SPEAKERS DIFFERENTIATE ENGLISH INTRUSIVE AND ONSET /r/, BUT L2 LISTENERS DO NOT

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ABSTRACT

We investigated whether non-native listeners can exploit phonetic detail in recognizing potentially ambiguous utterances, as native listeners can [6, 7, 8, 9, 10]. Due to the phenomenon of intrusive /r/, the English phrase *extra ice* may sound like *extra rice*. A production study indicates that the intrusive /r/ can be distinguished from the onset /r/ in *rice*, as it is phonetically weaker. In two cross-modal identity priming studies, however, we found no conclusive evidence that Dutch learners of English are able to make use of this difference. Instead, auditory primes such as *extra rice* and *extra ice* with onset and intrusive /r/s activate both types of targets such as *ice* and *rice*. This supports the notion of spurious lexical activation in L2 perception.

1. INTRODUCTION

In running speech, ambiguities may arise due to phonological processes. For instance, the French phrase "*dernieroignon"* may arise from *dernier oignon* ('last onion') or *dernier rognon* ('last kidney'). Native listeners efficiently exploit phonetic detail to disambiguate such phrases [6, 7, 8, 9, 10]. Spinelli et al. showed first that the /r/ is longer in *dernier rognon* than in *dernier oignon*. In a perception study, they found that target words were recognized fastest when targets matched the speaker's intended segmentation and a weaker facilitation when targets mismatched the intended segmentation.

In this study, we investigate whether non-native listeners are equally effective at exploiting phonetic detail. Our test case is /r/-intrusion in English. When an English speaker says *extra ice*, for example, an /r/-like sound is often produced between *extra* and *ice*, which leads to an ambiguous utterance that can be interpreted as *extra ice* or *extra rice*.

Non-rhotic accents of English like Received Pronunciation (RP) have the phonotactic constraint whereby /r/ can occur in syllable onsets but not at the end of words. However, an /r/, although word-final, does occur when the following word begins with a vowel (e.g. *hear it* /hɪərɪt/), as the /r/ occupies a syllable onset in connected speech (due to liaison). This phenomenon is known as 'linking /r/' [3, 4, 5]. The *extra ice* case, however, is known as 'intrusive /r/', which is the insertion of /r/ after a non-high vowel (e.g., [ə, a, ɔ]) and before vowel-initial words. In contrast to linking /r/, an intrusive /r/ is not represented in the spelling [3, 4, 5].

Especially the intrusive /r/ may be problematic for non-native listeners, because the acoustic evidence for /r/ cannot be attributed to any underlying or orthographic representation, as in the case of linking /r/. First of all, however, we need to show that there are indeed acoustic differences to distinguish phrases such as *extra ice* and *extra rice*, which listeners could exploit.

2. INTRUSIVE VERSUS ONSET /r/

To compare intrusive and onset /r/, 27 pairs of English sentences were constructed. An example sentence is "*My brother likes extra rice/ice when he has dinner*". In all sentences, a member of a minimal pair such as *ice/rice* followed a word ending on a low vowel. Trivially, the r-initial member of the pair in the sentence will trigger pronunciation of an /r/. More importantly, the vowel-initial member of the pair preceded by the low vowel (in this case, the last vowel of *extra*) creates a context in which an intrusive /r/ can occur in the pronunciation.

All sentences were recorded by a female native speaker of British English who was unaware of the purpose of the study and produces intrusive /r/s in casual speech. All sentences were recorded twice and some sentences multiple times because of disfluencies.

We measured both the duration of the /r/s (intrusive or onset /r/) and the decrease in intensity from the vowel preceding the /r/ to the lowest point in the /r/. Usually, the intensity decrement in dB is larger and the duration longer for onset /r/ tokens

than for intrusive /r/ tokens [4]. All /r/s were measured by the first author and a subset of these sentences was also measured by the second author to test reliability. The correlation between the two measurements was high (duration: r = .72; intensity difference: r =.95).

Table 1 shows the mean decrease in intensity, the mean duration of onset and intrusive /r/s, and the Cohen's d difference score. Overall, onset /r/s are longer [$F(1,124) = 8.74$, $p < 0.01$] and have a larger intensity decrement from the preceding vowel to the lowest point [$F(1,124) = 10.79$, $p < 0.01$]. The high difference scores are an indication that these specific differences between onset /r/s and intrusive /r/s can be relevant for listeners in their perception.

Table 1: Mean intensity decrement (in dB) and mean duration (in ms) for the target words.

	Type of /r/		d
	Onset	Intrusive	
Intensity decrement (dB)	7.9	2.2	1.9
Duration (ms)	89	69	1.6

Note: d is Cohen's d (Mean Difference / Standard Deviation), a power estimate. Values above 0.8 are indicative of a large effect size [2].

3. PERCEPTION EXPERIMENTS

We have shown that there are phonetic differences between intrusive and onset /r/s, but we do not know whether these differences are salient enough for listeners to be able to distinguish between the two types of /r/. Therefore, we conducted two cross-modal priming experiments to test whether intrusive /r/s create ambiguities in speech perception and are perceived as onset /r/s or whether listeners are able to perceive the difference between intrusive and onset /r/s.

The two experiments made use of the same auditory prime stimuli; only the visual target words differed. In Experiment 1 the target words were vowel-initial words (e.g., *ice*) and in Experiment 2 the target words were r-initial words (e.g., *rice*). The question was whether listeners show a stronger priming effect for vowel-initial target words when hearing *extra ice* (with an intrusive /r/) than when hearing *extra rice* and show a stronger priming effect for r-initial targets when hearing *extra rice* compared to hearing *extra ice*. Moreover, when we analyze the two experiments together we can see whether both types of primes (e.g., *extra ice* and *extra rice*) activate both vowel-initial and r-initial words (e.g., *ice* and *rice*). In other words, we can test whether listeners are able to make a distinction between an intrusive /r/ and on onset /r/.

3.1. Experimental methods

3.1.1. Participants

Thirty-six native speakers of Dutch participated in Experiment 1. Another 36 participants, from the same pool as in Experiment 1, took part in Experiment 2. All participants had a high level of proficiency in English as a second language and had no known hearing problems.

3.1.2. Stimuli

The same recordings as described in section 2 were used. In the sentences with an onset /r/, the /r/ was always longer and had a larger intensity decrease than in similar sentences with intrusive /r/s. Each experimental sentence contained a sequence in which the /r/-like sound could be interpreted as either an intrusive /r/ or an onset /r/, i.e., sentences in which one word ended with the /ɑ/, /ɔ/ or /ə/ and the subsequent string of phonemes could form either a r-initial or vowel-initial word. Thus, the experimental sentences are potentially ambiguous for listeners who do not perceive the difference between intrusive /r/s and onset /r/s. All sentences were truncated directly after the (potential) prime word (e.g., *My brother likes extra ice*).

In Experiment 1 the target words were vowel-initial words (e.g. *ice*) and in Experiment 2 the target words were the r-initial words (e.g. *rice*). Additionally, 27 control sentences were constructed with target words that were matched for English frequency to the /r/ minimal pairs (e.g., *My brother likes extra pages…*). Furthermore, 108 filler prime sentences with unrelated 54 word and 54 nonword targets were constructed. Finally, 27 "semi-experimental" prime sentences were constructed with nonword targets starting with a vowel in Experiment 1 and starting with an /r/ in Experiment 2. Nine of these sentences contained a potential linking /r/ (e.g., *I think that your explanation…*) and a related visual nonword target (*explint* or *rexplint*). Another nine sentences, contained geminate /r/s (e.g., *And then my neighbour refused…*) and had related nonword targets (e.g., *effint* or *reffint*). These 18 sentences

were included to prevent an association of phonological relatedness between prime and target with "yes" responses in the visual lexical decision task. Finally, nine sentences without /r/s near the place of truncation (e.g., *I heard on the news that taxes…*) with unrelated nonword targets (e.g., *ilems* or *rilems*) were constructed.

Additionally, 18 question trials were made. Participants would hear a complete sentence and directly after that they would receive a yes/no question about the previous sentences. This constituted a check on whether the participants were paying attention to the prime sentences as well as to the visual target words.

The filler sentences and question trials were recorded by the same female native speaker of British English who produced the critical items.

3.1.3. Design

In the cross-modal priming task, each participant was presented with each of the experimental visual targets only once, with nine targets in each of the three conditions: Identity, Mismatch and Control condition. In Experiment 1, the targets were the vowel-initial words (e.g., *ice*) and in the Identity condition targets were preceded by a matching auditory prime with an intrusive /r/, in the Mismatch condition targets were preceded by a prime with an onset /r/ (which mismatched the target), and in the Control condition targets were preceded by a phonologically and semantically unrelated prime.

In Experiment 2 the design was similar to the design of Experiment 1. The crucial difference was that the target words were now r-initial words (e.g., *rice*) and therefore the Identity and Mismatch conditions were reversed.

3.1.4. Procedure

Participants were tested one at a time in a sound proof booth. The participants received English instructions printed on the screen, informing them that on each trial they would hear a part of an English sentence, directly after which an English word or nonword would appear on the screen. They were instructed to press a green response button labeled "yes" with their dominant hand if they thought the visually presented item was an English word, and a red response button labeled "no" with their other hand if they thought the visually presented item was not an English word. Participants were asked to try to respond as fast as possible without making too many errors. The experiment started with seven practice trials and one practice question trial.

Each participant was presented with all of the filler words and filler nonwords, so that each participant saw a total of 81 words and 81 nonwords. Additionally, each participant was presented with 18 yes/no questions that they could only answer if they had paid attention to the previous auditory sentence. Item and question trials were randomized for each participant. After every 50 trials the participant could take a short break.

3.2. Results and discussion

Lexical decision reaction times (RTs) were measured from onset of the visual presentation of the target words. Responses slower than 1500 ms were treated as errors. Figure 1 shows the priming effects in Experiment 1 and 2.

Each experiment was first analyzed separately. A Mixed Model analysis on the log RTs was applied with trial number and prime type as fixed factors and participants and target word as random factors. In Experiment 1 an identity priming effect was found: Listeners were faster to respond to identical targets (e.g. to *ice* as *extra (r)ice* was heard) than to unrelated targets (e.g. to *ice* as *extra pages* was heard) [$t(614) = -2.4$, $p < .05$].

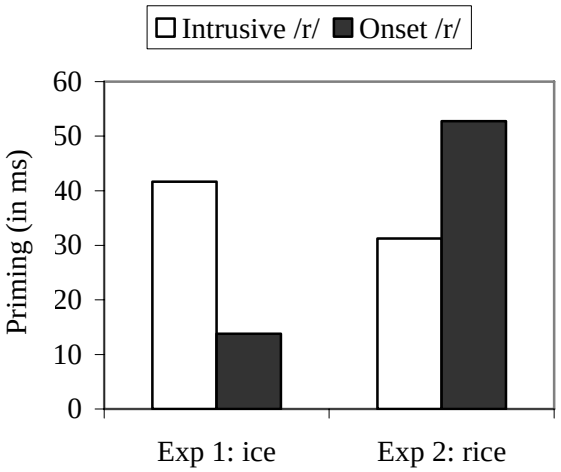
The phonological Mismatch condition with a strong onset /r/ was not statistically different from either the Control or the Identity condition. This result suggests that non-native listeners are able to exploit the phonetic details that distinguish intrusive and onset /r/s, because the primes with a strong onset /r/ did not prime reactions to vowel initial words.

In Experiment 2, the analysis of the log RTs showed that listeners were again faster to respond to identical targets (e.g. to *rice* as *extra rice* was heard) than to unrelated targets (e.g. to r*ice* as *extra pages* was heard) [$t(670) = -3.0$, $p < .05$]. There was no significant priming effect for mismatch targets (e.g. to *rice* as *extra (r)ice* with an intrusive /r/ was heard), although a trend into that direction was observed [$t(669) = -1.8$, $p = .08$].

As in Experiment 1, the phonological Mismatch condition with an intrusive /r/ was not statistically different from either the Control or the Identity condition. Again, on the basis of this result one could conclude that non-native listeners are able to perceive the difference between intrusive and onset

/r/s. However, only when we combine the two experiments in one analysis can we test whether both types of auditory primes (*extra ice* and *extra rice*) activate both types of target words (*ice* and *rice*).

Figure 1: Priming effects in Experiment 1 and 2.



3.3. Combined analysis

We pooled the data from both experiments and predicted reaction times as a function of prime type (intrusive /r/, onset /r/, and control) and target word (vowel-initial vs. r-initial). This revealed significantly faster reactions for intrusive and onset /r/ primes compared to the control condition. This was independent of the target type, as the interaction apparently present in Figure 1 failed to reach significance (p = 0.09). This indicates that despite the differences in the strength of the priming, both types of primes (e.g., *extra ice* and *extra rice*) do activate both vowel-initial and r-initial words (e.g., *ice* and *rice*).

4. GENERAL DISCUSSION

The results from our production study indicate that there are acoustical differences between onset /r/s and intrusive /r/s; onset /r/s are longer in duration and have a larger amplitude decrease than intrusive /r/s. Two cross-modal priming experiments produced, however, no conclusive evidence that Dutch learners of English can make use of these differences. Both intrusive /r/s and onset /r/s activate vowel-initial and r-initial words.

Previous studies showed that native listeners are able to resolve ambiguities in connected speech [6, 10][1]. In particular, the durations of individual segments has proven to be relevant for native listeners. When listeners need to distinguish, for example, the Dutch phrases *die pin* (that pin) and *diep in* (deep in) they make use of the fact that the /p/ in *die pin* is longer than the /p/ in *diep in*. [8, 7, 9, 10]. However, for non-native listeners who have difficulties to exploit such fine phonetic details, the difference between these phrases might not be heard. In fact, it appears that in non-native listeners certain minimal pairs can even activate each other, whereas in native listeners minimal pairs usually inhibit each other [1].

The present experiments with non-native listeners likewise show spurious lexical activation of words that were not intended by the speaker. Even though there are acoustical differences between onset /r/s and intrusive /r/s, non-native listeners appear unable to effectively use these differences in speech perception. As a result, more words are competing for recognition, which complicates the recognition of speech in a second language.

5. REFERENCES

[1] Broersma, M. 2005. *Phonetic and lexical processing in a second language*. Doctoral dissertation, Radboud University, Nijmegen (MPI Series in Psycholinguistics, Vol. 34). Wageningen: Ponsen & Looijen.

[2] Cohen, J. 1992. A power primer. *Psychol Bull*, 112, 155-159.

[3] Collins, B., Mees, I. M. 1999. *The phonetics of English and Dutch* (4th ed.). Leiden: Brill.

[4] Cruttenden, A., Gimson, A. C. 1994. *Gimson's pronunciation of English* (5th ed.). London: Arnold.

[5] Giegerich, H. J. 1992. *English phonology: An introduction*. Cambridge: Cambridge University Press.

[6] Gow, D. W. 2002. Does English coronal place assimilation create lexical ambiguity? *J Exp Psychol Hum Percept Perform*, 28, 163-179.

[7] Kemps, R. J. J. K. 2004. *Morphology in auditory lexical processing: Sensitivity to fine phonetic detail and insensitivity to suffix reduction*. Doctoral dissertation, Radboud University, Nijmegen (MPI Series in Psycholinguistics, Vol. 28). Wageningen: Ponsen & Looijen.

[8] Quené, H. 1992. Durational cues for word segmentation in Dutch. *J Phonetics*, 20, 331-350.

[9] Shatzman, K. B., McQueen, J. M. 2006. Segment duration as a cue to word boundaries in spoken-word recognition. *Percept Psychophys*, 68, 1-16.

[10] Spinelli, E., McQueen, J. M., Cutler, A. 2003. Processing resyllabified words in French. *J Mem Lang*, 48, 233-254.

[1] We are currently testing whether native English listeners can distinguish intrusive /r/ from onset /r/ with the same materials as described in this paper.