Learners' Proficiency and Lexical Encoding of the Geminate/Non-geminate Contrast in Japanese

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1. Introduction

Every speaker of a language stores the pronunciation of the words in his mental lexicon, so that each word is phonologically represented in the lexicon. Such lexical representations for words in a second language (L2) can be much less precise than for the native language, mostly because of misperception of the L2 phonemes (e.g., Pallier, Colomé, & Sebastián-Gallés, 2001). Hence, L2 lexical representations can be confusable or ambiguous, yielding spurious homophony (two different words will have the same representation) and spurious lexical access. For example, near-words can be mistaken as real words (e.g., */lɛmp/ for /læmp/ *lamp*, Broesma & Cutler, 2008; Dupoux, Sebastián-Gallés, Navarrete, & Peperkamp, 2008; Sebastián-Gallés, Echeverría, & Bosch, 2005). Furthermore, previous studies revealed that lexical access in L2 can be asymmetrical according to Cutler, Weber, and Otake (2006) and Weber and Cutler (2004); they looked at learners of English whose native language was Dutch. Dutch only has a mid-front vowel in its inventory. Thus, there is no contrast between a mid-front vowel as in *pen* /pɛn/ and a low front vowel as in *panda* /pænda/. The study showed with eye-tracking that fixations for targets containing a similar phonological category to learners' first language [L1] (/pɛnsɪl/) were more selective (earlier decrease of looks to the competitor with a new phonological category, i.e., a phoneme which does not exist in learners' L1) than fixations for targets containing a new category (/pænda/; later decrease of looks to a competitor with a similar category to learners' L1). Concretely, upon hearing an auditory prompt syllable (/pɛn…/ vs. /pæn…/), Dutch L2 English listeners fixated the target (/pɛnsɪl/) and successfully avoided looking at the competitor (/pænda/) earlier than in the opposite case, when the target contained a new, unfamiliar category (/pænda/). In this case, the fixations to the competitor (/pɛnsɪl/) along with the target were present for a longer period of time while hearing the auditory prompt. These findings suggest that when listeners hear a familiar category, their lexical activation is more specific, perhaps because words containing this sound are more clearly represented. When listeners hear the unfamiliar (i.e., new) category /æ/, they activated both the target and competitors more strongly, perhaps because the word representations containing this unfamiliar category are not represented in a target-like way. If the contrast between /æ/ and /ɛ/ was merged in lexical representations, fixations would be symmetrically (non)selective. Weber and Cutler's (2004) data therefore suggest that these two categories are not merged in lexical representations, unlike in the cases described by Ota, Hartsuiker, and Haywood (2009) or by Pallier, Colomé, and Sebastián-Gallés (2001). A possible cause of these effects is that L2 learners' lexical representations are fragmentary: although dominant and non-dominant categories are encoded separately (hence, lexical separation is achieved), the non-dominant category is perhaps represented as a poor match of the dominant category (Hayes-Harb & Masuda, 2008). Of note, the asymmetries reported by Weber and Cutler (2004) have been obtained with highly proficient Dutch L2 learners of English, who had no serious difficulties making a perceptual distinction between /ɛ/ and /æ/, a contrast not present in Dutch.

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It is a well-established linguistic fact that length distinctions in Japanese are phonemic; more specifically, Japanese has a length contrast both in vowels (e.g., *koto* “Japanese harp” *kooto* “coat”) and consonants (e.g., *kite* “to come” *kitte* “postal stamp”). Among the length contrasts, consonantal length has been widely investigated from various perspectives (moraic theory, Kubozono, 1999; speech perception, Han, 1992; Hardison & Motohashi-Saigo, 2010; speech production, Harada, 2006).

In the classroom, L2 learners of Japanese find the consonantal length contrast, known as the geminate (i.e., long consonant, also referred to as double consonants) and non-geminate (i.e., short consonant, also referred to as singleton) contrast, to be especially problematic, often misspelling it in writing, misperceiving it in listening, and mispronouncing it when attempting target-like speech. Length contrasts in Japanese have been shown to be somewhat difficult to distinguish both in perception and production when it is not contrastive in the learners’ L1: production data showed learners pronounced the contrast differently from native speakers; in perception, despite high accuracy levels (learners’ accuracy level was still above 80%), learners were still less accurate than Japanese native speakers (Han, 1992). Tajima, Kato, Rothwell, Akahane-Yamada, and Munhall (2008) revealed that perceptual training helped learners gain the ability to distinguish the geminate and non-geminate contrast. However, being able to distinguish the geminate and non-geminate contrast does not mean learners have encoded the distinction in lexical representations, or that they have encoded it in a target-like fashion (Hayes-Harb & Masuda, 2008). The major goal of this study was to examine asymmetries in lexical access or lexical encoding for consonants. The case of the Japanese contrast between singleton and geminate obstruents (/p, t, k/) is a good test case because the singleton will likely be a familiar category while the longer geminate consonant will most likely be an unfamiliar category. The degree to which this contrast is merged or separated in learners’ lexical representations has been less extensively explored, but is important in order to understand production difficulties related to this contrast in L2 learners of Japanese. Indeed, learners have been shown to have a good ability to discriminate the contrast in perception – yet they still have difficulties producing this contrast in a native-like way (Hayes-Harb & Masuda, 2008). In the current study, we therefore aimed to examine the degree to which this novel contrast for English L2 learners of Japanese is merged or separated in learners’ lexical representations. An additional goal was to use a method different from eye-tracking to investigate these questions. We used two different categorization tasks (with an ABX design) to establish learners’ ability to perceptually distinguish the two consonant types, accompanied by a lexical decision task.

In addition, little is known about how proficiency level affects the degree of lexical encoding, if any. Thus, this study investigated learners’ perception and lexical encoding of the geminate and non-geminate contrast by means of a categorization and a lexical decision task in learner groups of various proficiency levels.

2. ABX Tasks

2.1. Participants

Three groups, in total 34 participants, were recruited at Indiana University. Two learner groups and one native speaker group were tested (advanced learners: n = 14, 7 males and 7 females, mean age = 21; beginning learners: n = 9, 3 males and 6 females, mean age = 21; native Japanese speakers: n = 11, 4 males and 7 females, mean age = 31). Advanced learners were enrolled either in the second semester of third-year or fourth-year Japanese class, or were teaching Japanese as associate instructors at Indiana University at the time of recruitment. The average length of time spent living in Japan was 17.8 months. Beginning learners were enrolled in the second semester of first-year Japanese class and none of them lived in Japan. All participants in the advanced learners and beginning learners groups were native English speakers learning Japanese as their L2 since English does not have a phonemic length contrast. None of the participants reported any hearing or speech impairment.

Participants were first tested on two discrimination tasks (ABX) and then on the lexical decision task. Stimuli for all tasks were recorded using only one voice (a female, Tokyo dialect speaker recorded in a sound-isolated booth), in order to verify that learners were able to perceptually discriminate short from long consonants at least in the speaker who also produced the lexical decision tokens. This decision also contributed to reduce participants’ cognitive load during the testing, thereby also increasing the likelihood for any lexical encoding of these differences to become measurable.

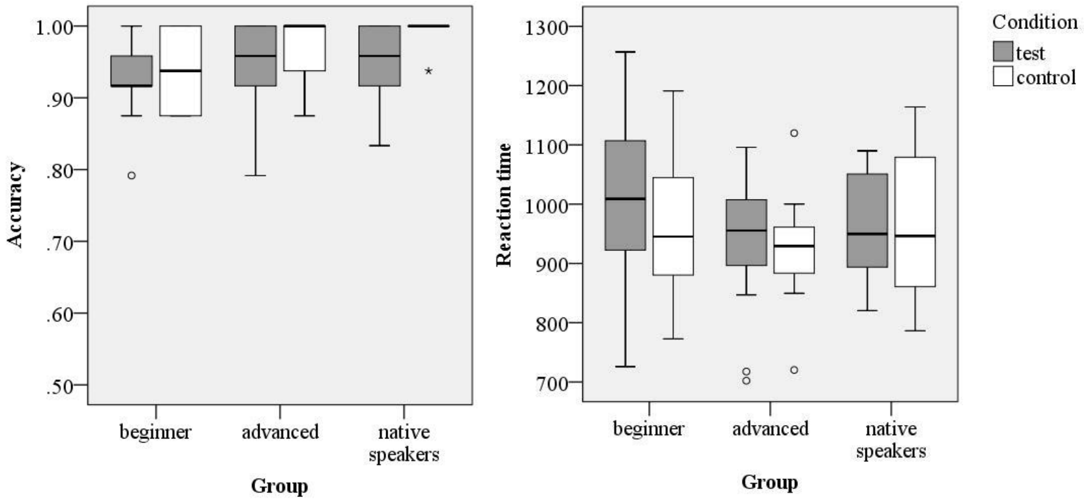
2.2. Materials and Procedures

An ABX task is a discrimination task used in L2 studies where a triplet of stimuli is presented and subjects are asked to determine whether the last stimulus they heard is more similar to the first or the second one. The participants started with a “classical” ABX task, using the geminate and non-geminate contrast. This task probed whether learners are able to distinguish the contrast. We refer to it as *ABX-using length*. Accuracy and reaction times were recorded. Participants were asked to listen to a triplet of stimuli consisting of non-words and decide whether the last stimulus they heard (X, e.g., *mete*) was the same as the first one (A, e.g., *mette*) or the second one (B, e.g., *mete*). The expected answer here was X = B. On the contrary, control stimuli differed in vowel quality; since Japanese only has five vowels and all of them are shared in the learners’ vowel inventory, we assumed learners would have higher accuracy compared to the test items. For instance, the participants heard a triplet such as *moke, moki,* and *moke* and had to decide whether the last one (*moke*) was similar to the first one (*moke*) or the second one (*moki*); the expected answer here was X = A. Participants went through 48 sets of test stimuli and 16 sets of control stimuli, 72 triplets in total, preceded by 8 practice sets with feedback. Stimuli were recorded at a sampling rate of 44,100 Hz at 16 bits and the 72 trials were strictly randomized. As mentioned, each trial consisted of three stimuli (A, B, and X) separated by 500 ms inter-stimulus interval (ISI). Presentation of stimuli sets was controlled by DMDX software (Forster & Forster, 2003). Four experimental blocks were constructed and randomization of and within a block was controlled by DMDX; each block had 12 test triplets and 4 control triplets with all possible orders of items (e.g., ABA, ABB, BAA, and BAB). The participants were asked to push the left ALT key when the third item was more similar to the first one, whereas they hit the right ALT key when they thought the third one was more similar to the second one. The participants were allowed to take breaks for as long as they wanted between the blocks.

The second ABX task was adapted from the methodology used in Dupoux, Pallier, Sebastián-Gallés, and Mehler (1997, Experiment 2). Participants were asked to ignore length, whereas participants were asked to ignore accent in Dupoux et al. (1997). We refer to this second task as *ABX-ignoring length*. The task was designed to see whether learners automatically attend to the geminate and non-geminate distinction in comparison with the native speakers’ performance. It was predicted that this task would be difficult for native speakers since they automatically pay attention to the distinction but they have to ignore it in this task. While the first ABX task was focusing on learners’ discriminatory abilities regarding the geminate and non-geminate distinction, the second task was focusing on how close their response patterns were to native speakers’. As was the case in the *ABX-using length* task, the participants were asked to listen to sets of triplets of stimuli (ISI = 500 ms) and press corresponding buttons. The test triplets differed from the *ABX-using length* task in that they differed in vowel quality in addition to the geminate and non-geminate contrast (e.g., *kepa, keppo,* and *keppa*) and *kepa* and *keppa* would be the same if and only if the participants successfully ignore the length. It would be plausible that native speakers would answer that *keppo* and *keppa* are similar despite the difference in vowel quality, since the length is the same. As was the case in the *ABX-using length* task, the control stimuli only differed in vowel quality and the participants heard a triplet such as *moke, moki,* and *moke* and decided whether the last one (i.e., *moke*) was more similar to the first one (i.e., *moke*) or the second one (i.e., *moki*). In this task, there were 48 sets of test trials and 16 control sets preceded by 12 practice sets with feedback. All the procedures were the same as for the *ABX-using length*. We assumed that the task would be harder for native speakers while the difficulty level for a learner would depend on how automatically they attend to the distinction. In other words, if the learner’s encoding was the same as the native speaker’s, the task would be difficult.

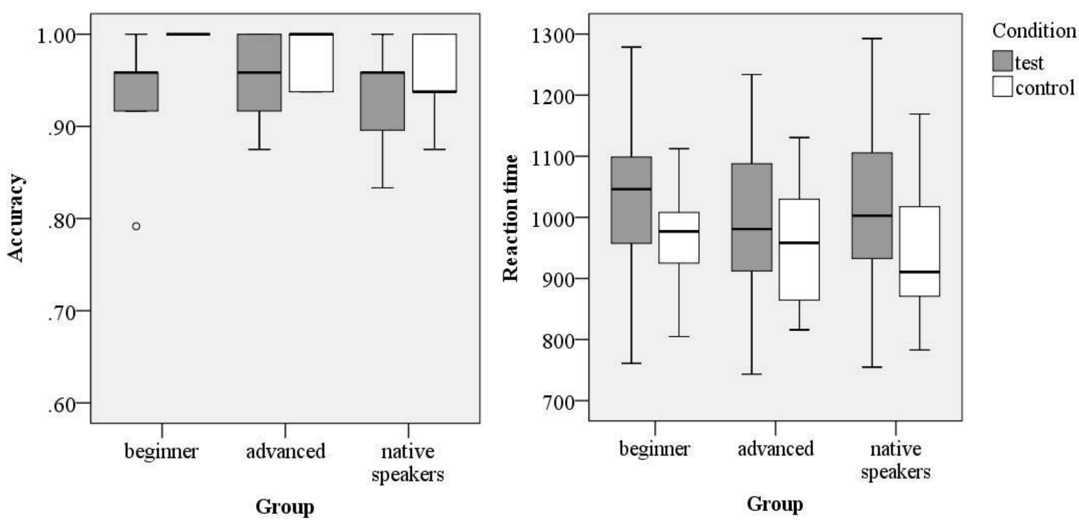
2.3. Results

Figure 1 shows the mean accuracy for the *ABX-using length* task. An ANOVA showed that there was an effect of group ($F(2, 90) = 5.6$, $p < .01$) and an effect of condition ($F(1, 90) = 5.2$, $p < .05$) on mean accuracy, but the interaction was not significant ($F < .1$). As can be seen in Figure 1, the accuracy was very high in all groups, even for the beginning learners (i.e., above 90%).



Figures 1 and 2**:** Mean accuracy (left) and reaction time (right) for the *ABX-using length* task on the test and control conditions in the three groups.

In addition, Figure 2 shows the mean reaction time for the *ABX-using length* task. An ANOVA run on reaction times showed that there was no effect of group ($F(1, 90) = 1.7$, $p > .1$), no effect of condition ($F < 1$), and the interaction was not significant ($F < 1$). That is, reaction times did not differ between learners and native speakers regardless of the stimuli type (i.e., test or control) in all three groups. These results indicate that learners can discriminate the geminate and non-geminate contrast, even at the beginning level, with high accuracy, closely resembling native speakers' performance. Figures 3 and 4 show the mean accuracy rates and reaction times for the *ABX-ignoring length* task. An ANOVA run on accuracy means found a significant effect of condition ($F(2, 90) = 12.2$, $p < .01$). Overall accuracy was slightly higher in the control condition (97%) than in the test condition (94%). However, there was no effect of group ($F(1, 90) = 1.2$, $p > .1$), and no interaction ($F < 1$).



Figures 3 and 4**:** Mean accuracy (left) and reaction time (right) for the *ABX-ignoring length* task on the test and control conditions in the three groups.

The same tendencies were found for reaction time as well; an ANOVA revealed that there was a significant effect of condition ($F(1, 96) = 4.0$, $p < .05$) but no effect of group ($F(2, 96) = .29$, $p > .7$) and no significant interaction ($F < 1$). Taking results from two ABX tasks together, we can say that learners are able to discriminate geminate from non-geminate sounds easily, even though they might still process them differently, perhaps less automatically, from native speakers.

3. Lexical decision

3.1. Materials and Procedure

The third task was a lexical decision task where participants had to decide whether the stimulus they heard was a real Japanese word or not. Test stimuli and control stimuli were either real words or non-words. Among all the stimuli, real Japanese words in this task were used as test stimuli from textbooks for the first-year and second-year students called *Genki I* and *Genki II* (Banno, Ohno, Sakane, & Shinagawa, 1999). In terms of the learning backgrounds of learners, most of the participants in the learner groups had taken Japanese courses at the same university, except for a limited number of people who tested out by a placement test. Since all three groups were given the same set of lexical decision items, using words from the textbooks made it possible to increase the likelihood that the words were familiar to the participants, according to their proficiency level (i.e., advanced learners group should be more familiar with the words that are used in the task). This gave us maximum control of the variables. However, we could not control word frequency. As for the test words, the real words with either a singleton (e.g., *akeru* “to open”) or geminate (e.g., *kippu* “ticket”) were used as test stimuli while test non-words with either a singleton or geminate were constructed out of the real words (see Table 1). For instance a non-word stimulus with geminate *akkeru* was made from the real word *akeru* “to open” whereas a non-word stimulus with the singleton *kipu* was made from the real word *kippu* “ticket”. The word size of the real words varied from two to five morae. Thus, the corresponding non-words varied from two to six morae. Real words and non-words were also used for control stimuli. However, the non-word control stimuli were made by changing a feature or a segment and they did not include a geminate. There were 84 test items (42 singletons and 42 geminates) and 168 fillers, resulting in a total of 252 stimuli items which were divided into two experimental blocks. Participants had 2200 ms to make their response, before the next trial was initiated. Participants were allowed to take a break for as long as they wanted between those blocks before moving on to the next one. Randomization by blocks and by items was controlled by the DMDX software and accuracy and response times were recorded.

Table 1. Construction of test and control words and non-words.

	Test Word Singleton	Test Word Geminate	Test Non-word Singleton	Test Non-word Geminate	Control Word	Control Non-word
Example	*akeru*	*kippu*	*kipu*	*akkeru*	*tenki*	*tengi*
Gloss	“to open”	“ticket”	N/A	N/A	“weather”	N/A

Commonly, the lexical decision task demands participants to compare the incoming input to stored phonological representations. Hence, having a clear phonological representation of a word is critical to correctly and quickly reject a non-word which is always a possible word (e.g., **akkeru*). All the non-words we developed remained possible Japanese words, and were phonotactically legal. However, when a learner’s L1 does not utilize a certain distinction, such as the length contrast in the current study, the L2 lexical encoding of the distinction might be deficient compared to native speakers, particularly in the earlier stages of the L2 acquisition. Hence, lower accuracy was predicted for beginning learners relative to the advanced learners. Furthermore, evaluating accuracy according to the specific sound (singletons vs. geminates) for non-words vs. words would allow us to uncover any asymmetries in lexical representations.

Weber and Cutler (2004) showed with eye-tracking that fixations for targets containing a dominant category were more selective (i.e., earlier rejections of competitors with a new category) than fixations for targets containing a new category (i.e., later rejections of competitors with a similar category). The asymmetrical pattern suggests that the representation of unfamiliar sounds might be less precise, or “fuzzy”, thereby allowing for more ambiguity in lexical activations. Conversely, representations for familiar sounds (the dominant category) are precise and do not produce as much ambiguity. Indeed, looks to targets containing the dominant category (/ɛ/) were less ambiguous, more selective. Translated into lexical decision patterns, this asymmetry would predict the following pattern:

in order to decide whether a stimulus is a real Japanese word or not, listeners have to already possess a lexical representation for these words. If the phonological form of the word is lexically represented in a precise and unambiguous way, rejecting a non-word will be easier than if the phonological form of the word is fuzzy and ambiguous. Indeed, in this case, a non-word (that is, a near-word, as our stimuli were minimally different from real words) might appear convincing as a potential word and yield a false-alarm "yes" answer in a lexical decision task.

Given that geminate consonants are less familiar to learners, words containing geminate consonants might be represented ambiguously. If lexical representations of words containing a geminate are deficient, non-words containing singletons (which can only be rejected as non-words by comparing the stimulus with stored representations of geminate-words) will be the most difficult to reject and accuracy will be the lowest. Conversely, non-words containing geminates will be easier to reject, since their paired lexical representations for words containing singletons will be precisely encoded. Accuracy on this condition will be higher. A singleton being a familiar category, no ambiguity was expected. For words, the opposite pattern is predicted: words containing singletons will be accepted with higher accuracy than words containing geminates.

3.2. Results

Figure 5 shows the mean accuracy in the lexical decision task for each condition (test vs. control) and lexical status (word vs. non-word). An ANOVA was run on accuracy rates declaring lexical condition (test-word, test-nonword, control-word, control-nonword) and group. There was a significant effect of group ($F(2, 33.0) = 9.9$, $p < .001$), of lexical condition ($F(3, 161) = 25.2$, $p < .001$), and a significant interaction ($F(6, 161) = 10.0$, $p < .001$). Pairwise comparisons showed that the simple effect of condition was significant for the beginner ($F(3, 161) = 10.5$, $p < .001$) and the advanced ($F(3, 161) = 39.0$, $p < .001$) groups, but not for the native speakers ($F < 1$). These results show that native speaker accuracy was stable regardless of the condition (test vs. control) and lexical status (word vs. non-word). By contrast, a learner's lexical decision accuracy seemed to depend on condition (i.e., test or control word) and lexical status (i.e., word vs. non-word). In particular, learners had the lowest accuracy on non-words for the test condition, which included the geminate vs. singleton contrast.

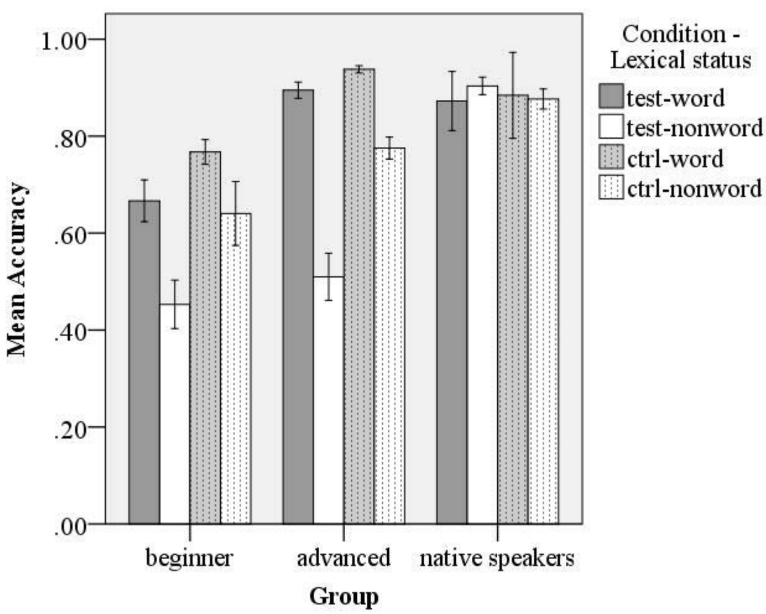


Figure 5. Mean lexical decision accuracy in each condition for each group. Error bars represent +/- 1 standard error.

In order to show that low accuracy stemmed from a difficulty in encoding a non-native distinction (i.e., geminates) in lexical representations for the learner groups, the effect of "sound" (i.e., geminates vs. non-geminates) was considered in its interaction with "lexical status" (words vs. nonwords) in an analysis restricted to each group in turn. These data are represented in Figure 6. An ANOVA declaring the factors sound and lexical status revealed that the interaction between variables on mean accuracy (sound and lexical status) was significant for both learner groups, but not the natives speakers (beginners: $F(1, 24) = 5.9$, $p < .02$; advanced learners: $F(1, 39) = 5.6$, $p < .02$). Clearly, the way native-speakers process input in the lexical decision task is different from the two learner groups. In addition, advanced learner accuracy was higher than that of beginning learners ($F(1, 24) = 4.7$, $p < .04$), implying that the learners' processing patterns were similar but they would gain more accuracy with greater exposure to Japanese.

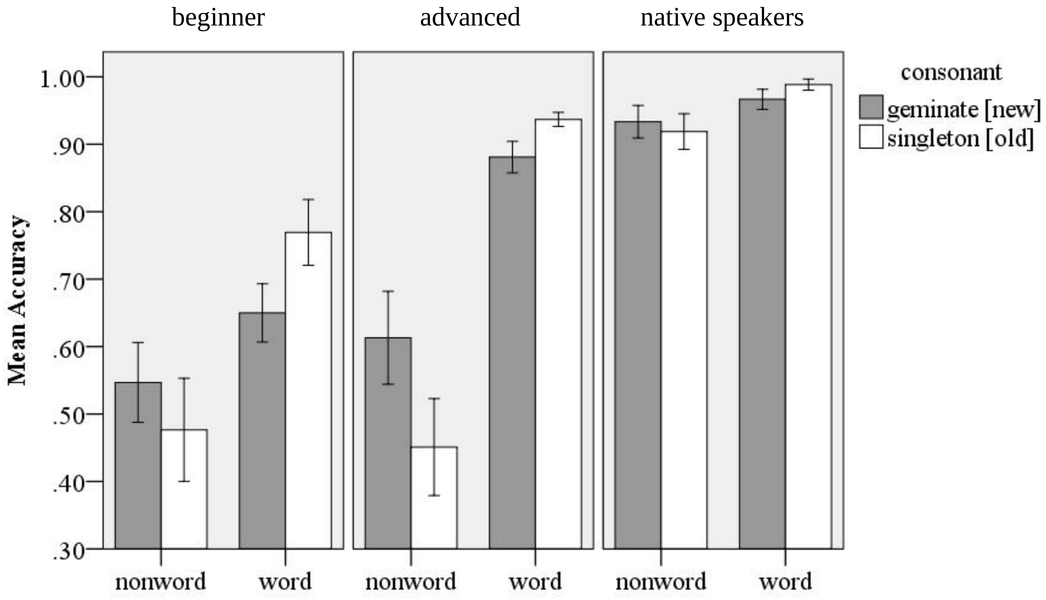


Figure 6. Mean lexical decision accuracy for geminate and non-geminate stimuli as a function of lexical status (word/nonword), for each group. Error bars represent +/- 1 standard error.

The order of accuracy in learners was as follows: word with singleton > word with geminate > non-word with geminate > non-word with singleton. In both learner groups, this is exactly the accuracy pattern that was predicted: words containing singletons were more accurately responded to than words containing geminates (i.e., new category) since singletons were familiar to the learners' phonological inventory (i.e., old category). However, when it came to non-words, the test items containing singletons were the hardest to reject as non-words since learners' stored representations of geminate-words were somewhat deficient. On the contrary, non-words with geminate seemed to be rejected more easily since learners can refer to lexical representations for words containing singletons to reject non-words with geminate (i.e., the words with singleton are properly encoded).

This suggests an interaction between sound (category type) and lexical status which mirrors the asymmetry reported by Cutler et al. (2006) and Weber and Cutler (2004). In the current study, a non-geminate sound can be seen as the dominant category whereas the geminate sound is the non-dominant, or unfamiliar, category. The significant interactions in each group suggest that indeed, lexical encoding for the singleton-geminate contrast in Japanese is asymmetrical. It seems that singleton consonants are the dominant category and are encoded precisely in lexical representations earlier than geminate consonants.

4. General Discussion

In this study, we looked at how learners lexically encode a new contrast that is not in their L1 (i.e., geminates) in comparison with native speaker performance. In the *ABX-using length* task, not only were reaction times for learners the same as the native speakers, but learners could discriminate geminates from non-geminates correctly even at beginning levels. This result corroborates previous findings that learners can discriminate the contrasts with high accuracy (Hardison & Motohashi-Saigo, 2010; Tajima et al., 2008).

In the lexical decision task, words were responded to faster than non-words in reaction times for all three groups, but native speaker reaction times were generally faster than learner latencies. For the mean accuracy on the lexical decision task, it was found that condition did not affect native speaker performance throughout the task, while learners' accuracy was greatly influenced by an interaction of condition and lexical status. In addition, learners exhibited an interaction of sound category (familiar singleton vs. unfamiliar geminate) with lexical status: we observed the lowest accuracy in non-words with singletons for both learner groups. In other words, native speaker response to inputs was symmetric while learner responses were asymmetric in the task. This asymmetric lexical encoding suggests that learners have encoded geminate and non-geminate categories separately. However, the lexical representation of geminate seems to be still somewhat unstable or fuzzy. As Hayes-Harb and Masuda (2008) suggested, the new category might be represented as a target-deviant exemplar of the dominant category.

To conclude, the way non-native speakers lexically encode the distinction is not the same as native speakers. Moreover, the current study as a whole showed that there was a clear dissociation between categorization and lexical encoding. Future research will be needed to investigate whether dominance in the L2 category is only determined by acoustic-phonetic similarity. Also, we observed that the accuracy rates in the lexical decision task for advanced learners were higher than that of beginners. We assume that the length of exposure to the language eventually promotes accuracy, including the ability to lexically encode the new category. However, we are not sure what factors would help in improving lexical encoding. Thus, further studies should investigate what causes phonological updates in the course of L2 learning.

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