAVEPLACE
Every segment must have some place.

In a grammar with *LINK ranked below HAVEPLACE, place features can be assigned via multiple linking.

In (33), the input contains an underspecified nasal in μ_2 position. The faithful candidate fatally violates HAVEPLACE, while the optimal candidate has a single place feature linked to the [b] in μ_1 position and the nasal in μ_2 position of the preceding syllable. This candidate violates *LINK, but satisfies the higher-ranking constraints. Candidate (c) has a nasal with an independent place feature, violating MORA_2CONDITION.

(33)

/kiNhosi/	MORA_2COND	HAVEPLACE	*LINK
a. kiNboʃi		*!	
☞ b. kimboʃi [lab]			*
c. kimboʃi [lab] [lab]	*!		

7 Intermediate representations

The tableaux and discussion above show how a fully specified input can map to an underspecified output for the special moras N, Q and R. In addition, we have shown how an underspecified input can map to an output where special moras have place features by virtue of multiple linking. Data from sakasa kotoba demonstrate that both mappings are necessary. Mapping from fully specified inputs to underspecified output representations is needed in order to map the rich base to output forms which obey restrictions on Japanese syllable structure. Constraint ranking at this initial level will repair hypothetical inputs containing complex clusters that are inconsistent with the phonotactic restrictions of Japanese, and will ensure that segments in μ_2 position are unspecified for place features. It is these underspecified representations that serve as the input to reversal. Place specifications of special moras are determined at a later level of evaluation. We therefore argue for a stratal version of Optimality Theory (e.g.

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Kiparsky 2000, Bermúdez-Otero 2003, 2018), with the output of the first level of evaluation serving as the input to the second level of evaluation in regular Japanese forms, and as the input to the game-specific grammar in sakasa kotoba. In Stratal OT, Richness of the Base holds only for inputs to the initial level of evaluation. Inputs to subsequent levels of evaluation are restricted to well-formed outputs of earlier levels of the grammar (e.g. Bermúdez-Otero 2003, 2007).

The data in (6) above contain game forms with special moras. These forms show that the features of the special moras in game forms depend on adjacent segments in the game forms themselves, not on features present in the regular Japanese forms. The realisation of the special mora R in the sakasa kotoba form for [ruutodo] is particularly relevant. Whereas reversal of fully specified segments in [kitte] and [kimboʃi] would result in forms that violate restrictions on Japanese syllable structure, i.e. *[tetki] and *[ʃibomki], reversal of the fully specified segments in [dotooru] would result in *[ruotodo], a well-formed sequence. The attested game form [ruutodo] is expected if reversal operates over representations in which the special moras lack place features, with such features being determined at a later level of evaluation.

Additional evidence that reversing operates over underspecified representations is found in forms where reversal results in sequences which violate restrictions on the distribution of special moras, discussed in preceding sections. In the example in (19a) above, /a.Q.ka/ [akka] → /ka.Q.a/ [kaʔa, kaʔʔa], Q is realised as a glottal stop. The patterning of this form provides support for the underspecified representations in (29).[28] In (19a), reversal results in the geminating mora Q occurring intervocalically. There is no consonant available for gemination, and Q is realised as a glottal stop. We take the glottal stop to be a possible realisation of an underspecified consonantal segment. Note that reversal of a fully specified [k] would give [kaka] or [kakka], both phonotactically licit forms.

Reversal can also lead to the vowel-length mora R surfacing in positions where it is not normally permitted. In cases where R is word-final in regular forms and word-initial in game forms, there is variation among speakers, as discussed in §3.3.3. One example is given in (17a) above, /ki.R/ [kii] → /R.ki/ [iki], /N.ki/ [n̩ki]. In this example, Speakers 1, 2 and 5 realise R with features identical to those of the following vowel, as [iki]. Speaker 6 realises R as a moraic nasal, and Speaker 3 judges reversal to be ungrammatical. For reversals in which word-initial R is realised as a vowel which shares features with the vowel in the

[28] Note also that the hiragana or katakana character used to represent Q can be realised as a glottal stop in some phonologically marked Japanese forms, as in いらっいら /iraQira/ [iraʔira]. This is an emphasised onomatopoetic form, in which っ, the character commonly used to represent Q, is written before a vowel and produced as a glottal stop. This raises the possibility that the intermediate representations referenced by the reversing operation are informed by orthography, as well as phonology.

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following syllable, the analysis using manipulation of underspecified representations and subsequent feature sharing has an obvious alternative. R is always preceded by a vowel when it occurs word-finally in Japanese and shares place features with that preceding vowel. After reversal, the vowel which previously preceded R will follow R in the game form. This means that an analysis in which R shares features of the following vowel after reversal will always result in the same feature specifications that we would find if a fully specified vowel was reversed in the game. The features of word-initial R are identical to the featural realisation of R in the regular form.

Although the pattern in which initial R has features of the following vowel is consistent with reversal of either underspecified or surface representations, support for the manipulation of intermediate representations is found in the pattern exhibited by Speaker 6, who realises the initial mora as a nasal. This pattern resembles phonological processes found elsewhere in the Japanese grammar. In the process of coda nasalisation (e.g. Itô & Mester 1986, Kawahara 2007b), a nasal mora is inserted in a context where gemination is expected, just in those cases where gemination would result in a marked structure such as a geminate liquid or voiced obstruent. Consider the examples in (34), from Kawahara (2015a: 149–150).

(34)	a.	/pita(-pita)/	/pittari/	‘precisely’
		/uka(-uka)/	/ukkari/	‘absent-mindedly’
	b.	/zabu(-zabu)/	/zamburi/	‘heavy rain’
		/uza/	/unzari/	‘fed up with’

Suffixation of /-ri/ is accompanied by gemination of the stem-final consonant, as in (34a). In those cases where that consonant is a voiced obstruent, as in (34b), a nasal mora is inserted in place of gemination. In this process, N is substituted for Q in cases where Q is marked. This is analogous to the behaviour of Speaker 6, although in the sakasa kotoba cases it is an ill-formed word-initial vocalic mora, R, that is replaced by the moraic nasal, rather than the geminating mora Q. Both patterns show that a nasal may be substituted for a distinct special mora in order to avoid marked structures. Such a substitution would be unexpected if the reversed mora was fully specified, as a vowel in initial position is well-formed.

Speaker 3’s judgment that reversal is ungrammatical in such cases also supports an analysis employing underspecified representations. If a fully specified vowel was manipulated by reversal, there would be no reason for the game forms for these examples to be ungrammatical.

In our analysis, the realisation of special moras results from a two-level evaluation in the regular Japanese grammar, with the output of Level 1

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serving as the input to the sakasa kotoba grammar. Relevant constraint rankings and examples are given in (35).

(35) *Regular form*

a. *Level 1*

/kinhosi/	MORA$_2$COND	MAX(μ)	*LINK	HAVEPLACE
i. kinboʃi	*!			
☞ ii. kiNboʃi				*
iii. kiboʃi		*!		
iv. kimboʃi [lab]			*!	

b. *Level 2*

/kiNboʃi/	MORA$_2$COND	HAVEPLACE	*LINK
i. kimboʃi [lab][lab]	*!		
☞ ii. kimboʃi [lab]			*
iii. kiNboʃi		*!	

In (35), the Level 1 evaluation shows a hypothetical fully specified input which maps to an output with an underspecified moraic nasal. In this grammar, MORA$_2$CONDITION and *LINK outrank HAVEPLACE. The output of this level serves as the input to Level 2, where HAVEPLACE outranks *LINK and the labial articulation of the nasal is determined by multiple linking.

(36) has the same input form and Level 1 evaluation as (35). In this case, however, the output of Level 1 serves as the input, not to the Level 2 evaluation of the regular Japanese grammar, but to the game-specific grammar.

(36) *Game form*

Level 2

/kiNboʃi/	CONTIGUITY	CROSS-ANCHOR	HAVEPLACE	*LINK
i. kiNboʃi		*!	*!	
ii. ʃiboNki			*!	
☞ iii. ʃibonki [dors]				*

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In this example, high-ranking CONTIGUITY ensures moraic reversal in the game form, and ranking of HAVEPLACE over *LINK results in place specification through multiple linking, as in Level 2 of the regular grammar.

This model involves two levels of evaluation in both regular Japanese forms and game forms. All surface forms undergo Level 1 evaluation, where the rich base is mapped to forms which obey the phonotactic restrictions of Japanese, including the ban on segments independently specified for place occurring in μ_2 position. In regular Japanese forms, the output of Level 1 serves as the input to Level 2, where place features of the special moras are specified through multiple linking. In game forms, the output of Level 1 serves as the input to the sakasa kotoba grammar, where the reversal operation takes place. Place features of special moras are also determined at this level in game forms.

The tableaux above show the two-level evaluation of a regular Japanese form containing the special mora N and its sakasa kotoba counterpart. The evaluation of forms containing the geminating mora Q are directly analogous. For forms containing the special mora R, an additional constraint is needed to ensure that R shares features with a preceding vowel, rather than a following consonant. We follow Itô *et al*. (1995) in using a family of *LINK constraints, with constraints penalising feature sharing between less similar segments ranked above constraints penalising feature sharing between more similar segments. This captures the generalisation observed in a range of phonological phenomena (see e.g. McCarthy 1986, Côté 2000, Hansson 2001, 2010, Rose & Walker 2004) that segments which are more similar to one another are more likely to interact. *LINKVC penalises feature sharing between consonants and vowels, and is ranked above the more general *LINK. This, in combination with faithfulness constraints requiring input values of [consonantal] to be present in outputs, will account for the requirement that the [+consonantal] special moras, N and Q, acquire features through linking with a following consonant, whereas the [−consonantal] special mora, R, acquires features by linking with a preceding vowel. In (37), this is illustrated with an evaluation of the game form for [dotooru].

(37) *Game form*

a. *Level 1*

/dotoRru/	MORA$_2$COND	MAX(μ)	*LINK	HAVEPLACE
i. dotooru	*!			
☞ ii. dotoRru				*
iii. dotoru		*!		
iv. dotooru [+bk]			*!	

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b. *Level 2*

/dotoRru/	IDENT [cons]	CROSS-ANCHOR	HAVEPLACE	*LINKVC	*LINK
i. dotoRru		*!	*!		
ii. ruRtodu			*!		
iii. ruR todo [−cns][+cns] [cor]				*!	*
iv. rut todo [+cns][+cns] [cor]	*!				*
☞ v. ruutodo [+bk] [+rd]					*

The Level 1 input in (37) contains an underspecified mora R. Underspecification in the output is enforced by the MORA$_2$CONDITION and *LINK. The output of Level 1 is the input to the sakasa kotoba grammar, where moraic reversal is motivated by CROSS-ANCHOR and HAVEPLACE outranks *LINK. Candidate (37b.i) has no reversal, and is eliminated due to violation of CROSS-ANCHOR, while candidate (b.ii) has an underspecified vocalic mora R in the output, and violates HAVEPLACE (as does (b.i)). Candidate (b.iii) shows multiple linking of the [coronal] feature of the consonant /t/ with the preceding R. This candidate fatally violates *LINKVC. Candidate (b.iv) satisfies *LINKVC by changing the feature specification of the vocalic mora R to [+consonantal], which results in a fatal violation of high-ranking IDENT [cons]. In the optimal candidate in (b.v), features of the underspecified R in the input are assigned by multiple linking with the preceding vowel, resulting in a long [uu] in the output.

The tableaux above illustrate how the realisation of the special moras N, Q and R is determined, both in regular Japanese forms and in game forms where general phonotactic restrictions of Japanese are obeyed. In some cases, reversal results in forms where special moras occur in positions where they are not normally permitted. In these contexts, N and Q can surface as [ɴ] and [ʔ], which we interpret as the phonetic implementation of output segments unspecified for place. For particularly marked reversals, such as those resulting in a word-initial special mora, we find additional variation between speakers. Formal analyses of some of this variation is provided in the following section.

8 Interspeaker variation in constraint ranking

Much of the variation described in previous sections involves variable realisation of the moraic nasal. In marked positions, the place of articulation of

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the nasal differs between speakers, with variants including uvular and assimilated realisations. Similar variation is found with the geminating mora Q in marked contexts, where some elicited forms have gemination of liquids and glides and others a glottal stop realisation. The variable realisation of these segments does not crucially bear on the constraint rankings and representations proposed in the analysis of the basic game pattern, and a formal analysis of this variation will not be considered here. In this section, we focus specifically on variation found in forms where strict adherence to reversal results in word-initial R.

8.1 Word-initial R: feature sharing

The most common pattern found in sakasa kotoba forms of words ending in R is moraic reversal with an initial vowel identical to that of the vowel in the following syllable. This is illustrated in the reversed form [iki] provided for the Japanese word [kii] by Speakers 1, 2 and 5 (cf. (17a) above). For such cases, we propose that the vocalic features of the vowel in the second syllable are linked to the preceding vowel as well as the intervening consonant. This mapping is optimal in a ranking in which the constraint penalising linking between consonants and vowels, *LinkVC, is ranked below constraints requiring segments to have place features as well as constraints penalising feature insertion. An illustrative tableau is provided in (38). This tableau represents the sakasa kotoba grammar, and takes the output of the Level 1 evaluation, not shown, as its input.

(38) *Level 2* (Speakers 1, 2, 5)

/kiR/	Max(μ)	Dep[bk]	Cross-anchor	HavePlace	*LinkVC	*Link
a. kiR			*!	*!		
b. Rki				*!		
c. ki	*!					
d. iki [−bk] [−bk]		*!				
☞ e. iki [−bk]					**	**

The faithful candidate in (a) is eliminated due to violation of Cross-anchor and HavePlace. Candidate (b) violates HavePlace, candidate (c) fatally violates the constraint against mora deletion and candidate (d) has an initial vowel with its own, unshared, feature specifications, represented with [−back]. This candidate violates Dep[back], and is eliminated. The optimal candidate satisfies these constraints, but violates both *LinkVC and *Link twice.

This analysis follows Kawahara's (2007a) approach to echo epenthesis. In Japanese, echo epenthesis occurs in loanwords only in cases where

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intervening consonants have no supralaryngeal place features, as in the examples in (39) (from Kawahara 2007a: 115).

(39) *Echo epenthesis in loanwords*

/bax/	[bahha]	'Bach'
/gox/	[gohho]	'Gogh'

Kawahara uses a constraint penalising shared feature association between vowels and supralaryngeal consonants, rather than the more general *LinkVC. This is motivated by the fact that a default vowel, rather than a vowel matching that of an adjacent syllable, is inserted in forms where epenthesis follows a non-glottal consonant. In his analysis of Kolami epenthesis, Kawahara uses feature sharing across all consonants. This is possible because the constraint penalising feature sharing across supralaryngeal consonants is low-ranked. This is the pattern we find in examples like (38). Differences between patterns of loanword epenthesis and feature-sharing in sakasa kotoba may follow from differences between the sakasa kotoba grammar and the Level 2 grammar of Japanese.[29]

8.2 Word-initial R: nasalisation

For Japanese forms ending in R, Speaker 6 produced a moraic nasal, rather than a vowel, in initial position of game forms. This speaker produced [ɴ̩ki] as the game form of [kii]. We propose that *LinkVC is ranked higher in Speaker 6's grammar than in that of speakers with initial vowels. We take the initial uvular nasal in these forms as the realisation of a nasal segment unspecified for place. Analysis of this pattern requires the constraint compelling place specification, HavePlace, to be divided into separate constraints, with a constraint requiring place specification in vowels ranked above one requiring place specification in nasals. A representative tableau is provided in (40). Candidates with deletion and candidates without reversal are omitted, for reasons of space.

(40) *Level 2* (Speaker 6)

/kiR/	Dep[bk]	Have Place(V)	*Link VC	Have Place(N)	Dep[nas]	*Link
a. kiR		*!				
b. iki [−bk] [−bk]	*!					
c. iki [−bk]			*!*			**
☞ d. ɴ̩ki				*	*	

[29] This pattern is also amenable to an analysis using surface correspondence between vowels (e.g. Kitto & de Lacy 1999, Stanton & Zukoff 2018).

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Candidate (a) contains underspecified R, and is eliminated due to violation of HAVEPLACE(V). Candidate (b) violates the constraint against vocalic feature insertion, DEP[back]. Candidate (c), which was optimal for Speakers 1, 2 and 5, is eliminated due to violation of *LINKVC. In this ranking, the constraints HAVEPLACE(N) and DEP[nas] are ranked below *LINKVC, allowing candidate (d) to surface as the winner.

As noted in §7, the nasalisation pattern exhibited by this speaker resembles the process of coda nasalisation (e.g. Itô & Mester 1986, Kawahara 2007b), in which a moraic nasal is found instead of gemination in contexts where gemination would otherwise result in marked forms. Kawahara (2007b) analyses coda nasalisation as resulting from a ranking in which faithfulness constraints referring to nasality rank below markedness constraints penalising voiced geminates. The analysis above is analogous, with DEP[nas] ranked below markedness constraints against both unspecified vowels and feature sharing between vowels and consonants.

8.3 Word-initial R: absolute ungrammaticality

Speaker 3 consistently judged reversal to be impossible for forms ending in R or N. Patterns in which a grammatical output is deemed impossible for some input have garnered significant attention in the OT literature (e.g. Prince & Smolensky 1993, Orgun & Sprouse 1999, Rice 2007 and the papers in Rice & Blaho 2009), in part because such patterns pose a challenge to the expectation that every potential input must map to some grammatical output. With respect to language games, the impossibility of generating game forms for some inputs has been observed in zuuja-go (Itô *et al*. 1996), Pig Latin (Vaux 2011) and *schm*-reduplication (Nevins & Vaux 2003).

Prince & Smolensky (1993) address the issue of absolute ill-formedness by proposing that every candidate set includes the null parse, a candidate that contains no prosodic structure and is unpronounceable. This candidate violates the constraint MPARSE. By stipulation, all other constraints are satisfied by the null parse. If MPARSE is ranked below markedness constraints violated by word-initial N and R, as well as below those faithfulness constraints that would be violated in order to repair relevant markedness violations, the null parse will be selected as optimal. For Speaker 3, MPARSE is ranked sufficiently low in the game grammar to ensure that no utterable output is possible for forms ending in N or R.[30]

8.4 Word-initial R: additional variation

In addition to the patterns described above, we found additional variants produced for some particularly marked cases. These include deletion of a mora, in the case of Speaker 2 in [garibaa] (see (17b)), and syllabic reversal,

[30] Alternatively, we could view CROSS-ANCHOR as a constraint requiring the expression of a morphological category, the sakasa kotoba form. If relevant constraints outrank CROSS-ANCHOR, inputs in which reversal results in violation of those constraints will not map to outputs which realise the sakasa kotoba category, as in Rice's (2007) analysis of phonologically motivated gaps in Norwegian paradigms.

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in the case of Speaker 1 in the same item, as well is in some items which contain assimilated vowels. Such forms suggest the presence of markedness constraints outranking MAX(μ) or CONTIGUITY, although these constraints are otherwise unviolated in game forms. These patterns were not systematically observed for any speakers, and we do not provide a formal analysis of them here.

9 Interaction with phonological processes

Up to this point, the motivation for a multi-level evaluation has come from the realisation of special moras. The feature specifications of special moras are determined by segments in their environment, both in regular Japanese forms and in game forms. This pattern follows from a two-step evaluation in which the output of Level 1 consists of underspecified representations of N, Q and R. In Level 2, the specifications of the special moras are determined through multiple linking. In marked contexts, where moraic reversal requires special moras to occur in contexts where they are not normally permitted, the underspecified segments themselves can surface as default segments.

Additional evidence for a multi-level evaluation comes from the interaction of sakasa kotoba with phonological processes, such as rendaku. In rendaku, the initial segment in the second member of a compound becomes voiced. When compounds undergo reversal, the sakasa kotoba forms show the effect of rendaku, even though the conditions for rendaku are not present after reversal, as in (41).

(41)

Root$_1$		*Root*$_2$		*Compound*	*Sakasa kotoba*
/kin/	'gold'	/hosi/	'winning'	[kimboʃi]	[ʃiboŋki] *[ʃihoŋki]
/ko/	'small'	/kitte/	'stamp'	[kogitte]	[teggiko] *[tekkigo]
/kami/	'god'	/kami/	(REDUP)	[kamigami]	[migamika] *[mikamika]
/te/	'hand'	/kami/	'paper'	[tegami]	[migate] *[mikate]

The data in (41) show the effects of rendaku voicing in compound forms. Underlyingly voiceless segments that undergo rendaku in the compounds also surface as voiced segments in the game forms. This suggests that reversal applies to intermediate representations which have already undergone rendaku, rather than to underlying representations.[31]

[31] The application of rendaku is restricted to the native Japanese vocabulary, and has numerous lexical exceptions even within this domain. This raises the question of whether forms showing the effects of rendaku are stored, rather than generated by the phonology. Kawahara (2015b) provides a summary of results from psycholinguistic studies as well as data from child language and phonological patterning that supports the view that rendaku is, at least in part, a productive phonological process. Although lexical storage also plays a role in rendaku, psycholinguistic studies show that both lexical listing and phonological computation are involved

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Other phonological processes apply subsequent to reversal, not prior to it. Japanese has a process in which a high vowel becomes devoiced between voiceless consonants (42a) or following a voiceless consonant before a pause (42b).

(42) a. [kiso̥] 'basis'
b. [kimboʃi̥] 'to be a giant-killer'

We found significant variation between speakers in terms of the application of devoicing in sakasa kotoba forms, including some speakers who did not show evidence of devoicing. This may follow from dialectal variation in devoicing (Fujimoto & Kiritani 2003) or may indicate that that the details of the devoicing operation differ between game forms and regular Japanese forms. In cases where speakers do show cases of devoicing in sakasa kotoba, devoicing applies after reversal.

The examples below are from Speaker 3, who produced particularly fluent game forms.[32] In (43a), the regular Japanese form does not contain a high vowel in the devoicing environment, which arises as a result of reversal. In this case, Speaker 3 devoices the high vowel in the game form, as seen in the spectrogram in Fig. 1b. In (43b), the final vowel is devoiced in the elicitation materials. The devoicing environment is not present in the game form, however, as reversal results in the high vowel occurring before another vowel. There is no devoicing in the game form, as indicated by the vertical striations present during the [i] in the spectrogram in Fig. 1b. These examples suggest that reversal does not apply directly to the surface form, but to a representation prior to the application of devoicing.

(43)

	Regular form	*Game form*	
a.	[sakura]	[raku̥sa] (S3)	'cherry blossom'
b.	[kooki̥]	[kiuko] (S3)[33]	'second half'

Given the variation across speakers and the relative lack of salience of this allophonic process, devoicing in game forms would benefit from

in morphophonological patterning (e.g. Schreuder *et al*. 1999, Baayen *et al*. 2002, Pierrehumbert 2006).

[32] We looked for representative examples from Speaker 3 because of his fluent productions, which contrast with the deliberate speech of some participants' game forms. If devoicing is considered a reduction process, we may expect it to be inhibited, both by slow speech and by the novelty of game forms. However, corpus studies of Japanese devoicing paint a more complicated picture. Martin *et al*. (2014) found higher rates of devoicing in careful read speech than in spontaneous speech but also found higher rates of devoicing in faster speech. Kilbourn-Ceron & Sonderegger (2018) found frequent items to have higher rates of devoicing in phrase-final position, but not word-internally or at phrase-internal word boundaries. Predictions for devoicing rates in novel game forms are not obvious, and this warrants additional study.

[33] The game form in this example also fails to show the effects of assimilation that are present in the regular Japanese form. This process is discussed immediately below.

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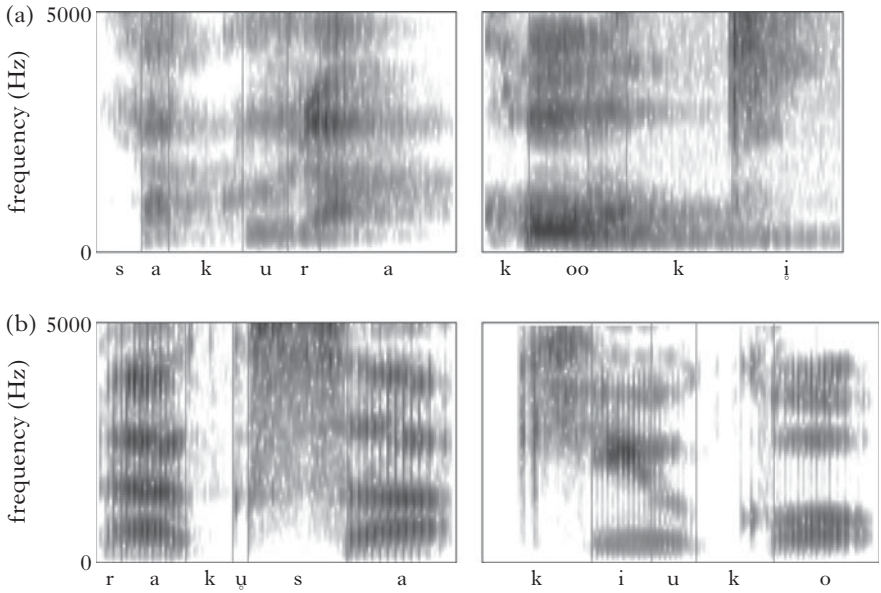

Figure 1
Spectrograms for (a) the elicitation materials for the regular forms [sakura] 'cherry blossom' and [kooki̥] 'second half' and (b) the corresponding game forms produced by Speaker 3.

instrumental and quantitative analysis. This is particularly relevant, as instrumental studies have played an important role in illuminating the patterning of high vowel devoicing in Japanese generally (e.g. Nielsen 2015, Tanner *et al*. 2019). Nonetheless, we take examples such as those shown in (43) as evidence that devoicing can apply to game forms, and that when it does, it applies subsequent to reversal.

In addition to high vowel devoicing, reversal also precedes the process of vowel assimilation in hiatus contexts, as discussed in §3.3.6. In cases where Japanese forms have undergone vowel assimilation, sakasa kotoba forms either fail to show the effect of assimilation or operate on an intermediate form in which the vowel undergoing assimilation is underspecified, but has not yet taken on features of the preceding vowel. Both possibilities are illustrated in (44), repeated from (23).

(44)

	Regular form		*Game form*	
a.	/touja/	[tooja]	[jauto] (S2–5)	'cultivation'
b.	/toRja/	[tooja]	[jaato] (S1,6)	

In (44a), reversal appears to operate on a representation prior to the application of assimilation. Most speakers used forms with this pattern for all cases in which the regular form contained the output of vowel assimilation.

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The pattern in (44b), on the other hand, was found in this item only. As suggested in the transcriptions above, this is consistent with a representation in which vowel length is the realisation of the special mora R. This is an intermediate representation in a multi-step process of vowel assimilation. In the first operation, the second vowel in the hiatus context loses its features, resulting in an underspecified R. Assimilation via feature sharing takes place in a subsequent operation. What is most notable in these cases is that we found no forms like [jaoto], which would be expected if reversal operated on the output of assimilation.

Our analysis suggests that rendaku applies at Level 1, whereas high vowel devoicing applies at Level 2. This is consistent with work on the morphophonology of Japanese (Itô & Mester 1986, 2003) which demonstrates that rendaku has properties characteristic of lexical rules, such as sensitivity to subdivisions of the Japanese lexicon, whereas high vowel devoicing has characteristics of postlexical processes, such as applying across word boundaries and creating allophones.

Vowel assimilation can also apply at Level 2, as demonstrated by cases of application across word boundaries, as in /iku ou/ [ikoo ~ ikou] 'let's go'. Reversal prior to Level 2 is consistent with game forms which show no effects of assimilation, as exemplified in (44a). Assimilation can also apply at Level 1, in which case the result is a loss of features of the second vowel. This is the representation reversed by Speakers 1 and 6 in example (44b). Feature sharing with the preceding vowel takes place at Level 2, but the output of Level 2 is not accessed by the reversing operation.

Our proposed analysis of sakasa kotoba is consistent with a two-level model of the phonological grammar with phonotactic restrictions, underspecification of special moras and rendaku at the lexical level, and feature specification of special moras and high vowel devoicing occurring postlexically. We leave open the question of whether or not multiple levels are necessary within the lexical phonology. Sakasa kotoba takes as its input the output of the lexical phonology.

10 Conclusion

We have reported on the language game sakasa kotoba, based on data elicited from six Japanese speakers. Our analysis shows that the general pattern of sakasa kotoba involves total moraic reversal, with variation between speakers in phonotactically marked forms. This provides evidence in support of the mora as a prosodic constituent and in support of the syllable structure in (11b), in which an onset and following vowel form a constituent, μ_1, to the exclusion of segments occurring in μ_2 position. The patterning of the special moras N, Q and R in game forms cannot be analysed with reference to other phonological constituents such as syllables. The reversing operation can be formalised in an OT analysis in which CONTIGUITY is ranked above LINEARITY. The reversal of special moras provides evidence for underspecified representations. This analysis requires

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multiple levels of evaluation in a stratal version of OT. Further support for a multilevel evaluation can be found in the interaction of sakasa kotoba with other phonological processes, such as rendaku, high vowel devoicing and vowel assimilation. This proposal is consistent with claims in the language game literature that language game operations generally target intermediate representations, rather than underlying or surface forms (Bagemihl 1989, Vaux 2011).

REFERENCES

Baayen, Harald, Robert Schreuder, Nivja de Jong & Andrea Krott (2002). Dutch inflection: the rules that prove the exception. In Sieb Nooteboom, Fred Weerman & Frank Wijnen (eds.) *Storage and computation in the language faculty*. Dordrecht: Kluwer. 61–92.

Bagemihl, Bruce (1989). The crossing constraint and 'backwards languages'. *NLLT* **7**. 481–549.

Bagemihl, Bruce (1995). Language games and related areas. In John A. Goldsmith (ed.) *The handbook of phonological theory*. Cambridge, MA & Oxford: Blackwell. 697–712.

Bateman, Leah, Michael O'Keefe, Ehren Reilly & Adam Werle (eds.) (2007). *Papers in Optimality Theory III*. Amherst: GLSA.

Bermúdez-Otero, Ricardo (2003). The acquisition of phonological opacity. In Jennifer Spenader, Anders Eriksson & Östen Dahl (eds.) *Variation within Optimality Theory: Proceedings of the Stockholm Workshop on 'Variation within Optimality Theory'*. Stockholm: Department of Linguistics, Stockholm University. 25–36.

Bermúdez-Otero, Ricardo (2007). Marked phonemes vs marked allophones: segment evaluation in Stratal OT. Handout of paper presented at the GLOW workshop 'Segment inventories', Tromsø. Available (February 2021) at www.bermudez-otero.com/GLOW2007.pdf.

Bermúdez-Otero, Ricardo (2018). Stratal Phonology. In S. J. Hannahs & Anna R. K. Bosch (eds.) *The Routledge handbook of phonological theory*. Abingdon & New York: Routledge. 100–134.

Borowsky, Toni & Peter Avery (2009). Dhochi: a Dholuo language game. *Australian Journal of Linguistics* **29**. 169–194.

Clements, G. N. (1986). Compensatory lengthening and consonant gemination in LuGanda. In Leo Wetzels & Engin Sezer (eds.) *Studies in compensatory lengthening*. Dordrecht: Foris. 37–77.

Côté, Marie-Hélène (2000). *Consonant cluster phonotactics: a perceptual approach*. PhD dissertation, MIT.

Davis, Stuart & Michael Hammond (1995). On the status of onglides in American English. *Phonology* **12**. 159–182.

Fujimoto, Masako & Shigeru Kiritani (2003). Vowel duration and its effect on the frequency of vowel devoicing in Japanese: a comparison between Tokyo- and Osaka dialect speakers. In M. J. Solé, D. Recasens & J. Romero (eds.) *Proceedings of the 15th International Congress of Phonetic Sciences*. Barcelona: Causal Productions. 3189–3192.

Hansson, Gunnar Ólafur (2001). *Theoretical and typological issues in consonant harmony*. PhD dissertation, University of California, Berkeley.

Hansson, Gunnar Ólafur (2010). *Consonant harmony: long-distance interaction in phonology*. Berkeley: University of California Press.

Hayes, Bruce (1989). Compensatory lengthening in moraic phonology. *LI* **20**. 253–306.

Hirayama, Manami & Timothy J. Vance (2018). Onset Cy and High Vowel Devoicing in Japanese. *Journal of Japanese Linguistics* **34**. 103–126.

Hombert, Jean-Marie (1986). Word games: some implications for analysis of tone and other phonological constructs. In John J. Ohala & Jeri J. Jaeger (eds.) *Experimental phonology*. Orlando: Academic Press. 175–186.
Hyman, Larry M. (1985). *A theory of phonological weight*. Dordrecht: Foris.
Itô, Junko (1989). A prosodic theory of epenthesis. *NLLT* **7**. 217–259.
Itô, Junko, Yoshihisa Kitagawa & Armin Mester (1996). Prosodic faithfulness and correspondence: evidence from a Japanese argot. *Journal of East Asian Linguistics* **5**. 217–294.
Itô, Junko & Armin Mester (1986). The phonology of voicing in Japanese: theoretical consequences for morphological accessibility. *LI* **17**. 49–73.
Itô, Junko & Armin Mester (1993). Licensed segments and safe paths. *Canadian Journal of Linguistics* **38**. 197–213.
Itô, Junko & Armin Mester (2003). Lexical and postlexical phonology in Optimality Theory: evidence from Japanese. In Gisbert Fanselow & Caroline Féry (eds.) *Resolving conflicts in grammar: Optimality Theory in syntax, morphology, and phonology*. Hamburg: Buske. 183–207.
Itô, Junko, Armin Mester & Jaye Padgett (1995). Licensing and underspecification in Optimality Theory. *LI* **26**. 571–613.
Katada, Fusa (1990). On the representation of moras: evidence from a language game. *LI* **21**. 641–646.
Kawahara, Shigeto (2007a). Copying and spreading in phonological theory: evidence from echo epenthesis. In Bateman *et al*. (2007). 111–143.
Kawahara, Shigeto (2007b). Sonorancy and geminacy. In Bateman *et al*. (2007). 145–186.
Kawahara, Shigeto (2012). Review of Labrune (2012). *Phonology* **29**. 540–548.
Kawahara, Shigeto (2015a). A catalogue of phonological opacity in Japanese. Version 1.2. *Reports of the Keio Institute of Cultural and Linguistic Studies* **46**. 145–174.
Kawahara, Shigeto (2015b). Can we use rendaku for phonological argumentation? *Linguistics Vanguard* **1:1**. 3–14.
Kawahara, Shigeto (2018). Phonology and orthography: the orthographic characterization of rendaku and Lyman's Law. *Glossa* **3**(1):10. https://doi.org/10.5334/gjgl.368.
Kilbourn-Ceron, Oriana & Morgan Sonderegger (2018). Boundary phenomena and variability in Japanese high vowel devoicing. *NLLT* **36**. 175–217.
Kiparsky, Paul (2000). Opacity and cyclicity. *The Linguistic Review* **17**. 351–365.
Kitto, Catherine & Paul de Lacy (1999). Correspondence and epenthetic quality. *Toronto Working Papers in Linguistics* **16:2**. 181–200.
Kubozono, Haruo (1989). The mora and syllable structure in Japanese: evidence from speech errors. *Language and Speech* **32**. 249–278.
Kubozono, Haruo (1999). Mora and syllable. In Natsuko Tsujimura (ed.) *The handbook of Japanese linguistics*. Malden, MA & Oxford: Blackwell. 31–61.
Labrune, Laurence (2012). Questioning the universality of the syllable: evidence from Japanese. *Phonology* **29**. 113–152.
McCarthy, John J. (1986). OCP effects: gemination and antigemination. *LI* **17**. 207–263.
McCawley, James D. (1968). *The phonological component of a grammar of Japanese*. The Hague & Paris: Mouton.
Martin, Andrew, Akira Utsugi & Reiko Mazuka (2014). The multidimensional nature of hyperspeech: evidence from Japanese vowel devoicing. *Cognition* **132**. 216–228.
Martin, Samuel E. (1975). *A reference grammar of Japanese*. New Haven: Yale University Press.
Nevins, Andrew & Bert Vaux (2003). Metalinguistic, shmetalinguistic: the phonology of shm-reduplication. *CLS* **39**. 702–721.
Nielsen, Kuniko Y. (2015). Continuous versus categorical aspects of Japanese consecutive devoicing. *JPh* **52**. 70–88.

Nogita, Akitsugu (2016). Arguments that Japanese [Cj]s are complex onsets: durations of Japanese [Cj]s and Russian [Cj]s and blocking of Japanese vowel devoicing. *Working Papers of the Linguistics Circle of the University of Victoria* **26**. 73–99.
Orgun, Cemil Orhan & Ronald L. Sprouse (1999). From MPARSE to CONTROL: deriving ungrammaticality. *Phonology* **16**. 191–224.
Padgett, Jaye (1995). Partial class behavior and nasal place assimilation. In Keiichiro Suzuki & Dirk Elzinga (eds.) *Proceedings of the 1995 Southwestern Workshop on Optimality Theory* (*SWOT*). Tucson: Department of Linguistics, University of Arizona. 145–183.
Pierrehumbert, Janet B. (2006). The statistical basis of an unnatural alternation. In Louis Goldstein, D. H. Whalen & Catherine T. Best (eds.) *Papers in Laboratory Phonology 8*. Berlin & New York: Mouton de Gruyter. 81–106.
Poser, William J. (1990). Evidence for foot structure in Japanese. *Lg* **66**. 78–105.
Prince, Alan & Paul Smolensky (1993). *Optimality Theory: constraint interaction in generative grammar*. Ms, Rutgers University & University of Colorado, Boulder. Published 2004, Malden, MA & Oxford: Blackwell.
Rice, Curt (2007). Gaps and repairs at the phonology–morphology interface. *JL* **43**. 197–221.
Rice, Curt & Sylvia Blaho (eds.) (2009). *Modeling ungrammaticality in optimality theory*. London & Oakville, CT: Equinox.
Rose, Sharon & Rachel Walker (2004). A typology of consonant agreement as correspondence. *Lg* **80**. 475–531.
Rubach, Jerzy (2003). Polish palatalization in derivational Optimality Theory. *Lingua* **113**. 197–237.
Schreuder, Robert, Nivja de Jong, Andrea Krott & Harald Baayen (1999). Rules and rote: beyond the linguistic either-or fallacy. *Behavioral and Brain Sciences* **22**. 1038–1039.
Smith, R. Edward (1980). *Natural phonology of Japanese*. PhD dissertation, University of Hawaii.
Stanton, Juliet & Sam Zukoff (2018). Prosodic identity in copy epenthesis: evidence for a correspondence-based approach. *NLLT* **36**. 637–684.
Tanner, James, Morgan Sonderegger & Francisco Torreira (2019). Durational evidence that Tokyo Japanese vowel devoicing is not gradient reduction. *Frontiers in Psychology* **10**. https://doi.org/10.3389/fpsyg.2019.00821.
Tateishi, Koichi (1989). Theoretical implications of the Japanese musician's language. *WCCFL* **8**. 384–398.
Vance, Timothy J. (1987). *An introduction to Japanese phonology*. Albany: State University of New York Press.
Vance, Timothy J. (2008). *The sounds of Japanese*. Cambridge: Cambridge University Press.
Vaux, Bert (2011). Language games. In John Goldsmith, Jason Riggle & Alan Yu (eds.) *The handbook of phonological theory*. 2nd edn. Malden, MA & Oxford: Wiley-Blackwell. 722–750.
Yoshida, Shohei (2003). The syllabic nasal in Japanese. In Stefan Ploch (ed.) *Living on the edge: 28 papers in honour of Jonathan Kaye*. Berlin & New York: Mouton de Gruyter. 527–542.