

Lexical familiarity and English-language experience affect Japanese adults' perception of /ɪ/ and /I/

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(Received 30 December 1993; revised 29 June 1995; accepted 5 October 1995)

This study assessed the influence of subjective lexical familiarity and English-language experience on Japanese adults' accuracy in identifying singleton word-initial tokens of English /ɪ/ and /I/. The inexperienced Japanese (IJ) subjects had lived in the U.S. for 2 years, whereas the experienced Japanese (EJ) subjects had lived there for 21 years, on average. The native Japanese subjects correctly identified English /ɪ/ and /I/ tokens less often than did a group of native English (NE) subjects, but they did not differ from the NE subjects in identifying the control consonants /w/ and /d/. The NE subjects, who were at ceiling, showed no effect of subjective lexical familiarity. However, the EJ and IJ subjects correctly identified /ɪ/ and /I/ tokens more often in words that were more familiar than their minimal pairs than in words that were *less* familiar than their minimal pairs. The EJ subjects identified liquids more often than did the IJ subjects, but usually less often than the NE subjects. However, the EJ subjects managed to identify /ɪ/ tokens at rates comparable to the NE subjects' rates in words that were matched in subjective familiarity to their minimal pair (experiment 1), and when identifying /ɪ/ tokens that had been edited out of their original word or nonword context (experiment 2). © 1996 Acoustical Society of America.

PACS numbers: 43.71.Hw, 43.71.An, 43.71.Es

INTRODUCTION

As is well known, Japanese speakers who learn English in adulthood often err in perceiving English /ɪ/ and /I/. Their difficulty is not due to auditory limitations (see, e.g., Dooling *et al.*, 1995) but instead follows from the fact that Japanese does not possess liquid consonants like English /ɪ/ and /I/ (Goto, 1971; Dickerson, 1974; Sheldon and Strange, 1982).¹ Japanese speakers' errors in identifying English liquids are apt to persist (see below). However, a recent production study by Flege *et al.* (1995) showed that Japanese adults may eventually overcome errors in producing /ɪ/ and /I/ in words like *read* and *lead*. In that study, 12 inexperienced Japanese (IJ) speakers of English who had lived in the United States for an average of 2 years produced English liquids that were often misidentified and rated as foreign-accented by native English-speaking listeners. However, tokens of /ɪ/ and /I/ spoken by 12 relatively *experienced* Japanese (EJ) subjects who had resided in the U.S. for an average of 21 years were identified correctly. Moreover, liquids spoken by 10 of these subjects received ratings that fell within the range of ratings obtained for native English (NE) speakers. This finding, which held true both for words read from a list and spontaneously spoken words, challenged the widely accepted view that segmental errors in second language (L2) speech production arise inevitably from an inability to learn to produce phonetic segments not found in the native language.

The present study had two aims. One aim was to determine if the EJ subjects, who were more experienced in English than Japanese subjects examined previously,² could *identify* English word-initial English liquids at rates comparable to those observed for NE speakers. Subjects from the Flege *et al.* (1995) study were tested in two identification experiments that made use of minimally paired English words beginning in singleton /ɪ/ and /I/. The second aim of this study was to assess the effect of subjective lexical familiarity on the identification of liquids by the experienced Japanese (EJ) subjects as well as the relatively inexperienced Japanese subjects in group IJ.

Many previous studies have shown that native Japanese subjects who are relatively inexperienced in English (e.g., those in our group IJ) frequently misidentify word-initial English liquids in a two-alternative forced-choice test. Previous studies examining the identification of synthetic continua ranging from /ɪ/ to /I/ (Miyawaki *et al.*, 1975; MacKain *et al.*, 1981; Shimizu and Dantsuji, 1983; Strange and Dittman, 1984)³ have shown that native Japanese subjects often identify continuum end points less consistently than do NE subjects. Other studies have examined the identification of word-initial singleton /ɪ/ and /I/ tokens in words spoken by native English speakers (Goto, 1971; Gillette, 1980; Mochizuki, 1981; Dissoway-Huff, Port, and Pisoni, 1982; Sheldon and Strange, 1982; Shimizu and Dantsuji, 1983; Logan *et al.*, 1991; Yamada *et al.*, 1992; Lively *et al.*, 1993; Nakauchi, 1993; Takagi, 1993; Lively *et al.*, 1994). The relatively inex-

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perienced Japanese subjects⁴ examined in these studies showed bidirectional errors, that is, misidentified /ɪ/ as /I/ and vice versa. Averaged over studies, the overall rate of correct identifications was just 69%.⁵

Two recent studies demonstrated that Japanese speakers who are first exposed to native-produced English in adulthood may have persistent difficulty in identifying English word-initial singleton liquids. Yamada (1993) administered 45 feedback training sessions (each with 272 trials) to Japanese monolinguals. The Japanese subjects made steady progress in identifying English word-initial tokens of /ɪ/ and /I/, but had not reached an asymptote, nor equaled the near-perfect performance of native English speakers, by the end of training.

Lively *et al.* (1994) administered training to Japanese monolinguals in 15 sessions (each with 272 trials) over of a three-week period. Correct identification rates for word-initial /ɪ/ and /I/ tokens increased significantly as a result of the training administered, from about 67% to 78% correct (estimated from their Fig. 1). The subjects, who lived in Japan, had little exposure to English following the training. Despite this, effects of the training were still evident 3 months later, although the percent correct scores had dropped to rates that were slightly below the pretraining rates 6 months after training. The authors suggested that the feedback training increased the native Japanese subjects' correct identification rates by modifying their "selective attention weights." They speculated that Japanese subjects' subsequent drop in performance occurred because of a return of attentional weights to their initial states.

Alternatively (or additionally), Japanese adults may misidentify English liquids because they lack long-term memory representations for English /ɪ/ and/or /I/, or have established representations for one or both liquids that differ from native English speakers' representations (Henley and Sheldon, 1986; Sekiyama and Tohkura, 1993). For certain Japanese adults, English word-initial /ɪ/ and /I/ tokens may be assimilated by a single Japanese consonant category (Best and Strange, 1992). For example, both English /ɪ/ and /I/ may be identified as exemplars of the Japanese /r/ category. If so, one would expect lower percent correct identification scores for native Japanese than NE speakers even if, as discussed below, exemplars of one English liquid category represented a better fit to Japanese /r/ for Japanese/English bilinguals than do exemplars of the other English liquid category (see Takagi, 1993).

Japanese subjects' misidentifications of English liquids might also be attributed in part to lexical factors. Among mature native speakers of English, lexical factors seem to influence the overt identification of consonants only in limited circumstances. For example, Ganong (1980) had NE subjects identify members of a synthetic voice onset time continua. In each continuum, one end point was a word (e.g., *task*) and the other was a nonword (e.g., *dask*). The identification of unambiguous end-point stimuli was not influenced by lexical status, but phoneme boundaries were observed to shift as a function of the lexical status of the end points. This is because ambiguous stimuli near the middle of the continua were more likely to be heard as words than nonwords.⁶

Japanese adults have reported to us that they are often uncertain as to whether English words they have heard began with /ɪ/ or /I/, even in instances where they have correctly identified a word-initial liquid. This led us to consider the possibility that English /ɪ/ and /I/ tokens that are unambiguous for NE speakers might be *ambiguous* for at least some Japanese adults, and thus subject to lexical effects on identification. This hypothesis is consistent with results reported by Yoshida and his colleagues (Lobo and Yoshida, 1982; Yoshida and Hirasaka, 1983; Arai, 1988; Matsumoto, 1989; Yoshida *et al.*, 1988; Yoshida and Seya, 1990), who found that inexperienced Japanese subjects were more likely to misidentify liquids in a nonword that had a real-word minimal pair (e.g., the /I/ in *lun**, which is paired with *run*) than to misidentify liquids found in a real word that is paired with another real word (e.g., the /I/ in *lock*, which is paired with *rock*).

Lexically oriented speech perception research with NE subjects has usually focused on the word versus nonword status of continuum end points. Lexical effects on phoneme identification may be influenced by variations in subjective lexical familiarity, however. For example, Pitt and Samuel (1993) speculated that the relatively small lexical identification shift observed in a study using *duke-tuke* and *doot-toot* continua may have been obtained because *toot* is a relatively "obscure" word.

We hypothesized that Japanese speakers' accuracy in identifying /ɪ/ and /I/ might be influenced by the *relative subjective familiarity* of the two words making up English minimal pairs. In support of this, work by Yoshida and others (cited above) revealed that inexperienced Japanese speakers tended to respond with the more familiar of the two members of a minimal pair when they knew both members of the pair. Yamada *et al.* (1992) observed a significant positive correlation between lexical familiarity ratings and the percentage of correct identifications of English /ɪ/ and /I/ tokens by Japanese subjects who identified English liquids poorly (<80% correct).⁷ The results obtained for certain minimal pairs were quite striking. For example, the Japanese subjects identified /ɪ/ far more often in *red* than *rook* (83% vs 29% correct). The difference might be accounted for by a difference in the subjective familiarity for the subjects of the two words beginning in /ɪ/. (As will be shown below, *red* was probably more familiar to them than was *rook*.) Alternatively, the difference might have arisen because *red* was more familiar than its minimal pair *led*, whereas *rook* was less familiar than its minimal pair *look*.

In summary, one aim of this study was to determine if experienced Japanese (EJ) speakers of English could identify word-initial singleton tokens of English /ɪ/ and /I/ at rates comparable to those observed for NE speakers. Another aim was to assess the effect of subjective lexical familiarity on experienced and inexperienced Japanese subjects' identification of English liquids. Among the English minimal pairs used as stimuli in experiment 1 were pairs consisting of a word and a nonword (e.g., *line* versus *rine**). Other minimal pairs consisted of two words likely to be of similar subjective familiarity to the native Japanese subjects (e.g., *read* versus *lead*), pairs in which the /ɪ/ member was apt to be the

TABLE I. Characteristics of the 12 subjects in each of three groups. Standard deviations are in parentheses.

	Native English		EJ subjects		IJ subjects	
	Mean	Range	Mean	Range	Mean	Range
Chronol. age ^a	36(7)	29–47	44(2)	40–47	35(5)	29–44
Age of arrival ^a	...	...	23(5)	18–32	34(5)	28–42
Residence in U.S. ^a	...	...	21(5)	12–29	2(1)	1–4
Use of English ^b	...	...	6.0(1)	4–7	2.4(1)	1–4

^aMean, in years.

^bEstimated use of English at home, at work, and in social settings on a scale that ranged from “never” (1) to “frequently” (7).

more familiar member (e.g., *room* versus *loom*), and pairs in which the /l/ member was likely to be more familiar (e.g., *look* versus *rook*). We began by having subjects attempt to define, and then to rate for subjective familiarity, all of the English words and nonwords used as stimuli. As expected, the Japanese subjects’ correct identification scores were influenced in experiment 1 by subjective lexical familiarity. In experiment 2, we presented a new set of words and nonwords to subjects, as well as isolated liquids that had been edited out of those words and nonwords. The question of interest here was whether lexical familiarity effects on phoneme identification would disappear for the liquids presented in isolation and, if so, whether the EJ subjects would identify English liquids at rates comparable to those observed for the native English subjects.

I. GENERAL METHOD

Three groups of subjects, each with four males and eight females, participated. One group consisted of monolingual native speakers of American English. Two other groups consisted of native Japanese speakers who had begun to study English in junior high school, but were not massively exposed to native-produced English until arriving in the United States (U.S.) as young adults. The 12 experienced Japanese (EJ) subjects had lived in the U.S. for an average of 21 years, whereas the 12 inexperienced (IJ) subjects had lived there for just 2 years, on average. As summarized in Table I, the EJ subjects were somewhat older than the IJ subjects, had arrived in the U.S. at an earlier age, and reported using English more often on a daily basis. Four EJ subjects, but no IJ subjects, were married to a native speaker of English. Three EJ and two IJ subjects had taken an intensive English course in the U.S.

The 60 items listed in the Appendix, which were all spoken by a male native speaker of American English, served as perceptual stimuli for experiment 1. (The same talker also recorded the words and nonwords used as stimuli in experiment 2.) The stimulus set included 19 minimal pairs beginning in /ɪ/ and /l/, and four /ɪ/-/l/ pairs made up of one word and one nonword (*line-rine**, *luck-ruck**, *wreck-leck**, *run-lun**). Two of the items referred to here as “nonwords,” *ruck** and *leck**, are actually very rare English words. However, inasmuch as neither the native nor the nonnative subjects were likely to know these items, use of the term “nonword” was deemed appropriate. Also, an item such as *rine* would be considered a word if spelled differently (i.e., as “Rhine”), However, given that the stimuli were presented

both auditorily and orthographically (see below), use of the term “nonword” seemed appropriate in such instances as well. Also included in the stimulus set were seven words each beginning in /w/ and /d/ (see the Appendix). These words served as controls. We expected the Japanese subjects to correctly identify English /w/ and /d/ at high rates because Japanese has /w/ and /d/ phonemes.

The 60 stimulus items were recorded (Marantz model PMD420) in isolation in a sound booth. Each was produced with a falling F0 contour. The stimuli were later low-pass filtered (9 kHz), digitized at a 20-kHz sampling rate, and normalized for peak intensity. As described below, they were recorded in random order on audio tapes for later off-line presentation. Prior to participating in experiment 1, the subjects participated in a lexical definition/familiarity rating task, which will be described below. All subjects were tested individually in a quiet room on the campus of the University of California—Irvine by a single experimenter (NT). The subjects responded to all three tasks using a specially prepared answer sheet.

II. LEXICAL TASK

The 46 words and nonwords with /ɪ/ and /l/ appeared in pseudorandom order on a written form. The 36 subjects were asked to define, if possible, each of the items beginning in /ɪ/ and /l/, then to rate the words they knew for subjective familiarity. Three possible definitions were given below each real word on the list. One was the correct definition (e.g., “street or avenue” for *road*), one was an incorrect definition (e.g., “a duck”), and one defined a minimal pair of the target word (e.g., “something to be carried; a burden,” a definition of the word *load*). Three definitions were also offered for each nonword: The definition of its (real) minimal pair plus two other incorrect definitions. Subjects were informed that some items were not real words. The two other response alternatives offered for each word and nonword were “not sure of meaning” and “never heard or read.”

As mentioned earlier, the items to be defined were presented both auditorily and orthographically. The subjects were given a written form that listed all of the stimulus items with /ɪ/ and /l/. The stimuli were presented via headphones, one at a time, in the same order in which they appeared on the written form. After each item was presented auditorily, the experimenter paused the tape recorder. This provided time for the subjects to respond. The subjects checked one of the five written response alternatives described above. If they thought they knew the meaning of the item they had just

heard (i.e., selected one of the three definitions), they then rated the item's subjective familiarity using a scale that ranged from "never heard or said" (1) to "very often heard and said" (7). The experimenter then released the pause button of the tape recorder, which initiated the next trial.

The EJ and IJ subjects seldom chose an incorrect definition for the English words (4.5% and 3.2% of instances, respectively). These are low rates when one considers that one of the two incorrect definitions offered for each word was the definition of its minimal pair (e.g., "a part of a house or dwelling" for the word *loom*). The EJ subjects correctly defined more of the 21 English words beginning in /l/ than did the IJ subjects (93% vs 82%), and more of the 21 words beginning in /ɹ/ (90% vs 69%). Both groups correctly defined more words beginning in /l/ than /ɹ/. If non-natives are biased to choose a known word rather than an unknown minimally paired word when uncertain in regard to segmental phonetic identity, one would expect more correct identifications of /l/ than /ɹ/. However, as will be shown below, both Japanese groups correctly identified /ɹ/ tokens more often than /l/ tokens.

The NE and native Japanese subjects responded somewhat differently to the four nonwords (*rine**, *ruck**, *leck**, *lun**), which did not have a "correct" definition. The native Japanese subjects in groups EJ and IJ gave more incorrect definitions for these items than did the NE subjects (35% vs 2%). Yoshida and Hirasaka (1983) suggested that native Japanese speakers may misidentify English nonwords as words based on orthographic rather than semantic or phonological similarity to known words. The NE and native Japanese subjects said they were "unsure" of the definition of the nonwords in about the same percentage of instances (27% versus 25%). However, the NE subjects correctly indicated that they had "never heard" the nonwords more often than did the Japanese subjects (71% vs 40%). In sum, it appears that the NE subject had greater lexical knowledge of the English words used as stimuli, including greater certainty that the nonwords were not part of the English lexicon.

The subjective familiarity ratings obtained for the subjects in groups EJ and IJ were correlated with the NE subjects' ratings [Spearman $r=0.90$ and 0.92 , respectively] and with one another [$r=0.94$]. To assess between-group differences in subjective lexical familiarity, we computed the mean familiarity of words beginning in /ɹ/ and /l/ for each subject.⁸ The means were submitted to a mixed-design group (NE, EJ, IJ) × consonant (/ɹ/, /l/) ANOVA, which yielded a significant main effect of group [$F(2,66)=7.0$, $p<0.01$]. The consonant effect [$F(1,66)=0.72$] and the two-way interaction [$F(2,66)=0.06$] were nonsignificant ($p>0.10$). A Tukey's HSD test revealed that the ratings obtained for the NE and EJ subjects ($M=5.0$ for both groups) did not differ significantly, but that the English words were significantly more familiar for the subjects in both of these groups than for the IJ subjects ($M=3.8$) ($p<0.05$).

III. EXPERIMENT 1

This experiment examined the rate at which subjects in the three groups correctly identified the initial consonant in English words beginning in /ɹ/, /l/, /w/, and /d/. One aim was

to assess the effect of subjective lexical familiarity (see above) on the percent correct scores. Another was to assess the difference between the NE subjects and the two groups of Japanese subjects.

A. Method

The 60 words and nonwords described earlier were randomly presented at a comfortable level two times each via headphones. The subjects were told to focus their attention on the initial consonant in each word, and to circle one of four choices on an answer sheet ("r", "l", "w", or "d") depending on what they heard. The intertrial interval was 3.2 s. The subjects were reminded that some items were not real words, and were told to guess if unsure.

B. Results and discussion

Figure 1 shows the percent correct identification scores obtained for the four English consonants. The subjects in all three groups, including the Japanese subjects, correctly identified the /w/ and /d/ tokens at high rates (>97%). This was expected because Japanese has /w/ and /d/ phonemes (Sekiyama and Tohkura, 1993). The NE subjects identified both English liquids in 100% of instances. However, lower percent correct scores were obtained for the EJ and IJ subjects for /ɹ/ (92% and 76% correct, respectively) and /l/ (77%, 63%). The results for the IJ subjects agree closely with those obtained previously for subjects with roughly comparable English-language experience (see the Introduction). On the other hand, the percent correct scores obtained from the EJ subjects, at least those for /ɹ/, were higher than those previously reported, apparently because the EJ subjects had far more experience in English than most if not all Japanese subjects examined previously.

The native Japanese subjects confused /ɹ/ and /l/. That is, they misidentified /l/ tokens as /ɹ/, and /ɹ/ tokens as /l/. However, they seldom misidentified /ɹ/ as /w/ (3.2% of instances) or /l/ as /w/ (1.4%). This may mean that English /ɹ/ and /l/, at least word-initial tokens spoken by certain talkers, are not identified by Japanese/English bilinguals as realiza-

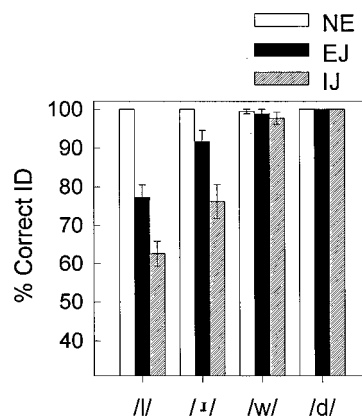


FIG. 1. Mean percent correct identification of /l/, /ɹ/, /w/, and /d/ tokens by the native English (NE), experienced Japanese (EJ), and inexperienced Japanese (IJ) subjects. The error bars in this and following figures bracket ± 1.0 SE.

tions of Japanese /w/, as suggested by Best and Strange (1992). This conclusion agrees with the results obtained by Takagi (1993), who found that English /ɹ/ and /l/ are not similar perceptually to Japanese /w/ for native Japanese subjects living in the U.S.⁹

As mentioned earlier, the NE subjects never misidentified /ɹ/ or /l/, and so their data could not be included in ANOVAs. The percentage of times that each Japanese subject identified /ɹ/ and /l/ was calculated based on 46 judgments of both liquids (23 words or nonwords × 2 replicate judgments). After arcsine transformation (Kirk, 1968), the EJ and IJ subjects' scores were submitted to a mixed-design group × consonant ANOVA. The percent correct scores were significantly higher for the EJ than IJ subjects [$F(1,22) = 14.8, p < 0.01$], and significantly higher for /ɹ/ than /l/ [$F(1,22) = 27.1, p < 0.01$]. The lack of a significant two-way interaction [$F(1,22) = 0.60, p > 0.10$] indicated that the differing rates for the two liquids were similar for both Japanese groups.

The results presented thus far suggest that the EJ subjects identified English liquids more accurately than did the IJ subjects, but were less accurate in doing so than the NE speakers, especially for /l/. The question pursued in the remainder of this section is whether the EJ and IJ subjects' errors were evenly distributed across all of the minimal pairs examined. More specifically, we were interested in testing the hypothesis that the native Japanese subjects' error rates were influenced by subjective lexical familiarity.

We calculated the average familiarity ratings given by the 24 native Japanese subjects to each of the 46 words and nonwords. The 23 minimal pairs (see the Appendix) were then rank ordered according to the difference in ratings accorded the /ɹ/ and /l/ members of the pairs. Based on these rankings, three sets of words beginning in /ɹ/ were defined. These sets were defined on the basis of the familiarity of the /ɹ/ words within the set *vis-à-vis* minimally paired words beginning in /l/. Items in the "positive" set (*rim, road, ride, root, red, wreck, room, run*) had a mean rating of 5.7. They were all more familiar than minimally paired items beginning in /l/ (viz., *limb, load, lied, loot, led, leek*, loom, lun**), which received a mean rating of 2.4. Items in the "neutral" set (*rot, rate, rack, ray, right, rock, read; M = 5.1*) were of roughly equal familiarity as their /l/ minimal pairs (*lot, late, lack, lay, light, lock; lead, M = 5.5*). Finally, words in the "negative" set (*ruck*, rook, rine*, rake, reek, reef, rip, row; M = 1.9*) received lower average subjective ratings than did their minimal pairs (*luck, look, line, lake, leak, leaf, lip, low; M = 6.0*).

Mean percent correct identification scores were calculated for the three sets of /ɹ/ words and nonwords. Similarly, percent correct scores were calculated for the three sets of items beginning in /l/. These sets consisted of the minimal pairs of the three sets of /ɹ/-initial items described earlier. The three /l/ sets will be referred to as the "negative," "neutral," and "positive" sets, respectively. It is important to note that items making up the "negative" /l/ set were less familiar than minimally paired words beginning in /ɹ/ (which defined the "positive" /ɹ/ set). And, items making up the "positive"

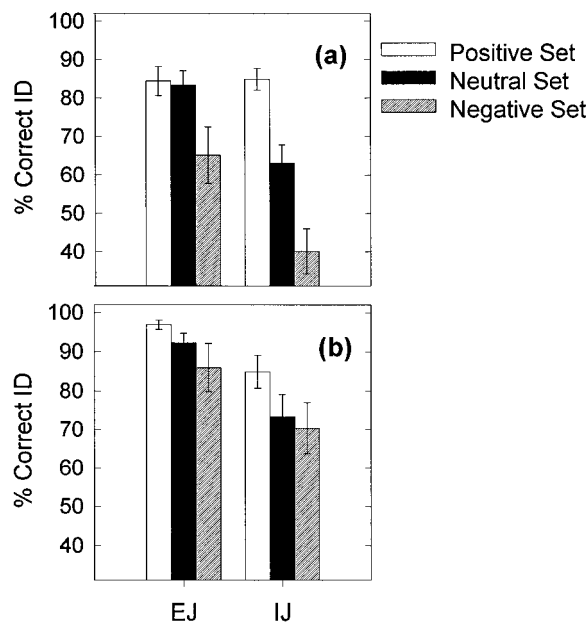


FIG. 2. Mean percent correct identification of English /l/ tokens (a) and /ɹ/ tokens (b) by experienced Japanese (EJ) and inexperienced Japanese (IJ) subjects in sets of words and nonwords that were more familiar than their minimal pairs ("positive set"), equally familiar ("neutral set"), or less familiar ("negative set").

/l/ set were more familiar than the paired words beginning in /ɹ/ (which defined the "negative" /ɹ/ set).

Three predictions were derived from the hypothesis that nonnatives' judgments of ambiguous L2 consonants are influenced by the relative familiarity of the two words making up minimal pairs. These predictions were based on the assumption that even clearly produced English liquids may be ambiguous to certain native Japanese subjects who, under these circumstances, will tend to respond with the more familiar of the two words in a minimal pair (at least in the unspeeded two-alternative forced choice used in the present study). Prediction No. 1 was that the percent correct identification scores would be higher for words in the positive than neutral sets, which in turn would receive higher scores than words in the negative sets. The second prediction was based on the assumption that English liquids would be more ambiguous for the IJ than EJ subjects because the EJ subjects had spoken English far longer in the U.S. than had the IJ subjects (21 vs 2 years). Prediction No. 2 was that the effect of relative lexical familiarity would be greater for the IJ than EJ subjects. Finally, the Japanese subjects identified /l/s less often than /ɹ/s, which suggested that the English /l/ tokens may have been more ambiguous for them than the /ɹ/ tokens. This led to the prediction that the effect of relative lexical familiarity would be greater for /l/ than /ɹ/. The three predictions were tested by submitting the six mean percent correct scores obtained for each subject to a group (EJ, IJ) × consonant (/l/, /ɹ/) × relative familiarity (positive versus neutral versus negative sets) ANOVA, with repeated measures on the last two factors.

Figure 2 shows the percent correct scores for /l/ (top panel) and /ɹ/ (bottom panel). Averaged over the two liquids and two groups, percent correct identification scores in the

positive, neutral, and negative sets were 88%, 78%, and 65%, respectively. These differences resulted in a significant main effect of relative familiarity [$F(1,22)=14.8, p<0.01$]. A Tukey's test revealed that scores were significantly higher for words in the positive than neutral sets, and significantly higher in the neutral than negative sets ($p<0.05$).

The difference between the positive and negative sets was twice as large for the IJ subjects (85% vs 55%) as for the EJ subjects (91% vs 76%). The prediction that the relative familiarity effects would be significantly greater for the IJ than EJ subjects was supported by a significant group \times relative familiarity interaction [$F(2,44)=3.37, p<0.05$]. Tests of simple main effects revealed that percent correct scores were higher for the EJ than IJ subjects in the negative (76% vs 55%) and neutral sets (88% vs 68%; $p<0.05$) but not in the positive sets (91% vs 85%; $p>0.10$).

Given that our subjects participated in an unsped task, the lexical familiarity effects seen here may represent postperceptual lexical biases (see Pitt and Samuel, 1993, for review). We speculate that the EJ subjects had a more adequate (although not necessarily nativelike) representation for English liquids in long-term memory than did the IJ subjects. If so, this may have permitted them to resist postperceptual biasing effects to a greater extent than the IJ subjects.

Finally, the difference between the positive and negative sets was greater for /l/ (85% vs 53%) than /ɹ/ (91% vs 78% correct). The prediction that the lexical familiarity effect would be greater for /l/ than /ɹ/ was supported by a significant consonant \times relative familiarity interaction [$F(2,44)=3.34, p<0.05$]. Tests of simple main effects revealed that the scores for /ɹ/ were significantly higher than those for /l/ in all three sets ($p<0.05$). The simple effect of relative familiarity was significant for both /l/ and /ɹ/ [$F(2,46)=20.7$ and 6.85 , respectively; $p<0.05$]. However, Tukey's tests revealed that, for /l/, scores were higher in the positive than neutral sets, and higher for the neutral than negative sets. For /ɹ/, on the other hand, the difference between the positive and neutral sets was significant ($p<0.05$) but not the difference between the neutral and negative sets. We interpret these findings as supporting the hypothesis that the Japanese subjects were influenced by the relative subjective familiarity of the two words making up English /ɹ/-/l/ minimal pairs when attempting to identify ambiguous English liquids in a forced-choice test.

The differing magnitude of lexical familiarity effects for the two English liquids, /l/ and /ɹ/, may have been a consequence of differences in the extent to which these liquids resemble the closest Japanese consonant, /r/. Takagi (1993) found that English /l/ was judged by Japanese speakers to be more similar to Japanese /r/ than was English /ɹ/. Perhaps the Japanese subjects were more likely to establish phonetic representations in long-term memory for English /ɹ/ than /l/ (e.g., Flege, 1995), and this made the English /ɹ/ tokens relatively less ambiguous for them.

Another plausible interpretation of the lexical familiarity effects obtained here is that subjects' accuracy in identifying liquids was influenced by the subjective familiarity of the word being identified rather than by the familiarity of the word (or nonword) *vis-à-vis* its minimal pair. The more fa-

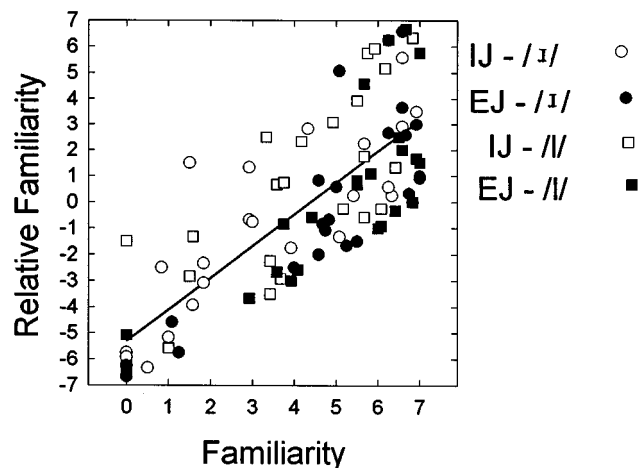


FIG. 3. Relation between the subjective familiarity of words and nonwords and the relative familiarity the same words and nonwords *vis-à-vis* their minimal pairs (see text).

miliar were the English words and nonwords for the two groups of Japanese subjects, the more familiar were these words (nonwords) in relation to their minimal pairs. This relation can be seen in Fig. 3. Plotted on the x axis are the mean familiarity ratings obtained from the EJ and EJ subjects for the 23 words and nonwords beginning in /ɹ/ and the 23 words and nonwords beginning in /l/. The mean ratings obtained for these 92 items ranged from a low of 0 (the rating assigned to items that were not known) to a high of 7. The relative familiarity derived for each item, which is plotted on the y axis, ranged from a low of -7 to a high of $+7$. For example, if an item received a rating of 0 (because it was not known) and its minimal pair received the highest possible rating of 7, then the item's *relative familiarity* was -7 ; and, if a word received a familiarity rating of 7 and its minimal pair received a rating of 0, then the word's relative familiarity was 7.

The correlation between the familiarity ratings obtained from the native Japanese subjects and the relative familiarity ratings derived for the 92 items was fairly strong [Spearman $r=0.75, df=90, p<0.01$]. Thus the lexical effects obtained here might have been due to variations in the familiarity of each word taken individually (see Yamada *et al.*, 1992). In fact, the correlation between the mean familiarity ratings obtained for the 92 items (x axis in Fig. 3) and the percent correct identification scores obtained for those items was quite similar [$r=0.50, df=90$] to the correlation between the 92 derived *relative familiarity* ratings (y axis) and the percent correct scores [$r=0.48, df=90$].

We cannot choose with certainty between the "absolute" and "relative" familiarity interpretations. However, indirect support for the hypothesis that relative familiarity is more important than individual lexical familiarity comes from two studies which provided percent correct identification scores for /ɹ/'s and /l/'s found in the initial position of words and nonwords (Yoshida and Hirasaka, 1983; Lively *et al.*, 1993). If the identification of English liquids increases as a function of individual lexical familiarity, then one would expect higher scores for words than nonwords. However, neither

TABLE II. The number (maximum=24) and percentage of times that liquids in three minimal pairs were identified correct by experienced (EJ) and inexperienced Japanese (IJ) speakers of English. Members of these minimal pairs were equally familiar to the Japanese subjects.

	EJ	IJ		EJ	IJ
rock	23(96%)	22(92%)	lock	21(87%)	13(54%)
right	22(92%)	21(87%)	light	19(79%)	12(50%)
read	24(100%)	20(83%)	lead	18(75%)	13(54%)
	$M=23(96\%)$	21(87%)		$M=19(81\%)$	13(53%)

study yielded a significant word versus nonword difference.

Other evidence in support of our preferred interpretation (viz., that relative familiarity is what matters in an unsped two-alternative forced-choice test) comes from a *post-hoc* analysis of the experiment 1 data. Inspection of Fig. 3 reveals that a wide range of relative familiarity ratings was sometimes evident for stimuli having a single (absolute) familiarity rating. Thus the aim of this analysis was to compare the percent correct scores obtained for sets of items that were matched in terms of familiarity ratings obtained from the native Japanese subjects but differed in terms of the “relative familiarity” ratings that were derived based on the items’ own familiarity and that of their minimal pairs.

We selected 23 pairs of items for the *post-hoc* analysis, 10 of which began in /ɹ/ and 13 of which began in /l/. (Eleven were for the EJ subjects, and 12 were for the IJ subjects.) The items in one set had higher relative familiarity than did the items in the other set [$M=3.6$ vs -0.4 ; $F(1,44)=45.6$, $p<0.01$], but the familiarity ratings of items in the two sets did not differ significantly [$M=5.3$ vs 5.4 , $F(1,44)=0.11$]. Despite this, items in the relatively familiar set were correctly identified significantly more often than were items in the relatively unfamiliar set [86% vs 76%, $F(1,44)=6.8$, $p=0.012$]. From this, one might conclude that liquids are identified more often when they occur in items that are relatively familiar in comparison to their minimal pair, even when what might be called “absolute” subjective familiarity is held constant.

Given our interpretation of the lexical effects, we felt it worthwhile to examine separately the scores obtained for the three minimal pairs which were balanced most closely in terms of subjective familiarity for the Japanese subjects. These pairs were *rock-lock*, *right-light*, and *read-lead*. The percent correct identification scores for liquids in these pairs are presented in Table II. The EJ and IJ subjects identified /ɹ/ more often in these pairs (96% and 87%, respectively) than /l/ (81% vs 53%). Inspection of these mean values suggests that, when not influenced by lexical familiarity, Japanese subjects who are highly experienced in English may be able to identify English /ɹ/ but not /l/ at rates that are comparable to those observed for NE speakers.

IV. EXPERIMENT 2

The rate at which the native Japanese subjects identified /ɹ/ and /l/ tokens in experiment 1 was influenced by subjective lexical familiarity. The aim of this experiment was to assess identification by the same subjects of /ɹ/ and /l/ in eight additional minimal pairs, all of which consisted of one

word and one nonword. Members of the eight pairs were randomly presented in two conditions. In the “whole-word” condition, the words and nonwords were presented without modification. In the “edited” condition, the initial liquids were edited out of their original word or nonword context and presented in isolation. We expected strong lexical effects to be evident in the whole-word but not the edited condition. Our primary interest was in assessing the native Japanese subjects’ identification of liquids in the edited condition, where lexical effects were unlikely to influence phonetic judgments postperceptually.

A. Method

Of the eight minimal pairs used as stimuli here, four consisted of a real word beginning in /l/ and a nonword beginning in /ɹ/ (viz., *rike*-like*, *roose*-loose*, *rone*-lone*, *ret*-let*), and the other four consisted of a real word with /ɹ/ and a nonword beginning in /l/ (*ripe-lipe**, *roof-loof**, *wrote-lote**, *wreck-leck**). The 16 items were low-pass filtered at 9.0 kHz, digitized at 20 kHz, and normalized for peak intensity. Initial liquids were removed from copies of the 16 digitized stimuli at the Department of Biocommunication in Birmingham, Alabama using the following procedure. A Kay Computerized Speech Lab (CSL) was used to display each waveform. Successively smaller portions of each stimulus were played by moving a cursor one glottal pulse at a time to the left (i.e., toward the beginning of the word or nonword). We removed as much of the waveform as possible without altering the perceived phonetic quality of the initial liquid. The resulting waveforms sounded like a liquid followed by a very short /ə/ or /ʌ/-quality vowel. The editing procedure shortened the original stimuli from an average duration of 269 ms (s.d.=31) to just 90 ms (s.d.=17).

The order of the two conditions (whole-word, edited) was counterbalanced across the subjects in each group. The 16 stimuli were randomly presented four times each, with an intertrial interval of 3.5 s. The subjects were told to circle “r” or “l” on an answer sheet, depending on what they heard, and to guess if unsure.

We expected the Japanese subjects to identify liquids correctly more often in words than nonwords in the whole-word condition, but expected no lexical effect in the edited condition. Preliminary analysis confirmed this expectation for /l/. However, the /ɹ/ tokens edited from words were identified significantly more often than those edited from nonwords. This unexpected finding was attributable to a single stimulus, the /ɹ/ edited from *ret**. This token was misidentified far more often than were the /ɹ/ tokens edited from the

other three nonwords beginning in /ɪ/. Subsequent reinspection of the acoustic stimuli revealed that the original *ret** token and the /ɪ/ token edited from it had been corrupted by peak clipping. We therefore excluded from analysis the data obtained for *ret**, the /ɪ/ edited from *ret**, *let*, and the /ɪ/ edited from *let*.

B. Results and discussion

Four percent correct identification scores were obtained for each subject, one each for /ɪ/ and /l/ in the whole-word and edited conditions. Each mean was based on 3 stimuli × 4 presentations = 12 judgments. The NE subjects made no errors identifying liquids in the whole-word condition, and just two errors (<1%) in the edited condition. The results for the whole-word condition suggested that the segmental identity of the English liquids was not ambiguous for the NE subjects, for even the strongest possible biasing context (viz., a contrast between a word and a nonword) did not affect their judgments measurably. The NE subjects' near-perfect performance in the edited condition confirmed that the editing procedure described above did not alter the perceived phonetic identity of the liquids.

Given the lack of variance for the NE subjects, their data could not be included in statistical analyses. A preliminary inspection of the data revealed that one of the EJ subjects who correctly identified /ɪ/ and /l/ tokens at high rates in the whole-word condition had very low scores ($M=17\%$) in the edited condition. This subject appears to have switched labels, so his data were also excluded from analyses. After arcsine transformation, the percent correct scores obtained from the remaining 23 Japanese subjects were submitted to group (EJ, IJ) × consonant × (/ɪ/, /l/) × word status (word, nonword) × condition (whole-word, edited) ANOVA, with repeated measures on the last three factors.

All four main effects were significant [F values ranging from 4.9 to 28.3, with 1 and 21 df 's, $p < 0.05$]. The percent correct scores were higher for the EJ than IJ subjects (87% vs 74%), higher for /ɪ/ than /l/ (86% vs 74%), higher for liquids in the edited than whole-word condition because of lexical effects evident in the whole-word condition (83% vs 77%), and higher for words than nonwords (86% vs 74%). The group factor did not interact significantly with any other factor. However, a significant condition × consonant × word status interaction was obtained [$F(1,21)=10.6$, $p < 0.01$], which is presented in Fig. 4.

Tests of simple main effects revealed the following. In the whole-word condition, the percent correct scores were significantly higher for words than nonwords, both for /l/ (88% vs 57%) and for /ɪ/ (88% vs 75%) [$F(1,34)=20.1$ and 6.3, respectively; $p < 0.05$]. However, scores for isolated liquids edited from words and nonwords did not differ significantly, either for /l/ (78% vs 73%) or /ɪ/ (91% vs 91%) [$F(1,34)=2.71$ and 1.0, respectively; $p > 0.10$]. One source of the three-way interaction appears to have been that scores for /ɪ/ were significantly higher ($p < 0.05$) than those for /l/ in just three of the four possible liquid × word status combinations (edited words, edited nonwords, and nonwords in the whole-word condition).

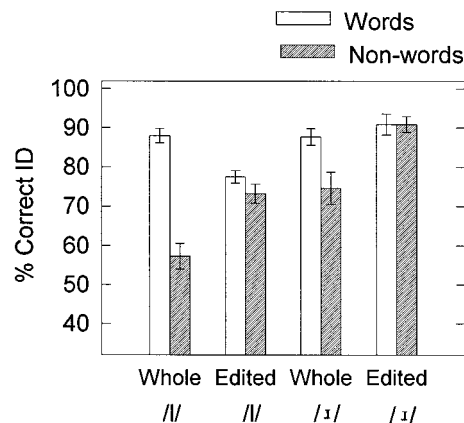


FIG. 4. Mean percent correct identification by 23 Japanese adults of English /ɪ/ and /l/ tokens in unedited words and nonwords presented in the whole-word condition ("W"), and for liquids edited from those words and nonwords and later presented in isolation ("E").

Another source of the three-way interaction may have been differing effects of editing. Tests of the simple main effect of editing were carried out for the four possible liquid × word status combinations. Scores were significantly higher for the /l/ tokens edited from nonwords than for the same /l/ tokens when presented in the whole-word condition (73% vs 57%), and for /ɪ/ tokens edited from nonwords than for the same /ɪ/ tokens in the whole-word condition (91% vs 75%) [$F(1,34)=6.9$, 8.4, $p < 0.01$]. We take this finding to mean that correct identification scores for the two liquids in nonwords were lowered in the whole-word condition as the result of a negative lexical bias. That is, the Japanese subjects were biased to respond with a word that they knew (e.g., *roof*) than with an item that was unfamiliar to them (e.g., *loof*).¹⁰

A different picture emerged, however, for the real-word stimuli. Percent correct scores were significantly *lower* for the /l/ tokens edited from words than for the same /l/ tokens presented in the whole-word condition (78% vs 88%), but there was not a significant difference between responses to /ɪ/ tokens edited from words and the responses given to the same /ɪ/ tokens when presented in the whole-word condition (91% vs 88%) [$F(1,34)=10.1$, $p < 0.01$; $F(1,34)=2.4$, $p > 0.10$]. We take the findings for /l/ to mean that percent correct scores obtained for /l/ tokens in unedited, real words benefited from a positive lexical bias (because they were paired with nonwords beginning in /ɪ/). However, the /ɪ/ tokens in unedited real words did *not* show a positive lexical bias (even though they were paired with nonwords beginning in /l/).

What accounts for the asymmetry between /ɪ/ and /l/? The data presented here do not afford a clear explanation, but we can offer a speculative account based on signal detection theory (e.g., Macmillan and Creelman, 1991). According to a model of nonnative /ɪ/-/l/ perception developed by Takagi (1995), English /ɪ/ and /l/ tokens give rise to distinct one-dimensional sensory distributions for adult Japanese listeners, who label English liquids by setting a response criterion along this dimension. The location of the response criterion

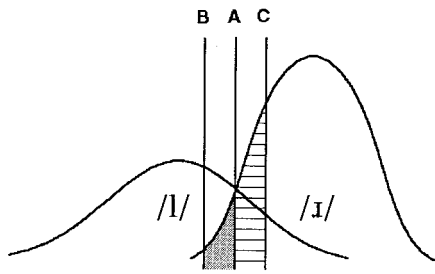


FIG. 5. Illustration of a signal detection theory account of the data obtained in experiment 2.

may vary according to stimulus range (Yamada and Tohkura, 1992), and can be manipulated through instruction (Takagi, 1993, 1995). Assume that the normal sensory distribution for /l/ is broader than the one for /ɪ/, as illustrated in Fig. 5. The vertical lines in Fig. 5 illustrate three possible response criteria that might be used by adult Japanese speakers of English. Sensations associated with tokens falling to the left of a response criterion are labeled /l/, whereas those falling to the right are labeled /ɪ/.

Assume further that Japanese subjects examined in the present study used something like criterion A when identifying liquids in the edited condition, where lexical bias was unlikely. Use of criterion A would lead to higher percent correct identification scores for /ɪ/ than /l/. This is because the area under the /ɪ/ distribution to the right of A is larger than the area under the /l/ distribution to the left of A. This prediction agrees with the data shown in Fig. 4. The Japanese subjects may have adopted a criterion like B in situations where a response bias toward /ɪ/ existed (i.e., when judging the /ɪ/ tokens in words presented in the whole-word condition, or when judging /l/ tokens in nonwords presented in the whole-word condition). Finally, criterion C may have been used when there was a bias toward /l/ responses (i.e., for /l/'s found in words presented in the whole-word condition, or /ɪ/'s in nonwords in the whole-word condition).

Consider first the Japanese subjects' responses to the /ɪ/ tokens. If the Japanese subjects shifted their response criterion from A (no bias) to C (negative bias), then a large decrease in /ɪ/ responses, equivalent to the cross-hatched area under the /ɪ/ curve between A and C in Fig. 5, would be expected. On the other hand, shifting the response criterion from A to B (positive bias) should result in a smaller increase in correct /ɪ/ responses (denoted by the shaded area under the /ɪ/ curve between A and B). In judging /l/'s, on the other hand, a shift from criterion A to C (i.e., positive bias) should result in a small increase in correct /l/ responses (the cross-hatched area under the /l/ curve between A and C), whereas a shift from A to B (negative bias) should result in a small decrease in correct /l/ responses (the shaded area under the /l/ curve between A and B). These expectations conform to the percent correct scores obtained for /ɪ/ and /l/ tokens presented in the whole-word and edited conditions (Fig. 4).

The TSD-inspired account just offered depends crucially on the assumption that, for adult Japanese speakers of English, the normal sensory distribution for /l/ tokens that are

heard is broader than the corresponding distribution for /ɪ/. We cannot offer direct evidence in support of this assumption, but believe it to be plausible. The distributions might differ as just suggested if, for example, Japanese adults tend to identify the English /l/ they hear in terms of their Japanese /ɪ/ category (thereby combining sensations for two distinct phone types), whereas they tend to identify English /ɪ/ tokens in terms of a newly formed English /ɪ/ category, defined just on the basis of their exposures to English /ɪ/ tokens (see Flege, 1988, 1992a, b, 1995). We acknowledge, however, that additional research is needed to test the predictions generated by this account as well as its underlying assumptions.

Our final task is to consider the native Japanese subjects' identification of liquids in the edited condition, where lexical effects were unlikely to influence phonetic judgments post-perceptually. The mean percent correct identification scores for isolated /l/ tokens edited from words and nonwords were 100% and 99% for the NE speakers, 84% and 83% for the 11 EJ subjects, and 72% and 65% for the 12 IJ subjects. Very few individual Japanese subjects identified /l/ tokens as accurately as did the NE subjects. (The numbers of EJ subjects who obtained scores falling within the range of values observed for the NE subjects were 0 and 3 for tokens from words and nonwords, respectively. For IJ subject, the numbers were 0 and 1.)

A different picture emerged for /ɪ/, however. The mean percent correct identification scores obtained for isolated /ɪ/ tokens edited from words and nonwords were 100% and 99% for the NE speakers, 99% and 97% for the EJ subjects, and 84% and 85% for the IJ subjects. The numbers of EJ subjects who obtained scores falling within the range of values observed for the NE subjects were 10 and 11 (out of 11 subjects) for tokens edited from words and nonwords. (The EJ subject whose data were excluded would also have fallen within the NE range had his response labels been switched.) For the IJ subjects, the numbers were 6 and 7 (out of 12 subjects). A consideration of these mean values brings us to the same conclusion drawn from the experiment 1 results: When not influenced postperceptually by lexical factors, highly experienced Japanese speakers of English may be able to identify word-initial singleton tokens of English /ɪ/ but not /l/ at rates that are comparable to those observed for NE speakers.

V. GENERAL DISCUSSION

This study examined the identification of word-initial English consonants by experienced (EJ) and inexperienced Japanese (IJ) speakers of English who had lived in the U.S. for averages of 21 and 2 years, respectively. Both the EJ and IJ subjects identified English /w/ and /d/ tokens at the same near-perfect rates as did a group of native English (NE) subjects. However, both Japanese groups, especially the IJ subjects, identified English /l/ tokens less often than did the NE subjects.

The Japanese subjects also erred in identifying /ɪ/, but with an important difference. On average, the EJ subjects identified English /ɪ/ tokens correctly more often than did the IJ subjects, but less often than the NE subjects. There were two contexts, however, in which the EJ subjects identified /ɪ/

tokens at rates that were comparable to those observed for the NE subjects. The members of the minimal pairs examined in experiment 1 varied in relative familiarity for the Japanese subjects. The EJ subjects made very few errors identifying /ɪ/ in words that were of equal subjective familiarity as minimally paired words beginning in /I/. In fact, many EJ subjects made no errors whatsoever in identifying /ɪ/ tokens in such words. In experiment 2, liquids were edited out of the word (or nonword) in which they had been produced originally. Here, too, the EJ subjects identified /ɪ/ tokens at near-perfect rates that were comparable to those observed for the NE subjects.

We hypothesized that although the naturally produced English liquids used as stimuli were not phonetically ambiguous for the NE subjects (and thus not likely to be influenced by subjective lexical familiarity), they would be ambiguous for at least some of the Japanese subjects. We tested three predictions derived from the hypothesis that the Japanese subjects' identification of English liquids would be influenced by the relative familiarity of the items making up /ɪ/-/I/ minimal pairs. The first prediction was that liquids would be identified correctly more often in a set of words that were more familiar than their minimal pairs (the "positive" set) than in a set of words that were less familiar than their minimal pairs (the "negative" set). The second prediction was that lexical familiarity effects would be larger for the IJ than EJ subjects. (We assumed that English liquids would be more ambiguous phonetically for the IJ than EJ subjects because they were far less experienced in English.) The final prediction was that the lexical familiarity effects would be greater for /I/ than /ɪ/. This followed from the observation that Japanese adults typically identify English /I/ tokens at lower rates than word-initial /ɪ/'s, suggesting that /I/ is more ambiguous for them than /ɪ/. All three predictions were confirmed.

One might hypothesize that variations in the familiarity of individual lexical items, not relative familiarity, were responsible for the lexical effects observed here (Yamada *et al.*, 1992). When a word was judged to be familiar by the Japanese subjects, it also tended to be more familiar than the word to which it was minimally paired. Indeed, familiarity ratings for individual lexical items accounted for about the same amount of variance in the percent correct identification scores as did the (derived) *relative* familiarity ratings. However, indirect support for our preferred interpretation (*viz.*, that the Japanese subjects were influenced by the relative familiarity of members of minimal pairs) came from two sources. First, it appears that Japanese speakers may not identify English liquids at higher rates in words than nonwords (Yoshida and Hirasaka, 1983; Lively *et al.*, 1993). Second, we carried out a *post-hoc* analysis of the experiment 1 results. Two set of items were selected that had the same mean (absolute) subjective familiarity ratings, but differed significantly in terms of relative familiarity. Liquids in the relatively familiar set were identified correctly significantly more often than were liquids in the relatively unfamiliar set.

Additional research will be needed to determine whether or not the lexical effects observed here were due to relative familiarity in minimal pairs. To do so, it will be necessary to

obtain independent ratings of the relative familiarity of the two members of minimal pairs, presented together, as well as separate ratings of the two members making up each minimal pair. Regression analyses could then determine if significantly different amounts of variance in percent correct scores are accounted for by the relative familiarity ratings and the ratings obtained for individual lexical items. An experimental manipulation that could help choose between the two competing interpretations would involve altering the perceived subjective familiarity of one member of selected minimal pairs through written vocabulary training and enrichment. Doing so would alter the relative familiarity of *both* members of each minimal pair while leaving the familiarity of one member unchanged.

The findings for /ɪ/ raise the question of whether the EJ subjects established a phonetic category for English /ɪ/. Lively *et al.* (1993, p. 1242) concluded that "context-sensitive representations" that are "talker-specific" may develop during the course of short-term laboratory feedback training. Flege (1988, 1992a, b, 1995) suggested that even adults may eventually establish new phonetic categories during naturalistic second language (L2) acquisition for certain position-sensitive allophones (or "sounds") found in L2 but not the native language (L1). By hypothesis, the likelihood of category formation increases as a function of the perceived phonetic distance of L2 sounds from the closest L1 sound. Best and Strange (1992) hypothesized, however, that category formation is more likely for L2 sounds identified as "discrepant exemplars" of an L1 category than for L2 sounds judged to be very dissimilar from any sound in the L1. These authors suggested (1992, p. 307) that category formation may lead to a "decline in the degree of assimilation" of L2 sounds by L1 categories.

The identification data presented here are insufficient in themselves to determine whether the EJ subjects did, or did not, establish a phonetic category for English /ɪ/. Additional research will be needed to resolve this question. The categorical discrimination task described by Flege *et al.* (1994) would provide an appropriate perceptual test. In it, subjects identify the serial position of the "odd" item in triads. Three aspects of the task ensure that it tests the grouping of phones into *phonetically relevant* categories: The interval between stimuli is relatively long; the three stimuli in each triad are always spoken by different talkers; and "catch" triads are included that do not contain an odd item. Japanese subjects who have established a phonetic category for /ɪ/ but continue to identify English /I/ tokens in terms of Japanese /ɾ/ would be expected to obtain substantially higher scores on such a discrimination task than would subjects who continue to identify realizations of both English /ɪ/ and /I/ as instances of Japanese /ɾ/.

The speech learning model (SLM) presented by Flege (1995) predicts that category formation will be more likely for younger than older native Japanese learners of English, and that subjects who establish categories for English /ɪ/ will produce this English liquid more accurately than those who do not. Data consistent with this last hypothesis was provided by a recent study which tested for effects of perceptual training on speech production (Yamada *et al.*, 1995). Japa-

nese subjects whose identification of /ɪ/ and /I/ improved as the result of training, but who had received no articulatory training, were judged to produce English liquids more accurately after than before perceptual training. No change in production over the same test interval was observed for control subjects who received neither perception nor production training.

Additional research is needed to determine how, or to what extent, native Japanese subjects' perception of English liquids changes as they gain experience with the English sound system. Flege (1995) hypothesized that the slow process of category formation is initially triggered by the implicit recognition that position-sensitive allophones in the L2 are not realizations of an L1 category. Best and Strange (1992, p. 307) suggested that category formation may result from an "improved recognition of phonetic properties within the L2 phonological system." Similarly, Lively *et al.* (1993, p. 1242) suggested that new categories arise through shifts in selective attention to dimensions that are phonetically relevant in the L2, but were previously unattended to because of a lack of importance in the L1.

Taken together, the results of this study suggest that Japanese adults who learn English naturalistically eventually establish a central phonetic category representation for English /ɪ/, but their representation for /ɪ/ may differ in some way(s) from NE speakers' representations. One possible explanation for the finding that the EJ subjects identified /ɪ/

tokens at very high rates in certain instances, but nevertheless showed lexical familiarity effects, can be derived from the speech learning model (Flege, 1995). The EJ subjects may have begun establishing a category for English /ɪ/ once they recognized that it differed from the closest Japanese category, but based their new /ɪ/ category on a somewhat different ensemble of features (and/or feature weights) than those specified in NE subjects' phonetic category representations for /ɪ/. These and other hypotheses will need to be tested in research using a variety of converging on-line and off-line tasks.

In summary, the present study showed that subjective lexical familiarity influences the accuracy with which adult Japanese speakers of English identify word-initial tokens of English /ɪ/ and /I/. The results suggest that liquids which are unambiguous for NE speakers may be ambiguous for native Japanese speakers. As expected, the experienced Japanese (EJ) subjects identified /I/ tokens more accurately than did a group of relatively inexperienced Japanese (IJ) subjects, but at lower rates than was observed for the NE subjects. The EJ subjects were also more accurate than the IJ subjects in identifying /ɪ/, but often identified /ɪ/ at lower rates than did the NE subjects. An important exception to this were instances in which lexical familiarity effects were unlikely to influence the EJ subjects' phonetic judgments postperceptually.

APPENDIX

TABLE AI. (top) Mean subjective familiarity ratings of English words and nonwords (*) by inexperienced Japanese (IJ), experienced Japanese (EJ), and native English (NE) subjects; (bottom) stimulus items beginning in /w/ and /d/.

	/ɪ/			/I/ initial			
	IJ	EJ	NE	IJ	EJ	NE	
rine*	0.0	0.0	0.0	line	5.8	6.3	5.3
ruck*	0.0	0.0	0.0	luck	5.9	6.7	6.0
rook	0.5	1.3	3.3	look	6.8	7.0	6.9
reek	0.8	1.1	3.7	leak	3.3	5.7	5.2
rake	1.0	4.6	4.8	lake	6.2	6.6	5.8
wreck	1.5	5.1	5.2	leck*	0.0	0.0	0.0
rip	1.6	4.8	5.1	lip	5.5	5.8	5.5
rot	1.8	4.8	5.0	lot	4.2	5.5	4.9
reef	1.8	4.0	4.5	leaf	4.9	6.5	6.0
rim	2.9	4.6	5.1	limb	1.6	3.8	5.4
ray	2.9	5.0	4.3	lay	3.6	4.4	5.8
rack	3.0	4.7	4.5	lack	3.8	5.5	5.2
row	3.9	5.3	4.4	low	5.7	6.9	6.3
root	4.3	6.3	5.3	loot	1.5	3.6	4.5
rate	5.1	5.5	5.7	late	6.4	7.0	6.8
rock	5.4	6.8	6.3	lock	5.2	6.4	6.0
ride	5.7	6.7	6.3	lied	3.4	4.1	5.4
read	6.3	7.0	6.7	lead	5.7	6.1	6.2
run	6.3	6.6	6.3	lun*	0.0	0.0	0.0
right	6.3	6.8	6.4	light	6.1	6.8	6.4
road	6.6	7.0	6.7	load	3.7	6.0	5.2
room	6.6	6.6	6.6	loom	1.0	2.9	3.7
red	6.9	6.9	6.8	led	3.4	3.9	5.3
<i>M</i> =	3.5	4.8	4.9		4.1	5.1	5.1
	(2.4)	(2.2)	(1.8)		(2.1)	(2.0)	(1.8)
	/w/ initial			/d/ initial			
dead	dim	done	date	weed	wine	weak	wide
day	duck	dot		wait	walk	one	

ACKNOWLEDGMENTS

This research was supported by grant DC00257 from the National Institute for Deafness and Other Communicative Disorders. The authors thank Nahoko Takagi for help locating subjects, and Elaina Frieda, Murray Munro, and two anonymous reviewers for their helpful suggestions.

¹The single liquid of Japanese, symbolized as /r/, is often produced as a flap. It differs in articulatory and acoustic terms from the dorsal approximant, sometimes retroflexed English /ɹ/ as well as the lateral continuant English /l/. Japanese /r/ does bear some degree of similarity to both English liquids, however, as revealed by loanword phonology. Both the /r/ and /l/ initiating English words borrowed into Japanese are rendered as /r/ (Lovins, 1976).

²There is a demographic explanation for why highly experienced Japanese subjects have not been examined previously. Very few Japanese citizens emigrate to the U.S. Typically, Japanese speakers who spend time in an English-speaking country for educational or business purposes return to Japan after 2 or 3 years.

³Most of the Japanese subjects tested in these studies had either not lived in an English-speaking environment, or else had done so for less than 6 years (but see Takagi, 1993).

⁴Just two studies (Nakauchi, 1993; Takagi, 1993) included any subject who had lived for more than 8 years in an English-speaking environment.

⁵The values used in calculating this mean were weighted according to the number of subjects and identification trials in the 12 studies cited. On average, the 291 Japanese subjects tested gave 51 identification responses (range=8 to 120) to word-initial singleton liquids. Just four of the 12 studies used words spoken by more than one native English speaker (Goto, 1971; Dissoway-Huff *et al.*, 1982; Sheldon and Strange, 1982; Yamada *et al.*, 1992).

⁶Shifts in the boundary region may be greater when subjects respond slowly than rapidly (Fox, 1984). This suggests that the "lexical identification shift" seen in many studies is the result of a postlexical process. However, many factors influence lexical effects on phoneme identification, and controversy exists as to whether (or to what extent) they are due to the perception of stimulus properties, or decisions made at a later stage of processing (see Pitt and Samuel, 1993, for review).

⁷The correlation for subjects with a low rate of correct identifications disappeared when just the initial consonant-vowel portion of words were presented. No such correlation was obtained for Japanese subjects who identified English liquids at higher overall rates perhaps because, for them, English liquids were not sufficiently ambiguous.

⁸Words that were defined incorrectly or "not known" were assigned a familiarity rating of "0." Those that subjects were "not sure" of were assigned a rating of "1."

⁹Takagi (1993) presented English nonsense words beginning in singleton /r/ and /l/ to inexperienced Japanese speakers of English living in the U.S. The subjects were asked to write the English words using katakana letters. They almost always used the letter for Japanese /rV/ to write English /rV/ and /lV/ syllables. In only 1.7% of instances did they identify English /rV/ syllables with Japanese /w/. In no instance did they do so when hearing nonwords beginning in /lV/.

¹⁰We hesitate to use the term "nonword" here because, as discussed earlier, the native Japanese subjects were less certain as to whether certain stimuli were or were not English words than the NE subjects.

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