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The sensitivity of native Japanese speakers to *On* and *Kun* kanji readings

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Abstract Japanese kanji reading can be divided into two types: On-readings, derived from the original Chinese pronunciation and Kun-readings, originating from the Japanese pronunciation. Kanji that are normally given an On-reading around 50% of the time were presented in a context of other kanji that had either a highly dominant On-reading or a highly dominant Kun-reading. The reading that was given in this experiment was very much biased toward the type of phonological environment in which it was embedded. So native Japanese speakers easily shifted between On and Kun readings, depending on phonological context, suggesting that separate On and Kun sub-lexica exist within the phonological lexicon.

Keywords Japanese lexicon · Kanji phonological lexicon · On- and Kun-reading · Phonological shift

Introduction

Japanese kanji readings can be divided into two types: *On*-readings, derived from the original Chinese pronunciation, and *Kun*-readings originating from the Japanese pronunciation (see Hirose, 1998; Kess & Miyamoto, 1999; Leong & Tamaoka, 1995). For example, the kanji 海 meaning 'ocean' is pronounced /kai/ in On-reading (or Sino-Japanese), but /umi/ in Kun-reading. On-reading is frequently used for multiple-kanji compound words such as 海岸 /kaigaN/ meaning 'seashore', 海賊 /kaizoku/

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meaning 'pirate', and 海藻 /kaisoR/[1] meaning 'seaweed'. Kun-readings frequently appear as a single kanji, often having a concrete meaning by itself. In the case of 海, this single kanji meaning 'ocean' or 'sea' is pronounced /umi/ in its Kun-reading. The psychological question can then be raised about how On- and Kun-readings of the same kanji characters are represented in the mental lexicon.

As for etymological types, Japanese lexical items (i.e., words) are classified into four categories, Japanese-origin words (*Wago*), Chinese-origin words or Sino-Japanese (*Kango*), alphabetic loanwords (*Gairaigo*) and onomatopoeia (*Gitaigo*). In linguistic studies (Fukazawa & Kitahara, 2004; Ito & Mester, 1995, 2003; Vance, 1987), it is proposed that etymological types define 'lexical strata' in the Japanese lexicon, each comprising their own unique constraints. In this conceptual framework of lexical stratum, there is a core of Wago lexical items surrounded by the two increasingly peripheral layers of Kango and Gairaigo, each defined by their own phonological constraints. Wago are composed of the phonological characteristics of Kun-readings, whereas Kango comprise phonological characteristics of On-readings. Consequently, characteristics of On- and Kun-readings relate, respectively to the phonological nature of the etymological types of Wago and Kango.

Among the 1,945 basic kanji, 40 have only Kun-readings while 737 have only On-readings (Tamaoka, Kirsner, Yanase, Miyaoka, & Kawakami, 2002; Tamaoka & Makioka, 2004). Thus, 1,168 kanji have both On- and Kun-readings. Native Japanese speakers can judge whether a spoken kanji element of a word is an On- or Kun-reading with relatively high accuracy (Tamaoka, 2003). However, when an On-reading kanji (mostly monosyllabic) with a concrete meaning involves a polysyllabic sound (such as 肉 /niku/ 'meat' and 菊 /kiku/ 'chrysanthemum'), native Japanese speakers exhibit some difficulty judging whether it is On- or Kun-reading (Tamaoka, 2003). These single-kanji words are constructed by phonological CVCV-structure, not containing any special sound (i.e., nasal /N/ , geminate /Q/ and long vowel /R/) which are frequently found in On-readings (Tamaoka et al., 2002). These words may be classified as *zokukango* (vulgarized Sino-Japanese) since they display phonological characteristics typically observed in Wago (Takayama, 1999).[2] Such erroneous judgments of On- and Kun-readings suggest that native Japanese speakers have an intuitive sense of the difference between On and Kun which influence the distinction they make between the etymological categories of Wago and Kango.

There are two possible lexical structures for On and Kun phonological representations in the Japanese kanji phonological lexicon. The first possibility is that each kanji pronunciation is labeled as On or Kun, like having a sound tag (i.e., direct kanji-to-sound tag with no On/Kun sub-lexica). Kanji are represented in the orthographic lexicon which is further connected to kanji sounds in the phonological lexicon. Thus, On- and Kun-readings are simply identified by a label associated with their pronunciations: There is a single phonological lexicon with no On/Kun

[1] The pronunciation of Japanese words in this paper is transcribed using Japanese phonemic symbols which indicate three special sounds in Japanese: /N/ for nasal, /Q/ for geminate and /R/ for long vowel.

[2] The single-kanji word /kiku/ is On-reading and is classified as Kango. This word, however, represents sequential voicing, or *rendaku* as in /no + giku/ (voiceless /k/ changes to voiced /g/) 'a wild chrysanthemum' which is usually a phonological feature of Wago. This is one of examples of vulgarized Sino-Japanese or *zokukango*.

sub-categorization. The second possible structure is that On and Kun are separated from each other in the lexicon (i.e., On/Kun sub-lexica). Independent On and Kun sub-lexica are divided by On/Kun phonological boundaries, and On- and Kun-readings are selected for use in appropriate lexical situations. However, native Japanese speakers occasionally confuse On- and Kun-readings because some On-readings resemble Kun-readings as seen in examples of vulgarized Sino-Japanese. Therefore, the question being address in this study is how On- and Kun-readings are represented and retrieved from lexical memory: Using direct kanji-to-sound tag or On/Kun sub-lexica.

Questions regarding On- and Kun-readings

In order to investigate the mental representations and selecting mechanism for kanji On- and Kun-readings, the present study conducted an experiment examining a possible phonological shift in On- and Kun-readings. Kaiho & Nomura (1983) calculated kanji On-reading ratios (%) by dividing the kanji frequency of On-readings by the total number of each kanji frequency. In the present study, kanji with an approximately 50% On-reading ratio (which implies a 50% Kun-reading ratio as well) were randomly embedded within a group of kanji all having a 100% On-reading ratio (for details see Appendix 1). For example, the kanji 歌 'a song' (/uta/ for Kun-reading and /ka/ for On-reading), with a 48% On-reading ratio, was embedded in a group of kanji each with a 100% On-reading ratio such as 郡 識 将 議 容 歌 銀 純 律 (the underlined kanji is the target). This was the On-reading phonological environment. Likewise, the same kanji 歌 was embedded in kanji with a high Kun-reading ratio (or a low On-reading ratio) as in 舌 顔 切 仲 割 歌 読 机 孫. This condition was the Kun-reading phonological environment. Native Japanese speakers were asked to transcribe each kanji in the Japanese phonetic script of hiragana.

Several different outcomes are possible in this task, each being explicable by a different theoretical account. If On/Kun-reading is tagged to each kanji sound without any On- and Kun-reading boundaries, the target kanji should be pronounced in a distribution reflecting its kanji sound frequency regardless of the On/Kun context. In the case of 歌 with a 48% On-reading ratio, this kanji should be pronounced as either an On- or Kun-reading equally often in either context. That is, the pronunciation given to a particular kanji should be specifically tied to that kanji and, hence, be unaffected by the pronunciation given to any other kanji. However, if On- and Kun-reading boundaries exist in the kanji phonological lexicon, the pronunciation of the kanji 歌 should shift depending upon the On or Kun phonological environment. The particular environment would lead to a bias toward the use of one or the other sub-lexicon, such that Kanji embedded in an On-reading environment should yield a high frequency of On-reading while kanji embedded in a Kun-reading environment should yield a high frequency of Kun-reading.

Another possible outcome is related to phonological accessibility. In early studies on On- and Kun-readings, Nomura (1978, 1979) found that kanji with a higher On-reading ratio (i.e., a lower Kun-reading ratio) were named faster than kanji with a lower On-reading ratio (i.e., a higher Kun-reading ratio) and, from this, proposed a different processing route for On- and Kun-readings. When readers can determine the meaning of a kanji faster than its pronunciation, they judge that these

slowly-activated sounds must be Kun-readings. In contrast, when readers can determine the sound of a kanji more easily and quickly than its meaning, they judge such sounds as On-readings. Such an explanation, however, is problematic in terms of the relevance of the speed of activating meaning relative to the speed of activating sound. Nomura (1978, 1979) was not looking at On/Kun judgments, but rather speed of naming. In addition, he did not research semantic aspects of kanji, so that his finding was simply that On-reading was activated more quickly than Kun-reading, implying that an On-reading can be discriminated from a Kun-reading. Nevertheless, if native Japanese speakers do use the putative naming-speed strategy as Nomura (1978, 1979) suggests, it is expected that the majority of the kanji presented as a single unit should be given their On-reading regardless of the On/Kun phonological environment.

Another possible outcome is predicted on the basis of kanji lexicality (i.e., meaningfulness). Kun-reading is often used for kanji when not compounding to other kanji. The single kanji 岩 has a concrete meaning ('rock') and is given its Kun-reading (/iwa/) when used as a free-standing word. In contrast, the On-reading /gan/ is used only in the form of compound words such as 岩窟 /gankutu/ meaning 'cave', 溶岩 /yoogan/ meaning 'lava', and 砂岩 /sagan/ meaning 'sandstone'. Thus, when a kanji is presented by itself, a bias might be expected for readers to choose the Kun-reading because of its lexicality. According to this account, we should see a high frequency of Kun-readings regardless of the phonological environment in which it was embedded.

Finally, grammatical category needs to be taken into consideration. A single kanji may often be a verb or adjective, in which case, it will contain an inflection and be pronounced as Kun. For example, the kanji 売 meaning 'to sell' is pronounced /bai/ in On-reading and /u(ru)/ in Kun-reading. This Kun-reading includes a verb inflection る /ru/ printed in hiragana (i.e., 売る). Arising from this, the prediction is that kanji with Kun-readings for verbs and adjectives will not easily shift On- and Kun-readings. To test this prediction, the present experiment selected kanji with Kun-readings that either do or do not take an inflection.

Method

Participants

Ninety-two undergraduate and graduate students (48 females and 44 males), all native speakers of Japanese, participated in this experiment. Ages ranged from 19 to 39 years.

Stimuli

Based on the On-reading ratio provided by Kaiho & Nomura (1983), 32 target items were chosen from kanji with a 45% to 55% On-reading ratio. All stimuli were taken from the 1,945 basic Japanese kanji. The present stimuli also included grammatical categories in Kun-readings by dividing the 32 kanji into those which required an inflection when given a Kun reading (i.e., verbs and adjectives) and those which did not (i.e., nouns). Of the former, there were 10 verb forms and 6 adjective forms.

Table 1 Characteristics of target kanji with a 50% On-reading ratio in function of Kun-reading with and without inflections

Kanji stimuli		On-reading ratio (%)	Kanji printed frequency	Number of strokes	Number of words produced	Number of homophones	School grade
Kanji with no inflections	*M*	49.63	17,036	8.94	141.44	16.88	2.63
Kun-readings ($n = 16$)	*SD*	2.66	38,580	4.57	132.03	12.39	1.41
Kanji with inflections	*M*	51.00	13,436	10.69	105.81	13.94	3.75
Kun-readings ($n = 16$)	*SD*	3.33	12,336	3.00	111.91	12.67	1.73

To create the On-reading phonological environment, 63 kanji with 100% On-reading ratio were chosen, and half of the targets were embedded amongst these. Because there are only 40 kanji with 100% Kun-reading ratio, the criterion of having a greater than 80% Kun-reading ratio was used for the 63 kanji that formed the Kun-reading environment. Again, half of the target kanji were embedded in this environment. Two lists for each pronunciation environment were created, with the embedded targets counterbalanced between them (for details, see Appendix 1).

The target kanji and their On- and Kun-readings are listed in Appendix 2. Characteristics of the two groups are shown in Table 1. A *t*-test showed no significant difference between the On-reading ratios for kanji that take inflections and those that do not, $t(30) = -0.026$, $p > .1$.

It is well-known that kanji printed-frequency (i.e., number of occurrences in written materials) affects kanji processing (e.g., Tamaoka & Hatsuzuka, 1995 for Japanese kanji, and Taft & Zhu, 1995; Taft, Huang, & Zhu, 1994; Wu, Chou, & Liu, 1994; Zhang & Peng, 1992; Zhou & Marslen-Wilson, 1994 for Chinese characters), so this needed to be matched between the two stimulus groups. Yokoyama, Sasahara, Nozaki, & Long (1998) published frequency of occurrence data based on all the kanji in Tokyo editions of the *Asahi* newspaper printed in 1993. Their index recorded actual kanji frequency of occurrence 17,117,320 times (i.e., token frequency) for 4,583 kanji (i.e., type frequency). As shown in Table 1, the means of kanji frequency were 17,036 for the target kanji with no inflections and 13,436 for the kanji with inflections, a non-significant difference, $t(30) = 0.355$, $p > .1$.

Because orthographic complexity has also been observed to affect the processing of Chinese characters (Leong, Cheng, & Mulcahy, 1987), we controlled the average number of strokes between conditions (figures taken from Tamaoka et al., 2002), $t(30) = -1.280$, $p > .1$.

Linguistic productivity refers to the number of two-kanji compound words that contain the particular single kanji (for details see Nomura, 1989). The index for this was provided by Kawakami (1997). There was no significant difference between the two sets of kanji items, $t(30) = 0.823$, $p > .1$.

The number of homophones was counted according to how many kanji out of the basic 1,945 shared the same sound (Tamaoka et al., 2002). For example, the sound /yoku/ can be written using five different characters in the 1,945 basic kanji. Both

On- and Kun-readings were calculated for kanji homophones. As seen in Table 1, the average numbers of kanji homophones were 16.88 for kanji with no infections and 13.94 for kanji with inflections. There was no significant difference between them, $t(30) = 0.663$, $p > .1$.

The school grade in which the target kanji are taught was also taken into consideration. The assignment of the 1,006 basic kanji to Grades 1–6 follows the Japanese language curriculum as was outlined by the Japanese Ministry of Education in 1989. Since the remaining 939 basic kanji are taught in Grades 7–9, these are all indicated with the number '7'. Using these figures, the averages of school grades were calculated as 2.63 for the target kanji with no inflection and 3.75 for kanji with inflections. These means did not significantly differ, $t(30) = -2.016$, $p > .1$.

Procedure

The 32 target kanji were randomly embedded within 63 kanji that either had 100% On-readings or less than 20% On-readings (i.e., over 80% Kun-reading ratio). In order to avoid the same target kanji being assigned to the same subject under different conditions, four lists (two for each phonological environment) were created. Both groups of participants received an On context list and a Kun context list, whereby the target kanji were equally divided between the two lists (8 with inflections and 8 without inflections per list). The assignment of items from the two lists was reversed for the two participant groups such that, over the two groups, every target kanji was presented in both contexts and no participant saw the same target kanji more than once. All lists were presented to participants in printed form. Going through the list from top to bottom, participants were asked to use the Japanese phonetic script of hiragana to write down either the On- or Kun-reading for each kanji, whichever first came to mind. Frequencies of On-readings were recorded for the target kanji. Reading errors were not included in the analysis because, with most kanji used in the present study being taken from the basic 1,006 kanji taught during the first six school grades, the university students made few reading mistakes.

Results

The means of On-reading percentages for kanji with and without inflections under both the high On- and Kun-readings are presented in Table 2. A 2 (inflectional status) × 2 (phonological environment) ANOVA was conducted on On-reading percentages. Inflectional status was analyzed as a between-stimuli factor while phonological environment was a within-stimuli factor.

There was a dramatic shift from On-reading to Kun-reading when the context changed from dominant-On to dominant-Kun, $F(1, 30) = 227.50, p < .001$. The main effect of inflection was also significant, $F(1,30) = 45.27, p < .001$. The target kanji which had inflections in their Kun-reading were given On-readings more often than those with no inflections. Since kanji with no inflections are more naturally read in their Kun-reading as a free-standing lexical unit, they were less frequently pronounced in their On-reading regardless of phonological environment. Yet, as

Table 2 On-reading frequency (%) of target kanji with a 50% On-reading ratio embedded in On- and Kun-reading dominant environments

Inflections in Kun-readings	Kanji phonological environment				Degree of On/Kun shift
	On-reading dominant		Kun-reading dominant		
	M	*SD*	*M*	*SD*	
Non-inflectional kanji	68.75	18.81	12.36	7.75	56.39
Inflectional kanji	90.49	7.65	21.77	14.89	68.72

shown in Table 2, both inflectional and non-inflectional types of kanji displayed a similar degree of On/Kun phonological shift: 56.39% for kanji with inflections and 68.72% for kanji with no inflections, with the interaction being non-significant, $F(1,30) = 2.21$, $p > .1$. Therefore, both the major factors of phonological environment and inflection independently affected the choice of On- or Kun-readings.

Discussion

The present study investigated how On and Kun pronunciations are represented in lexical memory and how On- and Kun-readings are distinguished and used in various situations. Various possible outcomes were proposed in the present study.

The first prediction was that native Japanese speakers are sensitive to On- and Kun-reading frequencies. All target kanji used in the present study were within the range of 45–55% On-reading ratio, so if Japanese pronounce the target kanji based on their frequencies of experience in seeing and sounding kanji, they would read the target kanji at roughly this ratio regardless of the On/Kun phonological context. However, the present study found that the phonological context surrounding the target kanji affected the selection of On/Kun-readings implying that the phonological context had more impact than On/Kun-reading frequency. In order for their On/Kun-reading to shift freely like this, Japanese speakers must develop a sense of On/Kun-reading boundaries within their lexical memory of kanji phonology.

Secondly, it was predicted that participants would tend to choose to read a target kanji either in an On- or Kun-reading depending on which phonological representation is more quickly activated. According to Nomura (1978, 1979), On-reading is associated with sound while Kun-reading with concepts, which means that the phonology of On-readings should be more quickly activated than those of Kun-readings. In fact, the meaning of 'On' literally refers to 'sound' and 'Kun' refers to 'concept'. If this claim is true, it would be expected that speakers would be more likely to choose On-readings for single target kanji presented alone than Kun-readings, a prediction that was not substantiated. On/Kun selection does not necessarily depend on how fast phonological representations are activated in the presentation of a single kanji, which rules out phonological accessibility as the basis for choosing On- or Kun-readings.

Another possibility was that the target kanji would be read as Kun because all the target kanji were presented as single free-standing lexical units which are characteristic of Kun-readings. For instance, the kanji 犬 has the lexical meaning

of ‘dog’ by itself which leads to the Kun sound /inu/ , regardless of phonological context. However, in the present study, the lexicality of a free-standing single kanji was not the preferred candidate for the selection of On/Kun-readings. Again, the finding supports the existence of On and Kun boundaries which allow Japanese to freely shift between the two readings.

A further hypothesis was that grammatical categories would affect On/Kun-readings. The present study manipulated inflections among the 32 target kanji when in their Kun-reading. The 16 target kanji were nouns with no inflection while the remaining 16 kanji were adjectives and verbs with inflections usually seen with hiragana in a Japanese written context. It was predicted that the nouns would be easier to read in their Kun-reading than the verbs and adjectives because no inflections were presented, and the results supported this. Nevertheless, since the degree of phonological shift for On/Kun readings was substantial regardless of whether an inflection was required or not, the results support the assumption that separate On- and Kun-reading sub-lexica exist within the Japanese phonological kanji lexicon regardless of grammatical categories.

Native Japanese speakers can easily identify kanji On- and Kun-readings. To make this On/Kun assignment possible, it is a fundamental requirement for each kanji to have On and/or Kun tags. Despite any outcome based upon On-reading frequency, phonological accessibility and free-standing lexical unit, native Japanese speakers noticeably shifted On/Kun sounds depending on the phonological surroundings of the target kanji. In this sense, the lexical memory of kanji On/Kun phonology included On/Kun boundaries. In the process of kanji acquisition, native Japanese speakers seem to develop a phonological sense of On/Kun-readings which become a basis of constructing the dichotomous On and Kun boundaries.

The existence of an inflection in the Kun-reading, however, indicated some effect on the choice of On/Kun-readings. In the phonological context of Kun-reading, participants chose Kun-readings of target kanji with no inflections more frequently than those with inflections while, in the On-reading context, the same target kanji with no inflections were read in On-readings less frequently than those with inflections. Single kanji nouns tend to be read in their Kun sounds because they are free-standing lexical units. In contrast, adjectives and verbs require extra hiragana attachments to kanji which add extra sounds to a Kun-reading. These additions to adjectives and verbs create a different degree of selection for On/Kun-readings. Regardless of the grammatical effects in Kun-readings, phonological context still strongly affected the On/Kun selection process.

The present study investigated whether On/Kun sub-lexica exist in the Japanese phonological lexicon. Sunning up the results, the phonological boundaries for On/Kun-readings must exist in the phonological kanji lexicon. Each kanji are not simply connected from kanji to On/Kun sounds. These kanji sounds are roughly divided into two On/Kun sub-lexica within the phonological lexicon. These On/Kun sub-lexica further act to display the phonological nature of the Wago and Kango etymological types. Further questions of On/Kun-readings may be raised about what kind of phonological clues native Japanese speakers use for distinguishing On and Kun, and how Japanese pre-school children acquire distinct phonological rules related to the Wago and Kango (and Giraigo) etymological types associated with On and Kun sounds in the absence of formal instruction.

Appendix 1

See Table 3.

Table 3 Target kanji with a 50% On-reading ratio in high On- and Kun-reading environments

(1) Kun-reading dominant environment (Type A1)

葉	浅	考	何	＊暗	姿	泣	橋	貝	＊疑	湯	麦
赤	窓	＊人	羽	取	＊軽	夕	忘	塩	＊眼	芽	鼻
丸	朝	耳	＊言	口	届	川	暑	買	＊群	笑	柱
灰	＊小	引	坂	歯	＊洗	胸	喜	花	矢	側	＊男
夏	組	株	＊暖	鳴	谷	畑	＊働	晴	森	穴	屋
＊池	舌	顔	切	仲	割	＊歌	読	机	孫	＊粉	型
起	秋	＊岩	黒	雨	筋	似					

(2) On-reading dominant environment (Type A2)

案	刊	閣	王	＊暗	完	禁	線	医	＊疑	界	検
点	仁	＊人	算	俗	＊軽	陸	胃	属	＊眼	専	堂
策	駅	輸	＊言	肺	税	茶	銅	発	兵	＊群	料
忠	票	＊小	電	院	福	＊洗	秒	職	警	気	旧
＊男	務	才	功	＊暖	毒	鉄	棒	＊働	京	億	格
軍	＊池	郡	識	将	議	容	＊歌	銀	純	律	＊粉
歴	週	害	＊岩	徳	法	式					

(3) Kun-reading dominant environment (Type B1)

葉	浅	考	何	＊悪	姿	泣	＊下	橋	貝	＊強	湯
麦	赤	窓	＊誤	羽	取	夕	忘	塩	＊鏡	芽	鼻
丸	朝	耳	口	＊終	届	川	暑	買	＊犬	笑	柱
灰	＊痛	引	坂	歯	胸	＊島	喜	花	矢	側	＊売
夏	組	株	鳴	＊南	谷	畑	晴	森	＊皮	穴	屋
舌	＊変	顔	切	仲	割	＊落	読	机	孫	型	＊妹
起	秋	黒	雨	＊旗	筋	似					

(4) On-reading dominant environment (Type B2)

案	刊	閣	王	＊悪	完	禁	＊下	線	医	＊強	界
検	点	仁	＊誤	算	俗	陸	胃	属	＊鏡	専	堂
策	駅	輸	肺	＊終	税	茶	銅	発	兵	＊犬	料
忠	票	＊痛	電	院	福	秒	職	＊島	警	気	旧
務	＊売	才	功	毒	鉄	＊南	棒	京	億	格	＊皮
軍	郡	識	＊変	将	議	容	銀	＊落	純	律	歴
週	＊妹	害	徳	法	式	＊旗					

Note: * refers to Target kanji. Types A1 and B1 are high Kun-reading dominant environments, while Types A2 and B2 are high On-reading dominant environments. Types A1 and B2 were assigned to 46 participants, while Types A2 and B1 were presented to 46 different participants. The total number of participants was 92

Appendix 2

See Table 4.

Table 4 On-reading frequencies (%) of each kanji with a 50% On-reading ratio

(1) Kanji with no inflections in Kun-readings

Kanji	Meaning	On-reading	Kun-reading	Kanji phonological environment	
				On-reading dominant	Kun-reading dominant
妹	sister	/si/	/imoRto/	93.48	4.35
犬	dog	/keN/	/inu/	93.48	13.04
群	crowd	/guN/	/mure/	91.30	8.70
池	pond	/ti/	/ike/	89.13	2.17
島	island	/toR/	/sima/	82.61	10.87
人	person	/ziN/	/hito/	78.26	13.04
旗	flag	/ki/	/hata/	76.09	10.87
男	man	/daN/	/otoko/	73.91	6.52
歌	sing	/ka/	/uta/	71.74	2.17
岩	rock	/gaN/	/iwa/	65.22	13.04
粉	flour	/huN/	/kona/	65.22	17.39
下	lower	/ka/	/sita/	47.83	6.52
鏡	mirror	/kyoR/	/kagami/	45.65	23.91
眼	eye	/gaN/	/me/	43.48	15.22
皮	skin	/hi/	/kawa/	41.30	17.39
南	south	/naN/	/minami/	41.30	32.61

(2) Kanji with inflections in Kun-readings

Kanji	Meaning	On-reading	Kun-reading	Kanji phonological environment	
				On-reading dominant	Kun-reading dominant
疑	doubt	/gi/	/utaga(u)/	100.00	23.91
誤	mistake	/go/	/ayama(ru)/	97.83	0.00
変	change	/heN/	/kawa(ru)/	97.83	2.17
悪	bad	/aku/	/waru(i)/	95.65	6.52
暗	dark	/aN/	/kura(i)/	95.65	13.04
言	say	/geN/	/yu(R)/	95.65	26.09
強	strong	/kyoR/	/tuyo(i)/	93.48	19.57
軽	light	/kei/	/karu(i)/	93.48	28.26
終	end	/syuR/	/owa(ru)/	91.30	6.52
暖	warm	/daN/	/atataka(i)/	91.30	10.87
洗	wash	/seN/	/ara(u)/	89.13	26.09
小	small	/syoR/	/tiR(sai)/	89.13	30.43
落	fall	/raku/	/oti(ru)/	86.96	22.28
痛	pain	/tuR/	/ita(i)/	78.26	34.78
働	work	/roR/	/hatara(ku)/	76.09	47.83
売	sell	/bai/	/u(ru)/	76.09	50.00

Note: Each percentage is calculated by the number of On-readings divided by the total readings among 46 native Japanese speakers (total of 92 participants due to the counter-balanced design) for 50 percent On-reading kanji in a phonological environments of high On- and Kun-reading dominants. Thus, percentages indicate how often On-readings (*shaded columns*) are used in each phonological environment. Only typical On- and Kun-readings are included in the table

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