Perceptual deletion and asymmetric lexical access in second language learners

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Abstract: French listeners have difficulty perceiving /h/, and as L2 speakers they frequently omit /h/ in English words. This study investigated their processing of English /h/-initial words. Participants performed a lexical decision task on words and nonwords, where the nonwords were created from /h/-initial and vowel-initial words by removing or adding /h/, respectively. The results mirrored the production pattern, with more misses on /h/-initial words (e.g., holiday) and more false alarms on vowel-initial nonwords (e.g., usband). These results are interpreted in light of previous research on asymmetries in L2 lexical access.

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1. Introduction

The phonology of our native language shapes our perception of foreign sounds, often resulting in perceptual distortions. In bilingual speakers such perceptual distortions have a detrimental effect on lexical processing in the non-native language. This was first shown by Pallier *et al.* (2001), who focused on early Spanish-Catalan bilinguals' processing of the Catalan /e/-/ɛ/ contrast. Using a lexical decision task with long-term repetition priming, they found that for these bilinguals, minimal pairs of words based on the /e/-/ɛ/ contrast prime one another; hence, they are treated as homophones. Likewise, in a standard lexical decision task, Spanish-Catalan bilinguals were found to have difficulty rejecting nonwords that are created from real words containing /e/ or /ɛ/ by replacing this vowel with its counterpart (Sebastián-Gallés and Baus, 2005). Similar effects in L2 lexical processing have been reported in studies using these and other paradigms (cross-modal priming, word identification, eye-tracking, semantic relatedness judgment), and focusing on a variety of bilingual populations with various levels of proficiency, including Dutch–English (Weber and Cutler, 2004; Escudero *et al.*, 2008; Broersma and Cutler, 2011; Díaz *et al.*, 2012), Japanese-English (Cutler *et al.*, 2006; Ota *et al.*, 2009), English–Japanese (Darcy *et al.*, 2013), Cantonese–Mandarin (Zhang *et al.*, 2012), and English–German (Barrios *et al.*, 2016).

Many of the above-mentioned studies have reported asymmetries, such that performance is better on one member of the L2 contrast than on the other one (Weber and Cutler, 2004; Escudero *et al.*, 2008; Cutler *et al.*, 2006; Broersma and Cutler, 2011; Díaz *et al.*, 2012; Darcy *et al.*, 2013; Zhang *et al.*, 2012; Barrios *et al.*, 2016). For instance, Weber and Cutler (2004) examined Dutch–English bilinguals using eye-tracking with a visual world paradigm. Given the target *panda* (containing the vowel /æ/, which does not exist in Dutch), a distractor picture of a pencil (containing the vowel /ɛ/) received longer fixations than unrelated distractors; the same did not hold when a picture of a panda was presented as a distractor for target *pencil*. Weber and Cutler (2004) argued that the /ɛ/-/æ/ contrast is maintained in lexical representations but that whichever member is heard in the input, only words containing /ɛ/ are initially activated, due to inaccurate phonetic perception. Thus, /ɛ/ is said to be the active category, presumably because Dutch has a vowel /ɛ/ but not /æ/. By contrast, Darcy *et al.* (2013) argued that perception is accurate but that the phonological representations of words containing the difficult category are—as they call it—fuzzy, i.e., imprecise. They tested American English learners of Japanese and German with a lexical decision task, and observed asymmetric performance in the processing of the Japanese contrast between singleton and geminate consonants and the German contrast between front

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and back rounded vowels. That is, in both cases performance was better on *words* with the category that *has* an English equivalent (Japanese: singleton consonant; German: back rounded vowel) and on *nonwords* with the category that *has no* English equivalent (Japanese: geminate consonant; German: front rounded vowel). Thus, for Japanese, there were more hits on *akeru* "open" than on *kippu* "ticket," and more false alarms on **kipu* than on **akkeru*; for German, there were more hits on *Honig* /h**o**nɪç/ "honey" than on *König* /k**ø**nɪç/ "king," and more false alarms on **Konig* /k**o**nɪç/ than on **Hönig* /h**ø**nɪç/.

While asymmetries seem widespread, in some previous studies they were absent or observed only in certain experiments or conditions (Escudero *et al.*, 2008; Broersma and Cutler, 2011). Moreover, asymmetries have also been observed in control native speakers, and in some of these cases the same asymmetries were absent or smaller in the bilingual speakers (Sebastián-Gallés and Baus, 2005; Díaz *et al.*, 2012). Thus, both the presence of bilingual-specific asymmetries in word recognition and the cognitive locus of such asymmetries in either inaccurate phonetic perception and/or imprecise lexical representations remain largely open questions.

All of the studies mentioned so far concern contrasts between two sounds in L2 that are difficult to distinguish. Here, we are interested in a case in which an L2 sound is not confused with another one, but rather, with its absence. Specifically, French lacks /h/, and native French speakers have difficulty perceiving the contrast between the presence vs absence of /h/ in English stimuli (Mah *et al.*, 2016). Of course, in a French–English bilingual's daily life, the perception of the presence vs absence of /h/ is completely asymmetric: French speakers have difficulty perceiving /h/ when it is present but do not hallucinate it when it is absent. This asymmetry is reflected in their English production. That is, while they occasionally insert /h/ (e.g., *hafter* instead of *after*), they much more frequently omit /h/ (*eadache* instead of *headache*) (Janda and Auger, 1992).[1] Given the inherent asymmetry of the contrast between the presence vs absence of /h/, we predict asymmetric lexical processing of English /h/-initial and vowel-initial words in French listeners. We also predict that in native English listeners, this asymmetry is—if anything—smaller.

Previous work has revealed difficulty in the processing of /h/ at the lexical level in French listeners: in an electroencephalography study by White *et al.* (2017), French–English bilinguals performed a semantic classification task on words and nonwords, where the nonwords were created from /h/- and vowel-initial words by removing or adding /h/, respectively. Crucially, they were not informed that the items contained nonwords as well as real words. Low-proficiency bilinguals failed to show an N400 nonword effect; thus, they processed the nonwords as if they were real words. As /h/-initial and vowel-initial nonwords were not analyzed separately, the question of a possible asymmetry was not addressed. Here, we report on an experiment with French–English bilinguals, using a lexical decision task in which, as in White *et al.* (2017), nonwords differ from real words in the presence or absence of /h/. We predict, first, that nonwords such as *usband* and *hofficer* will activate the representations of the real words *husband* and *officer*, respectively, and thus will cause false alarms. Moreover, given that French speakers produce *usband* more often than *hofficer* (and are exposed to it more often in the speech of other French speakers), we predict higher false alarm rates on the former than on the latter. Finally, for the same reason, we also predict more misses on *husband* than on *officer*, despite relatively good performance on real words.

2. Methods

2.1 Participants

Forty-one French intermediate to advanced learners of English participated. There were 20 women and 21 men, aged between 18 and 34 (mean: 25.6), who had started learning English at school. They filled in a questionnaire to self-evaluate their speaking, listening, reading, vocabulary, and grammar skills in English and French, on a scale from 1 to 10. The overall mean score was 7.4 [standard deviation (SD) = 1.2] for English and 9.8 (SD = 0.1) for French. In addition, 26 native speakers of American, British, or Canadian English, 13 women and 13 men, aged between 23 and 34 (mean: 26.8), were tested as controls. None of the participants reported a history of speech or language problems. They were paid a small fee for their participation.

2.2 Stimuli

We selected 80 English test words, 40 starting with /h/ (e.g., *husband*) and 40 with a vowel (e.g., *officer*). They consisted of nouns, verbs, and adjectives, and contained between two and four syllables. The /h/-initial and vowel-initial words did not differ in

mean frequency in the Subtlex database (Brysbaert and New, 2009) or in mean number of syllables (both $t < 1$). They also did not differ in mean familiarity, as rated by a group of 45 adult French learners of English who did not participate in the experiment ($t = 1.0$, $p > 0.1$). It was not possible to match for both frequency and cognate status; about one-quarter of the h-initial and half of the vowel-initial items had a French cognate, but none of these cognates were (near-)homophones.

For each word, we created a paired nonword by deleting or adding /h/ at the beginning (e.g., *husband* → *usband*, officer → *hofficer*). In addition, we selected 240 English control words (nouns, verbs, and adjectives), none of which starting with /h/. They were matched for mean frequency and mean number of syllables with the test words. For each control word, we created a paired nonword by replacing, deleting, or inserting one phoneme other than /h/.

The test and control items were divided into four lists.[2] Each list contained 10 /h/-initial and 10 vowel-initial words, 10 /h/-initial and 10 vowel-initial nonwords, as well as 60 control words and 60 control nonwords. No list contained both members of a given word–nonword pair. Finally, two additional words and two additional nonwords, none involving /h/, were selected for a practice phase.

All items were recorded by a male native speaker of American English in a soundproof booth, at 16 bits mono with a sampling rate of 44.1 kHz.

2.3 Procedure

Participants were tested individually in a soundproof booth. They were randomly assigned to one of the four lists. Hence, participants heard only one of the members of each word–nonword pair in both the test and control condition. They performed an auditory lexical decision task, using their dominant hand for "yes"—and their non-dominant hand for "no"—responses on a button box.

There were 160 trials divided over two blocks, each containing the same number of test and control stimuli. Trials were presented in a semi-random order such that between one to three control trials appeared between two experimental ones, and that no more than four trials of the same type (word or nonword) appeared in a row.

The first block started with a practice phase of four trials with control items, during which participants received feedback ("correct" or "wrong" written on the screen). In the case of an incorrect response or no response within 2500 ms, the trial was repeated until the correct response was given. During the test phase, participants received no feedback and if they did not give a response within 2500 ms the next trial was presented. An interval of 1000 ms elapsed between the participant's response or the time-out and the presentation of the next trial.

3. Results

Prior to analysis, we inspected the performance of English participants on words and nonwords separately to detect outlier items. Items were discarded if their rate of correct responses was three SDs below the mean of the corresponding items (words or nonwords). Two real words (*advise*, *holy*) and three nonwords (*essintial*, *acclord*, *advinture*) were thus discarded.

Mean accuracy for French and English participants on /h/-type items (e.g., *husband*, *usband*), vowel-type items (e.g., *officer*, *hofficer*) and control items, separated by lexicality, are shown in Table 1.

We started with a global analysis of accuracy, including both test and control items. As French participants had a strong bias for yes-responses (shown by their low accuracy scores on test nonwords), we used the A′ statistic. This statistic provides a non-parametric, unbiased, index of sensitivity (here: to the difference between words and nonwords), with 0.5 indicating chance performance and 1.0 perfect performance. The data from one participant in the French group were excluded, as this participant's

Table 1. Mean accuracy on test and control items for French learners of English and native English speakers (standard errors in parentheses).

	Words			Nonwords		
	h-type (husband)	vowel-type (officer)	control	h-type (usband)	vowel-type (hofficer)	control
French	88.11 (5.12)	92.07 (4.28)	95.86 (3.15)	32.98 (7.44)	47.14 (7.90)	82.44 (6.02)
English	92.31 (5.24)	97.67 (2.96)	97.71 (2.93)	93.70 (4.77)	94.14 (4.61)	97.29 (3.19)

Table 2. Mean A′ scores on test and control items for French learners of English and native English speakers (standard deviations in parentheses).

	test	control
French	0.72 (0.20)	0.94 (0.04)
English	0.97 (0.03)	0.99 (0.01)

A′ score was more than three SDs below the group mean. Mean A′ scores for the French and English groups are shown in Table 2.

An analysis of variance by participant with the factors Group (French vs English), Condition (test vs control), and Item List (1 vs 2 vs 3 vs 4) revealed main effects of Group [$F(1,58) = 42.3$, $p < 0.001$] and Condition [$F(1,58) = 54.6$, $p < 0.001$], as well as a Group × Condition interaction [$F(1,64) = 28.8$, $p < 0.001$]. Restricted analyses revealed that the interaction was due to the fact that although there was an effect of Condition in both language groups, with better performance on control than on test items, this effect was larger in the French group [French: $F(1,39) = 53.3$, $p < 0.001$; English: $F(1,25) = 10.8$, $p < 0.01$]. As there was no effect of nor an interaction with the counterbalancing factor Item List, this factor was omitted in further analyses.

Next, we focused on the test items. The A′ statistic cannot be used to test for possible asymmetries in the performance on h-type vs vowel-type items in words vs nonwords. Rather, a linear mixed effects model was run on the accuracy scores, with Group (French vs English), Lexicality (word vs nonword), and Item Type (/h/ vs vowel) as contrast-coded fixed factors, and intercepts for participants and items as random factors. *P*-values were obtained by likelihood ratio tests of the full model against the model without the effect or interaction in question. All three main effects were significant, with higher accuracy by English than by French participants [$\beta = 2.21$, standard error (SE) $= 0.33$, $\chi^2(1) = 37.4$, $p < 0.0001$], on words than on nonwords [$\beta = 1.81$, SE $= 0.18$, $\chi^2(1) = 103.8$, $p < 0.0001$] and on vowel-type than on h-type items [$\beta = 0.65$, SE $= 0.20$, $\chi^2(1) = 10.3$, $p = 0.001$]. There was also a Lexicality × Group interaction [$\beta = 2.76$, SE $= 0.35$, $\chi^2(1) = 43.0$, $p < 0.0001$], due to the fact that French learners performed better on words than on nonwords whereas there was no difference for English speakers. Crucially, the triple interaction between Group, Lexicality, and Item Type was also significant [$\beta = 1.40$, SE $= 0.70$, $\chi^2(1) = 4.17$, $p = 0.04$]. This triple interaction was examined in two mixed effects models on the French and English data, respectively, with Lexicality and Item Type as contrast-coded fixed factors, and intercepts for participants and items as random factors. For the French data, Cognate Status was also added as a contrast-coded fixed factor. For French learners there were main effects of Lexicality [$\beta = 3.18$, SE $= 0.18$, $\chi^2(1) = 508.8$, $p < 0.0001$] and Item Type [$\beta = 0.71$, SE $= 0.18$, $\chi^2(1) = 13.9$, $p < 0.0001$] but no interaction; performance was better on words than on nonwords and better on vowel-type items than on /h/-type items. There was no effect of Cognate Status ($p > 0.1$). For native English speakers, there was no effect of either Lexicality or Item Type but an interaction between these factors $\beta = 1.28$, SE $= 0.65$, $\chi^2(1) = 4.07$, $p = 0.04$. For real words, they were more accurate on vowel-type than on /h/-type items, while for nonwords they showed no such difference.

4. Discussion

We used a lexical decision task to test whether French learners of English encounter difficulty in processing /h/ at the lexical level, and whether they show the same asymmetry as observed in production (i.e., more incorrect deletions than insertions of /h/; Janda and Auger, 1992). While both the French learners and native English control participants performed better on control than on test items, this difference was much larger for the French learners. Thus, we found that French learners of English indeed have difficulty in the processing of /h/ at the lexical level, in agreement with White *et al.* (2017).[3] Furthermore, French learners made more errors on /h/-type items than on vowel-type items, both in words and nonwords, while native English speakers showed the same difference, but of a smaller magnitude and only in real words. Thus, as predicted, we observed an asymmetry in French learners that parallels the one observed in production. That is, just like these learners typically produce more /h/-initial words without the /h/ (e.g., *usband* instead of *husband*) than that they produce vowel-initial words with an added initial /h/ (e.g., *hofficer* instead of *officer*), they show more false alarms on *usband*-type than *hofficer*-type nonwords and more misses on *husband*- than on *officer*-type real words.

Similar asymmetries were reported in two case studies by Darcy *et al.* (2013), who also used a lexical decision task. They argued that these asymmetries are due to what they called fuzzy, i.e., imprecise, lexical representations of words containing the difficult category (i.e., the one without a native equivalent), and not to problems in phonetic perception. Based on data from a visual world paradigm, however, Weber and Cutler (2004) and Cutler *et al.* (2006) argued for the opposite view, namely, that asymmetries in L2 learners indicate inaccurate phonetic perception of the difficult category combined with accurate lexical representations. These two views are incompatible yet congruent with the respective datasets from lexical decision and the visual world paradigm, respectively, that they were meant to account for. To see why, first consider the present lexical decision data (the data of Darcy *et al.* show the same pattern): Lexical representations of /h/-initial words being less precise than those of vowel-initial words leads French listeners to be less accurate on h-type items (*husband/usband*) than on vowel-type items (*officer/hofficer*). By contrast, if the asymmetries were exclusively due to inaccurate perception of /h/, French learners should have performed worse on *hofficer*-type than on *usband*-type nonwords, contrary to fact. That is, failing to perceive the /h/ in *hofficer* should have led them to generally accept it as a real word, whereas they should have had no particular difficulty rejecting *usband* given their correct lexical representation of the word *husband*. (For real words, the prediction would be correct: that is, more errors on *husband*-type than on *officer*-type words, since a failure to perceive /h/ should make it more difficult to accept the former than the latter.)

As to the data from the visual world paradigm, Weber and Cutler (2004) and Cutler *et al.* (2006) found that whichever member of a difficult L2 contrast is heard, only words containing the category that has a native equivalent are initially activated. For instance, Dutch learners of English, whose native language has /ɛ/ but not /æ/, were found to briefly activate the word *pencil* upon hearing *panda* but not the reverse, supposedly due to misperception of the /æ/ of *panda* as the /ɛ/ of *pencil*. If perception were accurate, but the lexical representation of words containing /æ/ imprecise, the expected pattern of results would be different; there should be no brief activation of *pencil* upon hearing *panda*, but both *panda* and *pencil* should initially be activated upon hearing *pencil*.

To conclude, there are two contrasting accounts of asymmetric lexical access in second language learners: imprecise lexical representations versus inaccurate phonetic perception. Our data are in accordance with the former: they suggest that intermediate to advanced French learners—in addition to the difficulty they may have with the perception of /h/—have imprecise lexical representations of /h/-initial words. More comparative research with different contrasts, tasks, and populations is needed to further examine asymmetries in L2 lexical processing. As such asymmetries can also occur in native speakers (Sebastián-Gallés and Baus, 2005; Díaz *et al.*, 2012), it would be important to always compare the learners' performance to that of native speakers, such as to clearly identify asymmetries that are specific to L2 processing.

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References and links

[1]As argued by Janda and Auger (1992), insertion is a sign of hypercorrection, showing that French speakers have metalinguistic knowledge about /h/ in English.

[2]We used four rather than two counterbalanced lists, such that the stimuli can be used in a pre- and a post-test of a planned training study.

[3]In White *et al.* (2017) this processing problem was observed only in learners who, based on their overall pronunciation, were rated as having low proficiency. It is difficult to compare proficiency across the two groups, as the classification of our participants as intermediate to advanced was based on their self-evaluation of a range of skills. Note also that the participants in White *et al.* lived and were tested in Montreal, a French–English bilingual city; they thus received larger amounts of native English input than our participants, who lived and were tested in Paris.

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