المنجز الثالث: دراسة تأثير القواعد الصوتية للغة العربية باستخدام برنامج حاسوبي على تجزئ الكلام المنطوق في اللغة الانجليزية كلغة أجنبية

سنة المنجز: 2008

تحتوي هذه الوثيقة على:

أ. وصف المنجز وأثره
ب. الورقة العلمية المنشورة للمنجز

أ. وصف المنجز

نشر بحث علمي في عام 2008 في مجلة System الدولية وهي أحد أهم المجلات العلمية في تخصص اللغويات حيث تصنف من ضمن أفضل 4% من المجلات العلمية في تخصص اللغويات (ترتيبها 30 من بين 968 مجلة) حسب تصنيف SCOPUS العالمي. رابط التصنيف:
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الهدف: كان أحد أهم أهداف البحث دراسة تأثير القواعد الصوتية للغة العربية كلغة أولى على تجزيئ الكلام المنطوق في اللغة الانجليزية كلغة أجنبية.

الطريقة: استخدام برنامج DMDX الحاسوبي وهو برنامج يقيس سرعة تجزئ الكلام الى كلمات منفصلة بالجزء من الألف من الثانية.

النتيجة : القواعد الصوتية للغة العربية تؤثر بشكل مباشر على سرعة ودقة تجزيئ الكلام المنطوق في اللغة الانجليزية كلغة ثانية.

وقد حصل البحث على 86 استشهاد في أفضل المجلات العلمية وكتب المراجع في تخصص اللغويات.

رابط الاستشهادات حسب موقع الباحث من قوقل:

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ويمكن الوصول للمقال العلمي عن طريق هذا الرابط. كما تم ارفاق المقال ابتداء من الصفحة الثانية من هذه الوثيقة.

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The effect of teaching English phonotactics on the lexical segmentation of English as a foreign language

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Abstract

This paper reports on an intervention study which investigated the effect of teaching English phonotactics upon Arabic speakers' lexical segmentation of running speech in English. The study involved a native English-speaking group ($N = 12$), a non-native control group ($N = 20$); and a non-native experimental group ($N = 20$). Each group was pre-tested using a Word Spotting Task which investigated the extent to which illegal consonant clusters in English and Arabic supported the lexical segmentation of English. The non-native groups were post-tested with the same task after 8 weeks, during which the experimental group was given a treatment consisting of explicit teaching of relevant English phonotactic constraints. Post-test results showed significant gains in the segmentation ability of the experimental group.

Keywords: Listening comprehension; Lexical segmentation; Phonotactics; Bottom-up

1. Introduction

The standard approach to second language (L2) listening instruction is based on obtaining evidence of 'comprehension'. Learners are given abundant practice in listening and it is assumed that in this way they will somehow acquire L2 listening skills. The role of the teacher is to play tapes and check students' comprehension by asking them questions

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or getting them to report the gist or provide a summary. Consequently, some would argue that listening is tested rather than taught (Sheerin, 1987). Under this approach, the role of top-down processing 'using background knowledge of the situation, context and topic to interpret meaning'[1] (Norris, 1995, p. 47) is prioritised as it is believed that top-down cues can compensate for gaps in linguistic knowledge (e.g. Herron et al., 1998; Long, 1990).

Recently, however, calls have been made for more attention to perceptual processes. The argument is that, if L2 listeners are to process L2 connected speech fluently, they need to acquire the bottom-up processing skills which are involved in the decoding of the signal.

2. Lexical segmentation and phonotactics

Psycholinguistic research is a fertile source of information about bottom-up listening skills (Field, 2003, p. 326). It has been suggested that lexical segmentation (locating word boundaries in connected speech) is one of the most important elements in successful decoding. The lack of reliable auditory cues akin to the white spaces between written words makes it difficult for L2 learners to identify where one word ends and the next begins. Research has shown that both infants and adult native speakers use phonological cues in the signal to assist them in segmenting connected speech. These include allophonic cues (Jusczyk et al., 1999a; Nakatani and Dukes, 1977), prosodic features (Cutler and Norris, 1988; Jusczyk et al., 1999b) and phonotactic rules (Mattys and Jusczyk, 2001; McQueen, 1998).

Each language has its own phonotactic restrictions, which determine the sound sequences that can appear in a syllable and the positions in the syllable where particular sounds can occur (onset or coda). The identification of word boundaries is especially aided by the sequencing constraint which governs which sound classes can appear adjacent to each other. In English, for instance, a labial segment (e.g. /p/, /v/) cannot be followed by /w/ in an onset or in a coda (Davenport and Hannahs, 1998, p. 147). Similarly, clusters such as /pr/ and /br/, although completely legal in onset position, (e.g. *prime* and *bread*), are illegal in coda position. The opposite is true for /nt/. Most phonotactic conventions are language-specific. Standard Arabic, for example, does not allow consonant clusters in onsets, but other Arabic dialects allow these.

Native listeners make use of consonant sequences for the purpose of lexical segmentation by locating syllable boundaries between illegal clusters. The listener assumes that these syllable boundaries coincide with word boundaries. This first-pass assumption is always successful as far as monosyllabic words are concerned (e.g. the illegal clusters /pw/ and /vw/) mark out word boundaries as in *top wing* and *move where?* However, it may have to be revised in cases where illegal clusters mark out syllable boundaries that are word-internal syllable (e.g. /pw/ in *upward*).

Adults exhibit sensitivity to the phonotactic constraints of their L1. Phonotactic knowledge has been shown to affect speech sound identification by causing misperception of phonemes (Massaro and Cohen, 1983; Pitt, 1998), and even sometimes causes listeners to report hearing epenthetic vowels between consonants when presented with non-L1 consonant clusters (Dupoux et al., 1999, 2001). Even infants have been shown both to be sensitive

[1] But see Field (1999) for a more detailed description of what might be understood by this term.

to the phonotactic constraints of the language they are acquiring (Jusczyk et al., 1993) and to use this sensitivity to segment connected speech (Mattys and Jusczyk, 2001).

McQueen (1998) demonstrated that the impermissibility of a sound sequence is computed during connected speech recognition and used in segmentation. McQueen made use of a Word Spotting Task, in which subjects are asked to press a button when they identify a word embedded in a group of sounds. Their reaction time (the time it takes for the word to be spotted) can then be measured. McQueen found that Dutch speakers were faster and more accurate in detecting target words when they were aligned with what is a phonotactic boundary in Dutch (e.g. *pil* in *pil.vrem*) than when they were misaligned (e.g. *pil* in *pilm.rem*).

A relevant question for L2 listening is whether learners incorrectly apply their L1 phonotactic knowledge when listening to an L2. Recall that phonotactic constraints are language-specific. For instance, a German speaker for whom /tw/ is illegal may assume a word boundary between these two sounds when listening to the phrase *be twins* in English and hear 'beat wins'. Such missegmentation would delay the recognition of the word till this incorrect boundary location is revised.

To investigate this issue, Weber and Cutler (2006) asked native speakers of American English (control group) and advanced German EFL learners to spot English words in four different conditions. In the Word Spotting Task, what creates the conditions under which a word boundary is signalled is the impossibility of a consonant cluster that would bring together the last segment of an initial nonsense syllable and the initial sound of the target word (e.g. the occurrence of the illegal cluster /ml/ in *pumlock*). The four boundary conditions Weber and Cutler created were: (a) a boundary common to both English and German (e.g. *pumlock*, because /ml/ is illegal in onset in both English and German and therefore a boundary is signalled in both languages at the onset of the word *lock*); (b) a boundary that occurs only in English (e.g. *garshlock*, since /ʃl/ is only illegal in English); (c) a boundary that only occurs in German (e.g. *marslock* since /sl/ is only illegal in German); (d) no boundary condition (e.g. *fuplock* since /pl/ is illegal in neither language and therefore no boundary is signalled.

Weber and Cutler compared reaction times and miss rates in the first three conditions to those in the *No boundary* condition to find out which condition produced the greatest effect for both listener groups. They found that words in the *Common Boundary* condition were spotted the fastest and most accurately. In addition, both groups spotted words in the *English Boundary* condition faster and more accurately than those in the *No Boundary* condition. Finally, only German listeners responded significantly faster and more accurately to words in the *German Boundary* condition.

These results show that advanced L2 learners can and do exploit phonotactic constraints specific to their L2 in lexical segmentation. On the other hand, they show that L2 listeners also transferred their L1 phonotactic constraints when listening to their L2 even if these phonotactics are not helpful in the L2 (Weber and Cutler, 2006, p. 604).

However, these results leave very important questions unanswered. First, the nonnative subjects in this study were very proficient, having received an average of 15 years of L2 instruction and had excellent knowledge of English. Their results, as Weber and Cutler conceded, do not show how quickly L2 phonotactic conventions are acquired. Whether EFL learners at intermediate or lower levels possess the same knowledge remains unanswered. Secondly, is there a role for the explicit teaching of L2 phonotactics and their part in lexical segmentation, especially in contexts where learners receive little naturalistic input? The current study investigated these questions, adopting the assumption that explicit phonotactic teaching is potentially helpful in lexical segmentation.

Most EFL learners including those in the current study are unlikely to be exposed to much naturalistic input. Explicit teaching may help them to make the best out of the little input they receive by directing their attention to the presence of the relevant cues. The current study therefore investigated the effectiveness of this kind of awareness raising. Is the resultant knowledge applied to lexical segmentation? And if it is, how automated does this process become compared to that of native speakers?

3. Methodology

3.1. Participants

Twelve native speakers of North American English with no knowledge of Arabic comprised the native control group. The non-native EFL learners were 40 Arabic speaking undergraduate students in an English language department at a university in Saudi Arabia. Below are the learners' characteristics

- 18–20 years old.
- Male.
- Level 3 of four years (eight levels) university study.
- Six years secondary EFL prior to university.
- Native speakers of Qassimi Arabic (Henceforth QA).

The 40 subjects were divided into: a control group of 20 and an experimental group of 20.

3.2. Method

The study followed a pre-test-treatment–post-test design. In the pre-test, all three groups took a Word Spotting Task which tested their use of phonotactic cues relevant to English and Arabic in achieving lexical segmentation. The non-native groups were post-tested with the same task after 8 weeks during which only the experimental group received phonotactic training. As explained earlier, the Word Spotting Task requires subjects to spot real words embedded at the beginning or the end of nonsense sequences (e.g. *lock* in *garshlock*) which are aurally presented by computer; subjects react by pressing a response button. The dependant variables here are *reaction time* (i.e. the time it takes the subject to spot the word) and *error rate* (i.e. the number of times the target word is missed). Unlike some other psycholinguistic tasks such as lexical decision, which entail procedures that are not part of natural language processing, it has been claimed (McQueen, 1996) that this task has ecological validity. That is, although the sequences in the task are short, it resembles the listener's normal task of spotting words in continuous speech.

An advantage of the Word Spotting Task is that it allows the researcher to compare the detection of the same target word in different contexts (Weber and Cutler, 2006, p. 598). This is important because it means that one does not need to control certain properties of the target words such as frequency and neighbourhood density, which are difficult to determine in relation to L2 listeners as their linguistic experience is different from that of L1 listeners. Producing the required boundary conditions by manipulating the preceding context of the same target word makes it possible to avoid potential confounds.

3.3. Materials

In the present Word Spotting Task, as with Weber and Cutler's, what determines the phonotactic boundary condition is the last segment of the preceding nonsense syllable and the initial sound of the target word. The limited number of legal initial clusters in QA (the L1 of the non-native subjects) constrained the choices that could be made.[2] However, the sounds /l/, /w/ or /r/ were found to be appropriate for producing the four required conditions. Using 36 common monosyllabic English words starting with /w/, /l/ and /r/ (12 words each) and using the inventory provided by Yavaş (2006) of illegal English onset and coda clusters, it was possible to create the four required boundary conditions.

In one condition ('Common Boundary'), the phonotactic constraints of both languages require a syllable boundary. An example is the onset of the word *line* as in / viːtlain / since words in neither language start with /tl/. In a second condition ('English Boundary'), only English requires a syllable boundary as in /viːdlain/. Words in QA but not in English can start with the consonant cluster /dl/. In a third condition ('Arabic Boundary'), only QA requires a syllable boundary as in /viːblain/. English but not QA words can start with the cluster /bl/. In the last condition ('No Boundary'), neither language requires a syllable boundary between the consonants as in /viːflain/. /fl/ is a possible syllable onset in both languages.

As with Weber and Cutler (2006), the vowels in the preceding nonsense syllables were either long or diphthongs, so that the syllable was phonotactically legal without the coda. But unlike Weber and Cutler who used different nonsense syllables before the same target word in the four different conditions, the nonsense syllable preceding each word was identical in the four conditions except for the final sound, which determined the alignment condition.

Four lists of items were constructed. Each included the entire set of 36 target words, but the boundary conditions were varied between items. The four types of boundary condition were counterbalanced across lists. Each list also contained 24 fillers. These fillers were 10 bisyllabic nonsense sequences which contained monosyllabic words in final position that began with sounds other than /l/, /r/, and /w/ and 14 bisyllabic nonsense sequences which contained no English or Arabic words. The structure of the initial syllable in the nonsense filler items was identical to those used before the target words. There were also three practice items which appeared at the start of each list (see Appendix A for a sample of stimuli items in different boundary conditions).

The 168 bisyllabic sequences (144 target-bearing and 24 fillers) were recorded by a female native speaker of North American English using Cool Edit Creative Wave Studio software, version 5.00.06. They were sampled at 22.050 kHz 16 bit, mono. The speaker was asked to avoid any clear syllable boundaries in her production by not pausing between the nonsense syllable and the target word especially when there was an English Boundary.

[2] Since this Arabic dialect is relatively unstudied, steps were taken to determine the legal consonant clusters. These are /dl/, /mr/, /bw/, /fl/, /kl/, /gr/, /kw/ and /θw/.

Using the same software, silence at the end of each of the 144 target-bearing files was removed. Each stimulus was then edited into an individual sound file, and ultimately transferred to the hard disk of a portable computer.

3.4. Pre-test

In the pretest, the Word Spotting Task was used to answer one main research question, namely, do EFL learners compute the legality of L1 (Arabic) and L2 (English) phonotactics when listening to continuous English speech and use it to facilitate lexical segmentation? Presentation of the stimuli was controlled by a portable computer running DMDX experiment control software. Each subject, native and non-native, was tested individually using headphones and an equal number of subjects in each group (i.e. three from the native group and five from each of non-native groups) listened to each list.[3] DMDX software automatically randomised the presentation of items for each subject. Subjects were instructed to listen to the phoneme sequence and press the mouse key using their dominant hand as fast as possible whenever they detected an embedded English word at the end of the sequence and then say the word aloud. The computer measured and stored the RTs and oral responses were tape recorded for error analysis. The script of DMDX was adjusted to measure RTs from the offset of the sound file which coincided with the offset of the target word.

3.5. Treatment

Following the pre-test, each group was given on average one and a half hours of listening instruction per week for eight weeks. The material *Top-Up Listening 3* (Cooney et al., 2003) was used with both groups. It focuses on sound-level phenomena that characterise connected speech. At the end of each unit, a section called *listening clinic* highlights a particular phenomenon. These phenomena included reduction, contraction, assimilation, stress, and intonation. Both groups received standard instruction in these features but it was only the experimental group who received additional phonotactic training as described below.

For the control group, a unit was presented every week and the relevant feature (e.g. contraction) was discussed. Students were then set a weekly task. The task was to choose the conversation or speech of a native speaker of North American English using the radio, TV or the internet, record about 40 min of it, and transcribe 500 words of the material highlighting that phenomenon.

Students in the experimental group had to do the same in addition to highlighting the English phonotactic constraints they were taught. Experimental group teaching was in three stages:

Stage 1 (first 2 weeks: Awareness Raising): An explanation was given of how in English, as with all languages, there are constraints on consonants appearing together in a syllable and how native speakers use these as segmentation cues. The group was then told that the course aim was to help them do the same. Every experimental group student was given a list of 12 clusters that cannot appear in an English onset or coda and had to memorise it.

[3] Non-native speakers were given a phonetic transcription task of the target words one week prior to pre-test to ensure that inability to spot words in a certain condition is the result of a boundary effect rather than lack of knowledge of the word.

Some of the clusters were also illegal in QA. This list featured the clusters /dl/, /mr/, /bw/, /pm/, /bn/, /tf/, /dk/, /dg/, /kn/, /gm/, /fn/ and /θb/ and was collected based on the inventory of illegal onset and coda clusters provided by Yavaş (2006).

Stage 2 (Week 3 onwards): In addition to the task where they had to highlight a particular phonological feature, students in the experimental group also had to focus upon the English illegal consonant clusters appearing between words (e.g. *bad lady*).

Stage 3 (Week 5 onwards): In-class practice: students were asked to spot clusters online. Unlike the situation in the previous stage, in which student could play and replay the material to spot the illegal cluster, at this stage new material was played only once and students had to spot the between-words illegal clusters. Once a student spotted an illegal cluster he raised his hand and the researcher stopped the tape and asked the student to identify the cluster.

Two observations on the treatment should be noted here. Firstly, there was the problem of assimilation, which was expected. Students reported that, in a large number of between-words illegal clusters, one of the two sounds in the cluster was completely lost (e.g. bad guy /bægai/). The second problem was the slow progress made by subjects in their ability to spot illegal clusters rapidly.

3.6. Post-test

The treatment ceased after week 8 and then post-testing subjects in both groups started immediately. Approximately nine weeks separated the administration of the pre-tests and the post-tests, thus reducing the possibility that the outcomes evidenced were the result of memory or practice effects. The task and the same procedure used in the pre-test were used in the post-test. The only difference is that native speakers were not post-tested.

4. Results and discussion

4.1. Pre-tests

Practice items and real-word fillers were excluded from analysis. Errors were analysed where there was no response or a response was either not accompanied by a correct oral response or accompanied by a wrong one. RTs were measured by the software in milliseconds. Table 1 shows mean RTs measured from word offset and error rate for each listener

Table 1
Mean RTs in milliseconds measured from word offset and mean percentage of errors in the pre-test for native control, non-native control and non-native experimental groups in four different boundary conditions

Boundary type	Common Boundary	English Boundary	Arabic Boundary	No Boundary
(a) RTs in ms				
Native speakers	569	697	944	937
Non-native control	1114	1281	1245	1467
Non-native experimental	1137	1246	1283	1398
(b) % of Errors				
Native speakers	11	15.7	31.5	33.3
Non-native control	23.3	39.4	33.9	60
Non-native experimental	26.6	37.2	37.2	52.2

group in the four boundary conditions. In the following discussion, effects are considered statistically significant at $p \leqslant 0.05$.

Two one-way ANOVAs (one for RTs and another for error rates) were conducted to establish if there was a significant difference between the performances of the three groups in the same boundary conditions. Results of post hoc tests showed that there was no significant difference between non-native groups' RTs ($F(11, 196) = 10.56, p > 0.05$) and error rates ($F(11, 196) = 6.74$, $p > 0.05$) in the same conditions. These results also showed that native speakers produced significantly faster RTs in all conditions as compared to both groups of non-native speakers but lower error rates only in the English Boundary and No Boundary conditions. In the Common Boundary and Arabic Boundary conditions, there was no significant difference between the three groups' error rates. These findings show that native speakers' proficiency helped them react faster than non-native speakers. On the other hand, it seems that non-native speakers managed to exploit the boundaries which the Common and Arabic conditions involved and therefore reduced their error rate in these two conditions.

Four further one-way ANOVAs compared RTs and error rates for the Common, English and Arabic Boundary conditions with those in the No Boundary condition. Test results showed that native speakers were significantly faster ($F(3, 44) = 3.31$, $p < 0.05$) and more accurate ($F(3, 44) = 2.84$, $p < 0.05$) in the Common Boundary and English Boundary conditions than in the No Boundary condition, although the difference in RTs between the English Boundary and No Boundary conditions narrowly missed significance ($F(3, 44) = 3.31$, $p = 0.065$). However, in the Arabic Boundary condition there was no significant difference between the RTs ($F(3, 44) = 3.31$, $p = 0.837$) and error rates $F(3, 44) = 2.84$, $p = 0.835$).

The test results showed that both non-native groups were faster ($F(7, 152) = 2.93$, $p < 0.05$) and more accurate ($F(7, 152) = 6.18$, $p < 0.05$) in the Common Boundary condition than in the No Boundary condition. In the English Boundary condition, both groups were more accurate than in the No Boundary condition ($F(7, 152) = 6.18$, $p < 0.05$), though not faster. Lastly, in the Arabic Boundary condition, both groups were significantly more accurate. However, only one group (the non-native control group) was significantly faster ($F(7, 152) = 2.93$, $p = 0.027$) in this condition.

These results indicate that the Common Boundary condition facilitated phonotactic processing most strongly for the non-native speakers. The Arabic Boundary condition also facilitated processing, but to a lesser degree which did not show as faster RTs for the non-native experimental group. The fact that there was also an effect of the English Boundary condition (though a weaker one and one that showed in error rate but not in RT) seemed to suggest that the non-native groups had already implicitly acquired some knowledge of English phonotactics. It seems that the Word Spotting Task requires a high level of proficiency, which our non-native subjects lacked, thus producing a ceiling effect which could only be overcome when the Arabic and English phonotactic constraints joined forces in the Common Boundary condition.

4.2. Post-tests

We now turn to an examination of the results of the treatment. Fig. 1 shows the results of the post-test for the two non-native groups, expressed as mean percentage reduction in RTs and error rate in the post-test in all four conditions (Common, English, Arabic and No Boundary) compared to the pre-test results.

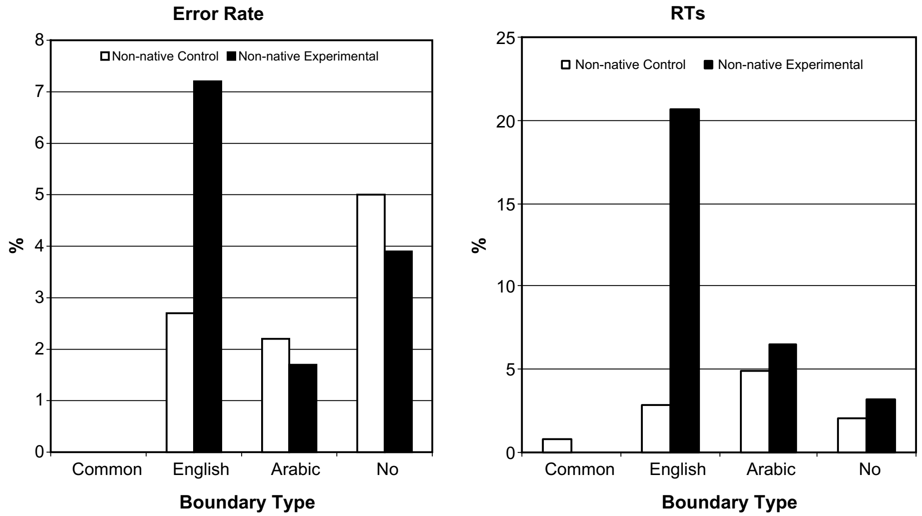

Fig. 1. Post-test results of the two non-native groups expressed as mean percentage reduction in RTs and error rate in all four conditions (Common, English, Arabic and No) compared to pre-test results. When the bar does not show as in the common boundary condition this means that there was an increase rather than a reduction in the post-test in RTs or error rate for that condition.

4.2.1. Non-native control

Two one-way ANOVAs were conducted to compare the non-native control group's post-test RTs and error rate to those in their pre-test results. The post-test results showed that reductions in RTs ($F(11, 196) = 11.87$, $p > 0.05$) and error rates ($F(11, 196) = 7.21$, $p > 0.05$) were not statistically significant when compared to pre-test results. In brief, non-native group's RTs and error rates had not changed at post-test.

4.2.2. Non-native experimental

Further one-way ANOVAs were conducted to compare the non-native experimental group's post-test RTs and error rates to those of the pre-test. Post hoc test results showed a statistically significant reduction ($F(11, 196) = 9.40$, $p < 0.05$) in their RTs in the English Boundary condition.

Post-test results for the experimental group were then compared with the earlier results obtained for the native speakers. Their RTs remained significantly ($F(11, 196) = 9.40$, $p < 0.05$) slower than those of native speakers in all conditions. So far as error rate was concerned, it remained significantly higher in the No Boundary condition and insignificant in the Arabic Boundary condition. However, it was noted that the difference in error rate in the English Boundary condition was no longer significant ($F(11, 196) = 5.20$, $p = 0.084$). In brief, the non-native experimental group showed signs of improvement in both RTs and error rate in the English Boundary condition.

5. General discussion

Let us first review our native control and pre-test findings. Results from the native speakers of American English lend support to previous findings (e.g. McQueen, 1998;

Weber and Cutler, 2006), that L1 listeners use their L1 phonotactic knowledge in lexical segmentation. These native speakers were faster and more accurate in detecting a word aligned with a boundary constraint common to English and Arabic (e.g. /ʒiːtlɔːrd/) than when it was not aligned (e.g. /ʒiːflɔːrd/). They were also faster and more accurate in detecting a word aligned with an English Boundary constraint (e.g. /ʒiːdlɔːrd/) than when it was not. Moreover, native subjects were faster than EFL learners in detecting words in all conditions. This suggests that a difficulty for EFL learners is the fact that their bottom-up word recognition skills have not achieved automaticity.

In addition, results from our non-native groups confirm Weber and Cutler's findings that L2 listeners transfer their L1 phonotactic constraints and use them when segmenting speech in an L2. Our EFL learners were faster and more accurate in detecting a word aligned with an Arabic Boundary constraint (e.g. /ʒiːblɔːrd/) than when it was not. The most interesting pre-test result, however, is that the low-intermediate level EFL learners seem to have implicitly acquired some knowledge of English phonotactic constraints which they use when segmenting speech in English. They were more accurate in detecting a word aligned with an English Boundary constraint (e.g. /ʒiːdlɔːrd/) than when it was not. This is also confirmed by the fact that subjects were on average fastest and most accurate when Arabic and English phonotactic constraints joined forces in the Common Boundary condition.

These results show that EFL learners, like L1-learning infants (Jusczyk et al., 1993), are able to explore the phonotactic regularities of English after exposure to a relatively small amount of input. We also have evidence that they have started using this knowledge on-line in lexical segmentation. There remains the problem with L2 learners that they have not lost L1 phonotactic constraints, a factor which interferes with the acquisition of L2 phonotactic constraints, especially in the case where there is little daily contact time with the L2. It is here that the role of awareness raising about these constraints and their use in lexical segmentation becomes vital.

Our results suggest that, given little input and L1 influence, teaching phonotactics provides a shortcut to using L2 English constraints in lexical segmentation by directing learners' attention to the presence of these cues. The post-test results are promising. The performance of the non-native experimental subjects improved in that they became faster in detecting words in the English Boundary condition after the treatment. However, although their error rate did not become significantly lower in the post-test, it became statistically indistinguishable from that of the native speakers. Recall that, whereas some of the clusters in the list presented to the experimental group during the treatment were also illegal in Arabic, the only clusters from the list used to form a boundary constraint in the Word Spotting Task were those illegal solely in English (/dl/, /mr/, /bw/). That is why an improvement was expected to occur in this condition only.

These results cannot be attributed to test or practice effects. First, training during the treatment period did not resemble the test. During training, subjects were asked to spot illegal clusters across word boundaries whereas the Word Spotting Task required them to spot target words. Second, given the long time between the two tests, these results cannot be a test effect. If they were, we would expect similar gains in the non-native control group's performance. Similarly, if they were the result of a test effect, we would expect gains in the scores of all conditions. Clearly, this is not the case, as the experimental group's scores deteriorated in the post-test in the Common Boundary condition.

However, the implications of these results should not be overestimated. First, the advantage of using phonotactic constraints in connected speech is limited in that not all word boundaries are marked by phonotactic cues and because some illegal clusters can be assimilated (e.g. bad guy /bægai/). Using a computer speech recognizer, it was shown by Harrington et al. (1989) that the faster the speech the more the variability in the signal limits the value of consonant sequences as segmentation cues. Therefore, future research might examine the effectiveness of phonotactic cues in segmentation by using tasks which include longer stretches of naturalistic connected speech[4]. Secondly, we should not overlook the fact that in the post-test the experimental group's RTs in the English Boundary condition were still significantly longer than the native speakers'. This suggests that the experimental group's lexical segmentation processes were still not as automatic as the native speakers'. Future research might therefore investigate the effect of longer training. Additionally, a delayed post-test could provide some information about the source of improvement. Is it a temporary training effect? Or is it a lasting effect such that learners will notice illegal clusters in subsequent input thereby accelerating automization of their lexical segmentation routines?

6. Conclusion

Our non-native speakers transferred their L1 phonotactic constraints when listening to English even when these phonotactics did not assist in processing the target language. Phonotactic training should therefore form part of L2 ear training and pronunciation programs. With appropriate practice, EFL learners can perhaps be trained to perceive and pronounce without epenthetic vowels the legal English consonant clusters that are illegal in their native language. Such training might play a role in limiting L1 transfer in auditory processing.

Researchers such as Field (2003) and Hulstijn (2001) have called for greater attention to be paid to L2 learners' bottom-up listening skills. The cues used in lexical segmentation vary from one language to another and constitute a source of listening difficulty for L2 learners. The current study showed that with appropriate training EFL learners can be taught to use certain English-specific phonotactic cues. Future research might consider the effects of training in the recognition of other cues such as stress and allophonic variation.

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Appendix A. Sample of target-bearing stimuli used in the Word Spotting Task

Common Boundary	English Boundary	QA Boundary	No Boundary	Embedded Target Word
1. Embedded words with initial /l/				
fautlɔːŋ	faudlɔːŋ	faublɔːŋ	fauflɔːŋ	Long
hɔɪtlɑːrʤ	hɔɪdlɑːrʤ	hɔɪblɑːrʤ	hɔɪflɑːrʤ	Large
2. Embedded words with initial /r/				
fausraɪs	faumraɪs	fauʃraɪs	faugraɪs	Rice
hɔɪsrʌst	hɔɪmrʌst	hɔɪʃrʌst	hɔɪgrʌst	Rust
3. Embedded words with initial /w/				
ðaunweɪʤ	ðaubweɪʤ	ðausweɪʤ	ðaukweɪʤ	Wage
ðuːnwɔːk	ðuːbwɔːk	ðuːswɔːk	ðuːkwɔːk	Walk

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