A usage-based account of /r/-liaison in Standard British English

Radoslav Pavlik

Address:
Institute of Philological Studies,
Faculty of Education,
Comenius University in Bratislava,
Račianska 59,
813 34 Bratislava,
Slovak Republic

E-mail: Radoslav.Pavlik@fedu.uniba.sk
Phone: +421 908 279 327

Abstract
The paper looks at the phenomenon of /r/-liaison in Standard British English and aims to assess the degree to which usage-based predictors, such as word frequency or collocability, contribute to its patterning and distribution. The sample consisting of 22 speakers is coded for the occurrence of [ɾ] and Ø in the potential /r/-liaison sites and the influence of the various phonetic, grammatical, and usage-based factors is tested and evaluated by means of a mixed-effects variable rule analysis. The present account tries to explain how the diachrony and synchrony of language use have given rise to linking and intrusive /r/ in British English. It is shown that a large part of the patterning of both /r/-liaison types can be explained through the influence of usage-based and cognitive determinants. The findings of the study lend support to functional (cognitive) models of language and speech production, and demonstrate that /r/-liaison cannot be adequately explained in purely abstract (generative) phonological terms.
1. Introduction

1.1 Definition of \(/r/-liaison\)

The term \(/r/-liaison\) or \(/r/-sandhi\) refers to a type of transition between two succeeding morphemes, where the \(/r/-sound\) is inserted at the end of the first morpheme (ending in a non-close vowel), if the second morpheme begins with a vowel. In the non-rhotic varieties of English, two separate kinds of \(/r/-liaison\) are usually distinguished: linking \(/r/\) and intrusive \(/r/\).

Linking is defined as a process of inserting a \(/r/-sound\) after morphemes ending in monophthongs /ə/, /ɔː/, /ɜː/, /ə/ and polyphthongs (diphthongs and triphthongs) ending in /ə/, in which the historically attested final r is no longer pronounced. In Standard British English pronunciation (RP), linking \(/r/\) occurs (or might occur) in the following contexts:

<table>
<thead>
<tr>
<th>Morpheme-final</th>
<th></th>
<th>Linking (/r/)</th>
</tr>
</thead>
<tbody>
<tr>
<td>diachronically elided (/r/)</td>
<td>car /kɑː/</td>
<td>car industry /ˈkɑːr.ɪndəstrɪ/</td>
</tr>
<tr>
<td>/ɑː/</td>
<td>war /wɔː/</td>
<td>war against /ˈwɔːr.ge(ɪ)nst/</td>
</tr>
<tr>
<td>/ɔː/</td>
<td>occur /əˈkɔː/</td>
<td>occur infrequently /əˌkɔːr.iˈfriːkwəntli/</td>
</tr>
<tr>
<td>/ə/</td>
<td>winner /ˈwɪnə/</td>
<td>winner of /ˈwɪnər.əv/</td>
</tr>
<tr>
<td>polyphthongs ending in /ə/</td>
<td>air /eə/</td>
<td>air attacks /ˈeərə.tæks/</td>
</tr>
</tbody>
</table>

Intrusive \(/r/\), on the other hand, is a type of liaison that is said to occur in similar contexts as linking \(/r/\) (i.e. in morphemes ending in /ɑː/, /ɔː/, /ə/ and /ɪə/ followed by a vowel), the difference being that the first morpheme in the sequence does not have a corresponding r letter in the spelling (Jones, 1972; McMahon, 2000; Cruttenden, 2014).
The occurrence of the intrusive /r/ has normally been attributed to analogy, i.e. it is claimed that this type of liaison arises from the tendency to treat the morpheme-final homophony as phonologically equivalent (Wells, 1982; Gick, 1999; Sóskuthy, 2013; Cruttenden, 2014). In this paper, /r/-liaison will be analysed from the point of view of several predictors, and various claims regarding its diachronic and synchronic determinants will be investigated.

1.2 Previous research

Empirical phonetic research into linking and intrusive /r/ carried out so far has been focused on a variety of issues. For the sake of systematicity, they are divided here into four areas.

(a) Phonetic factors

As far as the segmental phonetic features are concerned, /r/-liaison has been studied in terms of the degree of /r/-tongue constriction and /r/ length. In particular, Hay & Maclagan (2012) found that the more often a speaker uses linking /r/ in current New Zealand English, the greater the tongue constriction of /r/ tends to be. The length of intrusive /r/ and its role in perception has been evaluated by Tuinman, Mitterer, & Cutler (2011). Their analyses revealed that intrusive /r/ is significantly shorter than canonical /r/.

Other empirically studied phonetic factors include the quality of neighbouring vowels and the occurrence of /r/ in the preceding syllable. For example, it has long been hypothesized that intrusive /r/ occurs most frequently after /ə/ and least frequently after /ɔː/ (Jones, 1972; Wells, 1982; Cruttenden, 2014). However, other accounts (Brown, 1988; Spencer, 1996) state the exact opposite, i.e. they claim that the preceding /ɔː/ triggers the realization of intrusive /r/. For instance, Hay & Sudbury (2005) have shown that in 19th century New Zealand English, back vowels (preceding and following the /r/-liaison site) favour the use of linking /r/, and the
preceding /ɔː/ disfavours the use of intrusive /r/. A different result is reported by Hannisdal (2006) for her sample of TV newsreaders. She observed that intrusive /r/ is more likely to occur after /ɔː/ and /əː/ than after /ə/. Alternatively, some studies report no influence of preceding vowels on the realization of intrusive /r/, notably in Derby and Newcastle English (Foulkes, 1997) and Standard British English (Mompeán & Mompeán-Guillamón, 2009).

Furthermore, linking /r/ and intrusive /r/ have been claimed to be realized less frequently when they are preceded by another /r/ (cf. Jones, 1956, 1972; Lewis, 1975; Wells, 1982). This claim was tested by several researchers. For example, in their 19th century New Zealand English sample, Hay & Sudbury (2005) and Mompeán & Mompeán-Guillamón (2009) observed no relation between the presence of the preceding /r/ and the realization of /r/-liaison. On the other hand, Hannisdal (2006) claims that linking and intrusive /r/ tend to be avoided when preceded and/or followed by another /r/.

Finally, it has been suggested that stress might influence the use of linking /r/. Specifically, Jones (1972) hypothesizes that linking /r/ is avoided when followed by an unstressed syllable, while Foulkes (1997) and Allerton (2000) claim that linking /r/ is more likely to be avoided before a stressed syllable. The only study testing this hypothesis is Hannisdal (2006), who discovered that both linking and intrusive /r/ are disfavoured before a stressed syllable in the speech of TV newsreaders, thus lending support to the claim made by Foulkes (1997) and Allerton (2000).

(b) Grammatical factors

Lexical status of words (lexical words vs. grammatical words) has also been hypothesized to have an influence on the use of linking /r/. The two studies testing this hypothesis produced conflicting results. In particular, in their 19th century New Zealand English sample, Hay & Sudbury (2005) found no influence of lexical status on /r/-liaison, whereas Hannisdal (2006) determined that a combination of two lexical words disfavours the use of linking /r/ in standard British English. In addition to this, it has been determined that intrusive /r/ in derived and inflected words is more likely to occur when the suffix (beginning with a vowel) is more productive, i.e. intrusive /r/ is favoured before suffixes such as -ing and -ish in modern New Zealand English (Hay & Maclagan, 2010).
(c) Usage-based factors

It has been suggested that lexical frequency and collocability of words might have an influence on the realization of /r/-liaison. For instance, Brown (1988) hypothesizes that the frequency of occurrence of words may influence the realization of intrusive /r/, which might be more stigmatized (and therefore avoided) in more frequent words. So far, the only empirical study assessing the influence of word frequency on /r/-liaison is Hay & Sudbury (2005). They found that in 19th century New Zealand English, high lexical frequency of the following word disfavours the use of linking /r/. On a related subject, Hay and Maclagan (2012) have found out that the more often a word occurs before vowels, the more often it attracts [ɹ] when it is before a vowel.

As far as collocability of words is concerned, it has been claimed that linking /r/ is used more frequently in common expressions, such as for instance, after all, etc. (Jones, 1956; Lewis, 1975). This claim was tested by Hay & Sudbury (2005) and, in a limited way, also by Mompeán & Mompeán-Guillamón (2009), but only for linking /r/. Both studies have concluded that linking /r/ is more common in collocations than in free combinations of words.

(d) Sociolinguistic factors

Age/birthdate

A study by Bauer (1984) testing the sample of 37 RP-speakers revealed that younger speakers (born after 1940) tended to use more intrusive /ɹ/ than older speakers. On the other hand, in their 19th century New Zealand English sample, Hay & Sudbury (2005) found no influence of birthdate on the frequency of realization of linking /r/ (intrusive /ɹ/ was not tested due to small sample size). Foulkes (1997) tested the influence of age on the English spoken in Derby and Newcastle. While the Derby data showed no influence of age on linking or intrusive /ɹ/, the Newcastle corpus revealed that linking /ɹ/ was used more by older speakers.

Gender

Most studies dealing with the analysis of /ɹ/-liaison in English have concluded that there is no difference between males and females in the way they treat linking and intrusive /ɹ/. These

Class/education

Since intrusive /r/ has long been stigmatized, especially in standard British English (cf. Jespersen, 1961; Jones, 1956, 1972; Lewis, 1975, 1977; Pring 1976; Fox, 1978; Cruttenden, 2014), it is logical to assume that it will be less frequent with speakers of higher social status. This hypothesis is supported by the data on Newcastle English, where intrusive /r/ is used more often by working-class speakers, and linking /r/ is used more by middle-class speakers (Foulkes, 1997). Similarly, Tan (2012) has determined that in Singapore English, speakers with lower education use intrusive /r/ more frequently than educated speakers. On the other hand, English varieties spoken in Norwich and Derby show no influence of class on /r/-liaison (Trudgill, 1974; Foulkes, 1997).

Ethnicity

Research on the influence of ethnic factors on /r/-liaison is practically non-existent, the one exception being the study by Britain & Fox (2009). In their work on the resolution of V-to-V hiatus in different English varieties they found that in the London Borough of Tower Hamlets, white British and mixed-race boys produced linking /r/ more frequently than Bangladeshi boys.

Geographical region

Although there are many sources describing the behaviour of /r/-liaison in different varieties of non-rhotic English, only the studies based on corpus analysis are mentioned here. Most research into /r/-liaison, as might be expected, has been done on the language varieties spoken in England: Standard British English (Bauer, 1984; Hannisdal, 2006; Mompeán &
Mompeán-Guillamón, 2009; Mompeán & Gómez, 2011; Pavlík 2011), Norwich English (Trudgill, 1974), Derby and Newcastle English (Foulkes, 1997), and the Fens and London English (Britain & Fox, 2009). Other varieties of English include New Zealand English (Hay & Sudbury, 2005; Hay & Maclagan 2010, 2012) and Singapore English (Tan, 2012).

1.3 Formal and functional approaches to /r/-liaison

Although the phenomenon of /r/-liaison in English has received a lot of attention over the past few decades, it is still hotly debated how it should be approached in terms of phonological theory.

Traditionally, /r/-liaison has been dealt with within the framework of formal linguistics, e.g. generative phonology and lexical phonology. From this perspective, surface forms are generated from underlying representations by means of rules. As far as /r/-liaison is concerned, three main types of mechanism generating forms with either [ɹ] or Ø have been proposed: (a) deletion (/r/ is underlingly present and it is deleted in some environments), (b) insertion (/r/ is synchronically absent and it is inserted in specific contexts), and (c) a combination of the two possibilities (cf. Broadbent, 1991; McCarthy, 1993; Giegerich, 1999; McMahon, 2000; Orgun, 2001; Uffman, 2007; Heselwood, 2009, inter alia). All three mechanisms, however, are based on the assumption that there is only one abstract phonological form from which the specific realizations containing [ɹ] or Ø are derived. Since the main goal of formal phonological theories is to construct synchronic models of competence, the considerations of function, usage, and other factors are normally excluded (Walker, 2012; Sóskuthy, 2013). The upshot of such an approach is that /r/-liaison has been treated as a categorical abstract phenomenon.

In recent years, the functional approach to the analysis of /r/-liaison has been gaining ground. Specifically, usage-based and cognitive explanations have been proposed to explain some aspects of the patterning and distribution of /r/-liaison in English (Hay & Sudbury, 2005; Mompeán & Mompeán-Guillamón, 2009; Hay & Maclagan 2012; Sóskuthy, 2013). Such accounts are based on the general tenets of cognitive functional linguistics, which states that language is part of other human cognitive abilities (it is not an autonomous cognitive faculty), and the knowledge of language emerges from language use (Croft & Cruse, 2004; Bybee &
Usage-based theory tries to model linguistic phenomena in terms of usage patterns, frequency of occurrence, categorization, language variation, and language change. Within this framework, surface forms are not generated from underlying representations, but every word (or phrase) in the lexicon consists of a cloud/cluster of phonetic exemplars (variants) containing detailed information about the context in which they are used (Bybee, 2001, 2013). From this perspective, it is misguided to ask what the abstract underlying phonological representation of /r/-liaison is, or whether /r/ is deleted or inserted in particular contexts.

The present paper is an attempt to determine how much of /r/-liaison patterning can be explained and modelled by means of usage-based factors (e.g. token-frequency, usage patterns, speech rate, etc.), as opposed to phonetic and grammatical factors (e.g. sound environment, stress, word type, etc.).

1.4 Research tasks and hypotheses

The paper is concerned with three main tasks. First, it tries to determine the degree to which usage-based factors contribute to the patterning of linking and intrusive /r/ in British English. Second, it tries to show that the current variable distribution of linking /r/ (a remnant of the historical /r/ in morpheme-final position), and intrusive /r/ (the pendant of linking /r/ produced by analogical extension) can be explained in terms of token-frequency effects. Third, it attempts to find out whether linking /r/ and intrusive /r/ are influenced by the same set of factors. In line with these tasks, the following hypotheses have been formulated:

(a) All previous studies of /r/-liaison have shown that linking /r/ is more common than intrusive /r/. It is therefore hypothesized that the present study will confirm this general trend.

(b) The degree of /r/ preservation in V-to-V contexts is normally variable. For example, linking /r/ is fully preserved in one-word lexemes (simple, derived and compound words), but variable in phrases written as two separate elements (Heselwood, 2006, 2009; Mompeán & Mompeán-Guillamón, 2009). The absence of /r/ in such cases might be interpreted as the historical /r/-loss which is still in progress. According to usage-based theory, high-frequency sequences are more entrenched in their morpho-syntactic structure and therefore resist change (Bybee & Beckner,
2009, Bybee 2013). This is due to the conserving effect of token-frequency. A prediction can therefore be formulated that /r/-loss in V-to-V contexts will depend on the token-frequency of such usage patterns. Put differently, if /r/ is found to be more entrenched in high-frequency patterns than in low frequency patterns, this /r/-link could be interpreted as the remnant of the historical /r/ which continues to resist the /r/-loss in British English.

(c) It has been determined by several studies that vowel context seems to have an influence on the realization of /r/-liaison. However, the current articulatory and acoustic explanations are incomplete in that they have taken into consideration only some selected vowel types, e.g. back vowels and /ə/. No other explanations have yet been considered. If different types of vowels contribute differently to the /r/-liaison realization, what factors, other than phonetic, may determine whether [ɹ] or Ø is used? The hypothesis proposed here is that the use or non-use of an /r/-link may be correlated with the token-frequency of particular /Vr/ and /rV/ sequences in connected speech. For instance, if it is determined that /r/-liaison is disfavoured when followed by the open front vowel /æ/, the token-frequency of the sequence /(C)ræ/ in connected speech should also be disfavoured in relation to other /(C)rV/ sequences.

(d) There have been attempts to evaluate the role of the token-frequency of the words preceding and following the /r/-liaison site (Hay & Sudbury 2005). From the viewpoint of usage-based theory, however, different predictions will be made. In particular, it is predicted that neither the preceding, nor the following word will have any direct influence on the realization of /r/. If linking /r/ tends to be preserved in high-frequency usage patterns, then it must be studied within such patterns (collocations, word combinations). Regardless of their token-frequency, single words, whether preceding or succeeding the liaison site, should not have any direct frequency-related influence on the realization of /r/, because the liaison site occurs between the two words (Bybee, 2001).

(e) The influence of speech rate on the distribution of r/-liaison in English has not yet been tested. Since the present sample consists of spoken texts produced by a relatively homogeneous group of BBC Radio newsreaders, no dramatic differences in speech rate should theoretically be observed.
If such differences in tempo do emerge, however, it could be hypothesized that faster speech may reduce the likelihood of a pause made at the linking site and make the word combination tighter, thus increasing the chance of /r/ realization (McMahon, 2000).

2. Method

2.1 The sample

The sample used in this research consists of 22 newscasters (10 females and 12 males) presenting short top-of-the-hour news bulletins on BBC World Service, BBC 2, and BBC London radio stations. Approximately 90 minutes of connected speech per speaker were analysed, amounting to about 33 hours of recorded material. Around 30 consecutive tokens were collected per speaker (separately for each /r/-liaison type). Omitted were those /r/-liaison tokens where a breath pause was made at the /r/-liaison site, or when a pause occurred that was longer than 100ms (thus indicating a certain hesitation on part of the speaker).

Due to the fact that the BBC now admits announcers with regional accents, certain criteria had to be used to ensure a relative homogeneity of the sample. Only the speakers that can be characterized as having an RP accent have been selected. The choice was based on the following indicators (Wells, 1982; Trudgill, 2008):

(a) The newscasters were native speakers of Standard British English and showed no speech impediments.
(b) Their accent was non-rhotic (or, more correctly, partially rhotic), i.e. the orthographic ‘r’s in words like war, far, here, better, etc. were not pronounced when followed by a consonant or a pause.
(c) The vowels /iː/ and /uː/ were relatively monophthongal.
(d) The diphthongs /eɪ/, /aʊ/, /əʊ/, and /ɑː/ were not ‘Cockneyfied’.
(e) The vowel in words like past, dance, laugh, etc. was pronounced as /ɑː/ rather than /æ/.
(f) The vowel in words like up, cut, run, etc. was pronounced as /ʌ/ rather than /ʊ/.
The previous studies investigating /r/-liaison with samples of BBC speakers used a more varied range of subjects than the present study. In this research, only so-called newscasters (radio presenters of top-of-the-hour news bulletins) are analysed. Mompeán & Mompeán-Guillamón (2009) and Mompeán & Gómez (2011) studied the speech of BBC radio correspondents, which is a much larger and a much more diverse sample, and Hannisdal (2006) looked at the speech of TV newsreaders.

The main advantage of the current sample, in comparison with other studies of /r/-liaison in Standard British English, is that it uses more tokens of intrusive /r/ than any of the previous studies, and it is also more balanced, i.e. the difference in size between intrusive /r/ and linking /r/ samples is smaller (see Table 1) and the intrusive /r/ data are better distributed across the individual levels of the tested predictors (in comparison with the smaller intrusive /r/ samples tested in previous studies).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>linking /r/ tokens</td>
<td>276</td>
<td>6045</td>
<td>678</td>
<td>1476</td>
<td>300</td>
<td>647</td>
</tr>
<tr>
<td>intrusive /r/ tokens</td>
<td>74</td>
<td>558</td>
<td>148</td>
<td>399</td>
<td>300</td>
<td>613</td>
</tr>
</tbody>
</table>

Table 1. Token frequencies of linking and intrusive /r/ in the studies analysing Standard British English.

The present research is concerned with inter-word /r/-liaison only. That means that linking and intrusive /r/ found within individual words and compounds will not be studied. This decision is based on the following reasons:

(a) The intra-word realization of linking /r/ has been shown to be categorical (always realized as [ɹ]), when the linking-/r/ site is preceded or followed by an affix, e.g. overact, interactive, tolerable, boring, etc. (Giegerich, 1999; McMahon, 2000; Heselwood, 2006, 2009; Mompeán & Mompeán-Guillamón, 2009).

(b) The cases of inflected, derived, and compound words with a possible /r/-intrusion site (e.g. drawing, law-abiding, etc.), are so infrequent that it was impossible to obtain a large enough sample in the database analysed in this study.
The cases of a potential intrusive /rl/ in compound words (whether one-word compounds, hyphenated compounds or compounds written as two separate elements) were extremely limited in the sample. Despite the size of the corpus, only 10 tokens were found, e.g. media access, media empire, cholera epidemic, etc. This made the comparison with the linking /rl/ sample impossible. For this reason, the predictor Compound type was not tested for in the analysis. To make the samples of intrusive /rl/ and linking /rl/ compatible in this respect, the number of compounds in the linking /rl/ data-set was also limited to 10 tokens. Due to the sizes of the two /rl/-liaison samples (647 and 613 tokens), the small number of compounds (most of them written as two separate words) included in the analysis is not expected to skew the results in any way.

2.2 Variables

2.2.1 Dependent variable

Every instance of a /rl/-liaison site was inspected acoustically by the Praat software in terms of spectral characteristics (spectrogram), frequency changes (pitch), and energy envelope (intensity). Although several different realizations of /rl/-liaison were detected, the sample was coded for two variants only: postalveolar approximant [ɹ] and Ø (all non-rhotic realizations were treated as an /rl/-less link).

When the /rl/-liaison variable was realized as a rhotic consonant, its most common form was a postalveolar frictionless approximant [ɹ]. It was identified both perceptually and acoustically (by means of the lowered F2 and F3 formants). Other typical acoustic features were the regular structure of voicing pulses, and the relatively stable pitch and intensity contours (Fig. 1).
Fig. 1 Spectrograms, pitch contours, and intensity envelopes of the phrases their own (linking /r/) and media access (intrusive /r/). The shaded areas mark the place of the /r/-liaison site, which is realized as [ɹ].

The reliability of the coding of the /r/-liaison variable into [ɹ] and Ø variants was checked independently on two sub-sets of the main sample by another trained phonetician. The inter-coder agreement was measured statistically by means of Cohen’s kappa coefficient (Cohen, 1960). In both cases, the inter-coder agreement was very high (linking /r/ context: $\kappa = 0.8$; intrusive /r/ context: $\kappa = 0.94$).

2.2.2 Independent variables – predictors

The predictors investigated in this paper have been divided into two types: 1. Phonetic and grammatical (Preceding vowel, Following vowel, Neighbouring /r/, Stress, Word type), 2. Usage-based (Usage patterns, Vowel type frequency, Word combination frequency, Word frequency, Speech rate). Sociolinguistic factors, such as Age and Gender will not be discussed in
this paper, since most studies have determined that these predictors have no effect on the patterning of linking and intrusive /r/ in Standard British English.

(a) **Preceding vowel**

The influence of the preceding vowel context (i.e. a word ending in a non-high vowel) was tested in terms of 3 categories:

1. /ɑː/ (e.g. *Panama and beyond, Maracana in Rio, car industry, the star of the*, etc.)
2. /ɔː/ (e.g. *law aimed at, to draw attention, four of those, war on*, etc.)
3. Mid-central monophthongs /ə/, /ɜː/, and polyphthongs ending in /ə/ (e.g. *militia in the city, actor in the, Utoya island, a year after, their own*, etc.)

In the intrusive /r/ sample, only 7 tokens of the /ɑː/ vowel have been found. Instead of deleting them, these tokens were merged with vowel /ɔː/ because the hypothesis often posited is that these two vowels behave similarly in /r/-liaison patterning, and differ from the final schwa. This new level with /ɑː/ and /ɔː/ combined has been termed *back vowels*. 

(b) **Following vowel**

Due to the fact that the vowel following the /r/-liaison site can be any one of the 20 English vowel phonemes (+ triphthong combinations), it was necessary to group these sounds into a smaller number of categories. After testing several different categorizations, the one where the proportions of [ɪ] and Ø in the categories differed statistically the most (and thus had the highest explanatory power) has been chosen. The categories (variants) are the following:

1. Close front vowels /ɪ/, /iː/, /ɪə/ (e.g. *the law is, actor in the, car industry, for economic*, etc.)
2. Mid front vowels /e/, /eɪ(ə)/, /eə/ (e.g. *Fukushima area, Africa editor, over eighteen*, etc.)
3. Open front vowel /æ/ (e.g. *media access, similar action*, etc.)
4. Mid central vowels /əl, /ɔːl, /əʊ(ə)/ (e.g. area of the, in Gaza earlier, member of the, etc.)

5. Open central and open back vowels /ʌl, /aʊ(ə)/ (e.g. idea under consideration, nuclear arsenals, etc.)

6. Close-mid back and open back vowels /ɒl, /ɑːl, /aʊ(ə)/ (e.g. law on, umbrella organization, etc.)

Since there was an extremely low number of words beginning with /ʊl, /uːl, and /ʊəl, the category close back vowels could not be tested. These tokens were excluded from the analysis.

(c) Neighbouring /r/
This variable has been divided into 3 variants. Only the /r/ phonemes actually pronounced were taken into consideration, i.e. silent orthographic rs have not been included.

1. Preceding /r/: /r/ sounds occurring 1 or 2 syllables before the /r/-liaison site (e.g. cholera epidemic, Russia and Japan, etc.)

2. Following /r/: /r/ sounds occurring 1 or 2 syllables after the /r/-liaison site (e.g. China is preparing, their area, etc.)

3. /r/ preceding and following the /r/-liaison site: /r/ sounds occurring 1 or 2 syllables before and after the /r/-liaison site (e.g. forces in Syria are reported, gorilla at Bristol ZOO, etc.)

4. No /r/ in the vicinity of /r/-liaison site (e.g. the idea of, media attention, after it was, etc.)

For the linking /r/ sample, the variant /r/ preceding and following the linking-/r/ site contained only 3 tokens and this variant was therefore not included in the final analysis.

(d) Stress
The only study testing the influence of stress on /r/-liaison (Hannisdal, 2006) worked with only two levels of stress – stressed vs. unstressed syllables. However, the situation in connected
speech is usually more complex. All contexts with linking and intrusive /r/ have therefore been analysed acoustically in terms of the following stress levels:

(a) unstressed syllables – syllables carrying neither lexical stress nor post-lexical sentence stress
(b) stressed syllables – syllables carrying lexical stress
(c) stressed syllables with post-lexical sentence stress (pitch-accented syllables).

These three categories can be combined into the following levels:

1. unstressed syllable + unstressed syllable (e.g. 'Russia and Ja'pan; 'winner of the, etc.)
2. unstressed syllable + pitch-accented syllable (e.g. from the Fuku'shima 'area; 'popular 'uprising, etc.)
3. unstressed syllable + stressed syllable (e.g. 'talks in Geneva, aimed at; for 'Ivory Coast, etc.)
4. pitch-accented syllable + unstressed syllable (e.g. the i'dea of the; a year a'go, etc.)
5. stressed syllable + unstressed syllable ('war of words, etc.)

Other combinations contained fewer than 10 tokens and have therefore been excluded from the analysis.

(e) Collocability

Collocations (multiword phrases, prefabs) are defined as ready-made chunks of words (relatively transparent in their meaning) which are not produced by means of the application of generative rules, but which are stored in the memory as prefabricated wholes (Fernando, 1996; Stubbs & Barth, 2003; Bybee & Beckner, 2009). The collocational status of a word combination in this research has been determined on the basis of collocation dictionaries. Two sources were used: Oxford Collocations Dictionary and the Internet dictionary Just the Word, both based on the British National Corpus (about 100 million words). In these dictionaries, word combinations
are given which occur statistically more frequently than by chance. All word combinations with a /r/-liaison site were analysed and labelled as either a collocation or a free combination of words.

1. Collocation – a collocation which includes a /r/-liaison site (e.g. the idea of, air attacks, etc.).
2. Free combination – word-groups which do not collocate (e.g. Georgia and its neighbours, Cuba is facing, others were injured, seven or eight, etc.)

(f) Word combination frequency

In addition to Collocability, which is a categorical predictor, the token frequencies of the word combinations containing a /r/-liaison site have also been determined. The particular frequencies of the combinations are based on the frequency counts obtained from the British National Corpus. Since both Collocability and Word combination frequency reflect the same property of multiword units, they are collinear to a large extent and have not been used in the same statistical model simultaneously (see 3.1).

(g) Vowel type frequency

The individual types of vowels preceding and following the /r/-liaison site will be compared against the frequency of /Vr/ and /rV/ sequences in single-word lexemes. In particular, the degree of linking and intrusive /r/ realization in V-to-V sequences will be checked against the frequency of the individual /Vr/ and /rV/ syllables in connected speech. The token frequencies of /Vr/ and /rV/ sequences (e.g. /ər/, /ɑːr/, /rə/, /rɒ/, /ræ/, /rɛ/, etc.) are based on a manually coded mini-corpus of written English consisting of approximately 15 000 words culled from three main sources – The British Academic Spoken English corpus (BASE), the Gutenberg project fiction books, and a selection of current British newspapers.

(h) Word frequency

The token frequencies of the words preceding and succeeding /r/-liaison site have been determined on the basis of the frequency counts obtained from the British National Corpus.
(i) Word type

Based on the degree of lexicality, words can be divided into two main groups – lexical (e.g. nouns, verbs, adjectives, adverbs) and grammatical (e.g. determiners, prepositions, conjunctions, auxiliary verbs, pronouns). After testing several different combinations, the ones with the largest effect size contribution in the final model have been selected. For linking /r/, the following categories were set up:

1. Lexical word + any word (e.g. air attacks, doctor in, etc.)
2. Grammatical word + any word (e.g. for election, were in, etc.)

In the intrusive /r/ sample, the only two possible categories were the following:

1. Lexical word + grammatical word (draw a, Patricia and, etc.)
2. Lexical word + lexical word (media activity, Geneva aimed, etc.)

(j) Speech rate

The speech (speaking) rate of the newsreaders has been calculated as a proportion of time (measured in milliseconds) and the number of syllables. Between 5 and 15 syllables of text in which the /r/-liaison site was embedded have been used for analysis. That is, every word combination containing a /r/-liaison site with some preceding and/or following text was measured in milliseconds and this measurement was divided by the number of syllables of that particular string of words. The resulting number represents the averaged time interval per one syllable of the context in which each particular /r/-liaison site was embedded. The speech continuum was segmented in line with the principles specified in Machač and Skarnitzl (2009).
3. Statistical analysis and results

3.1 Multivariate analysis of linking /r/

The main statistical model used to analyse the patterning of linking /r/ includes the following predictors: *Preceding vowel, Following vowel, Neighbouring /r/, Stress, Word type, Word 1 frequency, Word 2 frequency, Word combination frequency, Collocability and Speech rate*. All predictors were tested for multicollinearity, which was found to be within acceptable limits (VIF < 2.5). The individual frequency values of all continuous variables were log-transformed to obtain similarly scaled values (Walker, 2012). The model was tested by means of logistic regression in the Rbrul programme written by Daniel E. Johnson (Johnson, 2009). It is a sophisticated analytical tool for linguistic research which operates within the open-source statistical platform R (R Core Team, R Foundation for Statistical Computing, 2015). A mixed-effects analysis was performed using 10 fixed effects (the predictors specified above) and 3 random effects – random intercepts for *Speaker, Word 1* (the word preceding the /r/-liaison site), and *Word 2* (the word following the /r/-liaison site). This resolved the non-independence problem that stems from having multiple responses from the same speaker and multiple tokens of the same word (Johnson, 2009, 2010; Tagliamonte & Baayen, 2012; Winter, 2013).
Linking /r/ n = 647

Best step-down model: Speaker (random), Word 1 (random), Word 2 (random), Stress (p < 0.001),
Word combination frequency (p < 0.001), Word type (p < 0.001),
Following vowel (p < 0.001), Speech rate (p=0.023),

<table>
<thead>
<tr>
<th>Deviance</th>
<th>AIC</th>
<th>df</th>
<th>intercept</th>
<th>grand mean</th>
<th>R^2-fixed</th>
<th>R^2-random</th>
<th>R^2-total</th>
</tr>
</thead>
<tbody>
<tr>
<td>603.326</td>
<td>635.326</td>
<td>16</td>
<td>7.525</td>
<td>0.623</td>
<td>0.434</td>
<td>0.229</td>
<td>0.663</td>
</tr>
</tbody>
</table>

**Categorical predictors**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Factor</th>
<th>Logodds</th>
<th>Tokens</th>
<th>Proportion of [r]</th>
<th>Centred factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td>lexical stress + unstressed</td>
<td>2.243</td>
<td>44</td>
<td>0.864</td>
<td>0.904</td>
</tr>
<tr>
<td></td>
<td>unstressed + unstressed</td>
<td>0.481</td>
<td>419</td>
<td>0.706</td>
<td>0.618</td>
</tr>
<tr>
<td></td>
<td>post-lex accent + unstressed</td>
<td>0.427</td>
<td>59</td>
<td>0.627</td>
<td>0.605</td>
</tr>
<tr>
<td></td>
<td>unstressed + lexical stress</td>
<td>-1.540</td>
<td>63</td>
<td>0.270</td>
<td>0.176</td>
</tr>
<tr>
<td></td>
<td>unstressed + post-lex accent</td>
<td>-1.610</td>
<td>62</td>
<td>0.242</td>
<td>0.167</td>
</tr>
</tbody>
</table>

Range = 74 \( R^2 \)-fixed = 0.066 \( f^2 \)-fixed = 0.117

| Following vowel | /æ/, /ɑː/ | -0.527 | 32 | 0.250 | 0.371 |
|                | /æ/, /ɑː/ | -0.081 | 65 | 0.323 | 0.293 |

Range = 50 \( R^2 \)-fixed = 0.069 \( f^2 \)-fixed = 0.122

| Word type | /æ/, /ɑː/ | 1.358 | 311 | 0.781 | 0.795 |
|           | /æ/, /ɑː/ | 0.100 | 164 | 0.640 | 0.525 |
|           | /æ/, /ɑː/ | -0.011 | 39 | 0.308 | 0.497 |
|           | /æ/, /ɑː/ | -0.039 | 36 | 0.389 | 0.49 |

Range = 31 \( R^2 \)-fixed =0.015 \( f^2 \)-fixed = 0.027

**Continuous predictors**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Logodds</th>
<th>( R^2 )-fixed</th>
<th>( f^2 )-fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word combination frequency</td>
<td>+0.674</td>
<td>0.081</td>
<td>0.143</td>
</tr>
<tr>
<td>Speech rate</td>
<td>-3.909</td>
<td>0.012</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Table 3. Results of the step-up/step-down analysis of linking /r/ with the statistically significant predictors.

The analysis has shown that 5 of the tested predictors have a statistically significant influence on the patterning of linking /r/, which is realized as [ɹ] in about 62% of the cases. All 10 predictors were tested for mutual pairwise interactions in Rbrul. Three interactions were detected: Word type + Word 2 frequency, Stress + Neighbouring /r/, and Stress + Speech rate. However, when tested in the full model, these interactions were not selected as significant by the step-up/step-down procedure.
For all predictors, the factor weight range, $R^2$-fixed values, and Cohen’s $f^2$-fixed values are given to determine their contribution in the model (Selya et al. 2012; Nakagawa & Schielzeth, 2013). Since the $R^2$ values (calculated as $R^2_{\text{model}} - R^2_{\text{model without predictor } x}$) underestimate slightly the real effect of the predictors (because they are partially correlated), Cohen’s $f^2$-fixed effect size coefficients ($f^2 = \frac{R^2_x}{1-R^2_{\text{model}}}$) were used to determine the effect sizes the individual predictors (see Table 3).

To determine whether there is any correlation between the impact of the individual vowel types on /r/-liaison realization and the frequency of their corresponding sequences in connected speech (see 1.4), a small corpus of connected speech texts was analysed to determine the token frequencies of the English vowels combined with consonant /r/. Since the predictor Preceding vowel turned out to have no statistically significant influence on the realization of /r/-liaison, its comparison with corpus /Vr/ sequences has not been carried out. The corpus consisting of approximately 15 000 words (collected by the author of the present study for the purpose of this research) was coded manually to determine the token frequencies of the syllable sequences /(C)rV/. They are presented in Table 4.

<table>
<thead>
<tr>
<th>/(C)rV/ Sequences</th>
<th>Example words</th>
<th>Corpus frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C)r + ə, ɛ, οʊ(ə)</td>
<td>from, different, programme</td>
<td>458</td>
</tr>
<tr>
<td>(C)r + i, iː, ɪə</td>
<td>history, three, really</td>
<td>455</td>
</tr>
<tr>
<td>(C)r + e, et(ə)</td>
<td>arrest, concentrate</td>
<td>210</td>
</tr>
<tr>
<td>(C)r + a, ə, aʊ(ə), aɪ(ə)</td>
<td>run, drama, proud, around, right</td>
<td>148</td>
</tr>
<tr>
<td>(C)r + u, ʊ, ʊə</td>
<td>room, through, cruel</td>
<td>64</td>
</tr>
<tr>
<td>(C)r + ɔ, ɔː, ɔɪ(ə)</td>
<td>wrong, drawn, royal</td>
<td>58</td>
</tr>
<tr>
<td>(C)r + æ</td>
<td>travel, ran</td>
<td>42</td>
</tr>
</tbody>
</table>

Table 4. Corpus token frequencies of /(C)rV/ syllable sequences.

The correspondences are almost perfect and it is obvious that there is a correlation between how frequent a specific /(C)rV/ sequence is in connected speech and the occurrence of [ɹ] before particular vowels in the /r/-linking context (compare Tables 3 and 4). Regression analysis with the Vowel type frequency predictor included in the model (Table 5) shows that it
has a statistically significant influence on the realization of linking /r/. Both predictors, i.e. *Following vowel* and *Vowel type frequency*, cannot be run in the same model because they are multicollinear (VIF > 2.5).

<table>
<thead>
<tr>
<th>Linking /r/ n = 647</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best step-down model: Speaker (random), Word 1 (random), Word 2 (random), Stress (p &lt; 0.001), Word combination frequency (p &lt; 0.001), Vowel type frequency (p &lt; 0.001), Word type (p &lt; 0.002), Speech rate (p=0.026),</td>
</tr>
<tr>
<td>Deviance</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>611.658</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R²-fixed</th>
<th>f²-fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vowel type frequency</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Table 5. Simplified results of the step-up/step-down analysis of linking /r/ with the statistically significant predictors, including the *Vowel type frequency* predictor.

The R² (R²_{model} - R²_{model without predictor x}) and f² (R²/(1-R²_{model})) effect size coefficients have been calculated for the *Vowel type frequency* predictor to enable its comparison with other predictors (see Fig. 2). Since, in addition to comparable AIC values (Akaike, 1974), the effect size of the *Following vowel* predictor (f²-fixed = 0.122) is larger than the effect size of *Vowel type frequency* predictor (f²-fixed = 0.050), the *Following vowel* predictor is a better choice for the model. However, it also proves that much of the patterning of the following vowel can be explained by the influence of the token frequencies of /(C)rV/ sequences in connected speech.

<table>
<thead>
<tr>
<th>Linking /r/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phonetic and grammatical predictors</td>
</tr>
<tr>
<td>f²</td>
</tr>
<tr>
<td>Following vowel</td>
</tr>
<tr>
<td>Stress</td>
</tr>
<tr>
<td>Word type</td>
</tr>
<tr>
<td>Total f² = 0.266</td>
</tr>
</tbody>
</table>

Fig. 2 A comparison of the contribution of phonetic/grammatical predictors and usage-based predictors based on the f² effect size coefficients (Linking /r/). The f² values are taken from Tables 3 and 5.
3.2 Multivariate analysis of intrusive /r/

The set of predictors used in the intrusive /r/ statistical model was identical to that of linking /r/. The following predictors were tested: Preceding vowel, Following vowel, Neighbouring /r/, Word combination frequency, Collocability, Stress, Word type, Word 1 frequency, Word 2 frequency, and Speech rate. Multicollinearity was not detected (VIF < 2.5). All predictors were tested for interactions in Rbrul. Four interactions were detected: Word type + Word combination frequency, Stress + Neighbouring /r/, Word 1 frequency + Speech rate, and Word 2 frequency + Word combination frequency. When tested in the full model, however, all of these interactions were either non-significant or there was a step-up/step-down mismatch and/or convergence error reports. Therefore, they do not form part of the main model.

### Intrusive /r/ (n = 613)

Best step-down model: Speaker (random), Word 1 (random), Word 2 (random), Collocability (p < 0.001), Following vowel (p < 0.001), Speech rate (p = 0.004), Stress (p = 0.017)

<table>
<thead>
<tr>
<th>Deviance</th>
<th>AIC</th>
<th>df</th>
<th>intercept</th>
<th>grand mean</th>
<th>R²-fixed</th>
<th>R²-random</th>
<th>R²-total</th>
</tr>
</thead>
<tbody>
<tr>
<td>500.671</td>
<td>530.671</td>
<td>15</td>
<td>12.166</td>
<td>0.209</td>
<td>0.341</td>
<td>0.226</td>
<td>0.567</td>
</tr>
</tbody>
</table>

#### CATEGORICAL PREDICTORS

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Factor</th>
<th>Logodds</th>
<th>Tokens</th>
<th>Proportion of [r]</th>
<th>Centred factor weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Following vowel</strong></td>
<td>/ɑ/, /ɔ/, /aʊ(ə)/</td>
<td>1.293</td>
<td>252</td>
<td>0.306</td>
<td>0.785</td>
</tr>
<tr>
<td></td>
<td>/ɪ/, /iː/, /ɪə/</td>
<td>0.885</td>
<td>190</td>
<td>0.200</td>
<td>0.708</td>
</tr>
<tr>
<td></td>
<td>/ʌ/, /ɑː/, /aʊ(), /aɪ(ə)/</td>
<td>0.159</td>
<td>42</td>
<td>0.143</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>/ɒ/, /ɔː/, /ɔɪ(ə)/</td>
<td>-0.053</td>
<td>37</td>
<td>0.108</td>
<td>0.487</td>
</tr>
<tr>
<td></td>
<td>/e/, /eɪ(ə)/</td>
<td>-0.518</td>
<td>27</td>
<td>0.074</td>
<td>0.373</td>
</tr>
<tr>
<td></td>
<td>/æ/</td>
<td>-1.766</td>
<td>65</td>
<td>0.015</td>
<td>0.146</td>
</tr>
<tr>
<td><strong>Stress</strong></td>
<td>lexical stress + unstressed</td>
<td>1.603</td>
<td>46</td>
<td>0.522</td>
<td>0.832</td>
</tr>
<tr>
<td></td>
<td>post-lex accent + unstressed</td>
<td>0.679</td>
<td>32</td>
<td>0.312</td>
<td>0.664</td>
</tr>
<tr>
<td></td>
<td>unstressed + unstressed</td>
<td>0.006</td>
<td>467</td>
<td>0.191</td>
<td>0.502</td>
</tr>
<tr>
<td></td>
<td>unstressed + lexical stress</td>
<td>-0.446</td>
<td>28</td>
<td>0.143</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>unstressed + post-lex accent</td>
<td>-1.843</td>
<td>40</td>
<td>0.025</td>
<td>0.137</td>
</tr>
<tr>
<td><strong>Collocability</strong></td>
<td>collocation</td>
<td>0.847</td>
<td>115</td>
<td>0.435</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>free combination</td>
<td>-0.847</td>
<td>498</td>
<td>0.155</td>
<td>0.3</td>
</tr>
</tbody>
</table>

#### CONTINUOUS PREDICTORS

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Logodds</th>
<th>R²-fixed</th>
<th>f²-fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech rate</td>
<td>-6.362</td>
<td>0.029</td>
<td>0.044</td>
</tr>
</tbody>
</table>
Table 6. Results of the step-up/step-down analysis of intrusive /r/ with the statistically significant predictors.

The step up/step down analysis has selected the following predictors as significant: Following vowel, Collocability, Stress, and Speech rate. Intrusive /r/ was realized as [ɹ] in about 21% of the cases. It has thus been confirmed that linking /r/ is more frequent than intrusive /r/, and the results are comparable with those of other studies (Mompeán & Mompeán-Guillamón, 2009, Mompeán & Gómez, 2011).

To test the relation between the occurrence of intrusive [ɹ] before particular vowel types and the frequencies of /(C)rV/ syllables in connected speech, a regression analysis with the Vowel type frequency predictor included in the model was run to determine its effect on the intrusive /r/ realization.

<table>
<thead>
<tr>
<th>Intrusive /r/</th>
<th>n = 613</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best step-down model: Speaker (random), Word 1 (random), Word 2 (random), Stress (p &lt; 0.001), Word combination frequency (p &lt; 0.001), Vowel type frequency (p &lt; 0.001), Word type (p &lt; 0.001), Speech rate (p = 0.028),</td>
<td></td>
</tr>
<tr>
<td>Deviance 503.881</td>
<td>AIC 525.881</td>
</tr>
</tbody>
</table>

Table 7. Simplified results of the step-up/step-down analysis of intrusive /r/ with the statistically significant predictors, including the Vowel type frequency predictor.

Although the f²-fixed value of the Following vowel predictor (f²-fixed = 0.165) is higher than that of the Vowel type frequency predictor (f²-fixed = 0.120), the same is true of the AIC values of the two models: 530.7 vs 525.9 (note that a lower AIC indicates a better model). For this reason, it cannot be concluded that the model with the Following vowel predictor is necessarily a better model. Nevertheless, what is clear is that, in common with linking /r/, the occurrence of intrusive [ɹ] before particular vowel types is significantly correlated with the frequency of /(C)rV/ syllables in connected speech.
Intrusive /r/

<table>
<thead>
<tr>
<th>Phonetic and grammatical predictors</th>
<th>Usage-based predictors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Following vowel</td>
<td>Vowel type frequency</td>
</tr>
<tr>
<td>Stress</td>
<td>Collocability</td>
</tr>
<tr>
<td></td>
<td>Speech rate</td>
</tr>
<tr>
<td>f^2 0.165</td>
<td>f^2 0.120</td>
</tr>
<tr>
<td></td>
<td>0.097</td>
</tr>
<tr>
<td></td>
<td>0.044</td>
</tr>
</tbody>
</table>

Total f^2 = 0.245

Total f^2 = 0.261

Fig. 3. A comparison of the contribution of phonetic/grammatical predictors and usage-based predictors based on the f^2 effect size coefficients (Intrusive /r/). The f^2 values are taken from Tables 6 and 7.

4. Discussion

Evaluation of the Predictors

Phonetic and grammatical predictors

As far as phonetic and grammatical predictors are concerned, the Following vowel, Stress and Word Type predictors were found to be statistically significant. It was shown that both /r/-liaison types pattern similarly in terms of the influence of the following vowel – mid central vowels and close front vowels favour [ɹ], open front and back rounded vowels favour Ø. There have been attempts to explain the frequent occurrence of [ɹ] after particular vowels (i.e. /ɔ/ and back vowels) in articulatory and/or acoustic terms (Gick, 1999, Hay & Sudbury 2005, Heselwood, 2009). Nevertheless, this research has shown that there is no statistically significant influence of the Preceding vowel context (once the non-independence of the individual tokens is resolved). That is, back vowels and /ɔ/ standing before the /r/-liaison site do not seem to play any role in the choice between [ɹ] and Ø. As for the Following vowel context, we do find a high occurrence of [ɹ] before /ɔ/, and it could be argued that this is because of the articulatory and acoustic similarities between the two sounds. However, it is difficult to explain why /ɪ/-like vowels, which are not phonetically similar to [ɹ], should also trigger [ɹ] realization, or why back
vowels and /æ/ should favour Ø. Since both linking /r/ and intrusive /r/ show similar order of the
vowels favouring or disfavouring [ɛ] (see Tables 3 and 6), it was hypothesized that this regularity
might be related to some usage-based parameter, specifically, the frequency of occurrence of
/(C)rV/ syllables in connected speech.

The individual levels of the Stress variable show the same effect on the distribution of
linking and intrusive /r/. When the syllable following the /r/-liaison site is unstressed and
preceded by a syllable with lexical or post-lexical stress, the /r/-liaison has a higher than average
chance of being realized as [ɛ]. On the other hand, when the /r/-liaison site is preceded by an
unstressed syllable and followed by a syllable with lexical or post-lexical stress, Ø variant is
preferred. These findings confirm the results of Hannisdal (2006) and lend support to the
hypothesis proposed by Foulkes (1997) and Allerton (2000), that [ɛ] is more likely to be avoided
before a stressed syllable. Two explanations will be offered here, both based on the same
underlying principle.

When a syllable is stressed, it is likely to be realized more canonically, e.g. there will be
an increase in intensity and duration, a decrease in coarticulatory overlap, hyperarticulation, etc.
(Van Santen, 1992; Van Bergem, 1993; de Jong, 1995). This suggests that at the time when /r/-
loss was in progress, the stressed syllables with etymological r preceding the /r/-liaison site were
more likely to keep [ɛ] than unstressed syllables. This is a principle which operates both
diachronically and synchronically. Such /ˈ(C)V#V/ contexts (articulatory schemas, exemplars)
became automatized and were carried over to the speech of future generations during language
acquisition. Similarly, it could be argued that since stressed syllables following the /r/-liaison site
constitute the beginning of a separate word, they will resist the inclusion of the ambisyllabic /r/
because such a /r/ is not part of the canonical hyperarticulated exemplar of that word. We can
find parallel processes functioning at other types of syllable- and word-boundaries in English. For
example, linking /l/ and /w/ tend to be replaced by a glottal stop before an accented syllable, and it
is unusual for a word-final consonant to be carried over as initial in a word beginning with an
accented vowel, as in run /ˈɒf/, give /ɪn, lɛs ˈəʊf/, etc. (Cruttenden, 2014: 317, 318).
The Word type predictor was selected as significant only in the linking /t/ model, and its effect size was one of the smallest of the predictors in that model. We can conclude that grammatical words with the r letter in the last syllable tend to trigger the use of [ɹ] while lexical words inhibit the use of [ɻ].

Usage-based predictors

Three usage-based predictors were found to be statistically significant: Collocability/Word combination frequency, Vowel type frequency and Speech rate. As predicted in 1.4, the Word frequency variable turned out to have no influence on the patterning of the /t/-liaison.

It has been suggested that linking /t/ is a remnant of the historical coda /t/ in British English, which was lost in pre-consonantal and pre-pausal contexts, but has been fully preserved in one-word lexemes (simple, derived, and compound words), and also tends to resurface in high-frequency word combinations. Two usage-pattern predictors were tested to see which one had a stronger influence on the patterning /t/-liaison – Collocability (a categorical predictor) and Word combination frequency (a continuous predictor). In both /t/-liaison models, these predictors ranked high on the effect size scale. In particular, Word combination frequency had the largest effect size of all significant predictors in the linking /t/ model, and Collocability was second in terms of effect size in the intrusive /t/ model. These findings lend support to the claim that linking /t/ is not an arbitrarily chosen linking sound inserted or deleted in particular contexts, but it is the historical /t/ which has been (variably) preserved in multiword phrases due to the conserving effect of high token-frequency. The patterning of intrusive /t/ can be explained as a result of analogical extension – intrusive /t/ appeared in words and patterns without the corresponding r under the analogical influence of words and patterns with the historically attested r in the spelling (Sóskuthy, 2013).

The frequency of /t/-liaison occurrence before particular vowel types was tested against the frequency of /(C)rV/ syllables in connected speech. In both linking and intrusive /t/ models, the Vowel type frequency predictor had a statistically significant influence on the patterning of [ɹ] and Ø across the individual types of vowels. Specifically, text frequencies of the individual types of /(C)rV/ syllables (e.g. /(C)rə/, /(C)rɪ/, /(C)ræ/, etc.) have been found to be correlated with the
frequency of occurrence of [ɹ] and Ø in both linking and intrusive /ɾ/ models. For example, [ɹ] is strongly favoured in /ɾ/-liaison when followed by mid central vowels and close front vowels, and, by the same token, the /C(r + ø)ə, øæ, øə, øi, øæ, øi/ syllables are also the most frequent /C(r)V/ sequences in connected speech. This explains why [ɹ] is more favoured before some vowels and less favoured before others. Put differently, no formal phonological account is necessary to explain the patterning of [ɹ] and Ø before vowels (which is not to say that a priori there cannot be one). Frequently used speech patterns (e.g. /C(r)V/ syllables) become entrenched and automatized, and eventually become an unconscious routine (Bybee & Beckner 2009). /ɾ/-liaison can thus be explained in terms of the frequency of occurrence of such patterns.

Even though no influence of Speech rate was predicted (due to the relatively homogeneous group of speakers and the same style of speech), it was determined that speech rate has an inverse influence on the production of [ɹ] in /ɾ/-liaison. That is, there is a negative correlation between the frequency of [ɹ] and speech rate – as the rate increases, the occurrence of [ɹ] decreases. This has been observed for both linking and intrusive /ɾ/, although the effect sizes in both cases were small (in comparison with other variables). Therefore, the hypothesis in 1.4 (e) has not been confirmed.

In conclusion, comparing the overall effect sizes of the factors studied in this paper (see Figures 2 and 3), it is apparent that approximately half of the patterning of /ɾ/-liaison in English can be explained in terms of usage-based predictors.

A USAGE-BASED ACCOUNT OF /ɾ/-LIAISON

It has long been suggested that linking and intrusive /ɾ/ are diachronically tightly related in that they are both the result of the historical /ɾ/-loss in English (Wells, 1982, Giegerich, 1999, McMahon, 2000). Recently, empirical evidence has been provided for this process, showing that linking and intrusive /ɾ/ had developed slowly and largely simultaneously, the latter being formed by the process of analogy (Hay & Sudbury, 2005; Sóskuthy, 2013). Specifically, the loss of pre-consonantal and pre-pausal etymological r gave rise to mergers such as sore/soar – saw, court –
caught, cheater – cheetah, etc. More importantly, however, this has produced homophonous morpheme-final syllables of words with etymological r and those without it, e.g. /tə/ (butter – vendetta), /mə/ (former – comma), /tɑː/ (guitar – Bogota), /fɔː/ (four – guffaw), etc. Since etymological r was preserved in pre-vocalic positions (invariably within the word, variably across the word boundary), syllable sequences /(C)VrV(C)/ with linking /r/, such as /(t)ərɪŋ/ (buttering), /(m)əre(m)/ (former MP), /(st)ərə(v)/ (star of), /(f)ərə(l)/ (before all), etc. have become automatized neuromotor articulatory patterns (schemas, exemplars) and they began to be reused in syllabic sequences without the etymological r. This is why even those r-less words which do not have a homophonous r-full counterpart (whether native words, loan words, foreign names, or newly coined words) can reuse the /(C)VrV(C)/ patterns when followed by a vowel, e.g. words like draw, banana, Ouattara, junta, FIFA, etc.

One of the hypotheses proposed in this study was that if /t/-liaison is the residue of the etymological r (and not a synchronically inserted linking element), it should be preserved more often in high-frequency sequences, which have strengthened memory representations and are more resistant to reformations (Bybee, 2001; Bybee & Beckner, 2009). In contexts where linking and intrusion are used variably (i.e. at the word boundary), this is really the case, and it can be ascribed to the conserving effect of high token-frequency. If the /t/-liaison phenomenon was a purely synchronic process based on some formal phonological mechanism, high token-frequency combinations would not be expected to preserve /t/. Indeed, the weakening of /t/ would be more natural in such cases. Furthermore, it has been determined that the occurrence of [ɹ] and Ø in /t/-liaison /(C)VrV(C)/ patterns depends to a large extent on the type of the vowel following the /t/-liaison site. Surprisingly, the patterning of /(C)VrV(C)/ is also highly correlated with the token-frequency of particular /(C)rV/ syllables in connected speech. Therefore, for the time being, the use of [ɹ] and Ø in /t/-liaison is easier to explain in terms of their frequency correspondence to /(C)rV/ syllables in connected speech (a usage-based explanation) than in terms of the quality of the individual vowel types (a formal phonological explanation).

Another predictor that turned out to have a strong effect on /t/-liaison realization was stress. In both /t/-liaison types it figures as an important factor in the selection of [ɹ] and Ø, in
that it helps preserve etymological r in stressed word-final /r/(C)Vr/ syllables followed by a vowel, and disfavours its use before stressed word-initial syllables – /r/(C)VØV(C)/. Speech rate and word type (for linking /r/), on the other hand, have been shown to have only a minor role to play in the patterning of /r/-liaison.

The results of the paper thus lend support to cognitive, usage-based, and exemplar models of language production, where diachronic as well as synchronic determinants are used to explain the behaviour of linguistic units. Both linking and intrusive /r/ arose gradually and simultaneously through language change, and have been determined not only by phonetic and grammatical factors, but also by usage-based factors. The individual /r/-liaison realizations can be modelled on the basis of the existence of exemplars, and are to a large extent explicable in terms of token-frequency effects and the influence of stress. The two liaison types can thus be characterized as the same V-to-V hiatus-resolution strategy, although intrusive /r/ is usually less productive than linking /r/. Since this research has shown that both liaison types are governed by the same predictors (whether usage-based or phonetic/grammatical), the difference in the productivity of the two types can be explained by the fact that intrusive /r/ has been always stigmatized, even in the very early stages of its occurrence (Jespersen, 1961). Other factors that have been suggested to explain the lower occurrence of intrusive [ɹ] are the influence of orthography and the so-called adaptive rules, where younger speakers might be suppressing the use of intrusive [ɹ] as an adaptation to the speech of older interlocutors (McMahon, 2000).

In conclusion, abstract generative rules and mechanisms have not yet been able to explain adequately the rise and patterning of /r/-liaison in Standard British English. Usage-based accounts, on the other hand, are able to capture both diachronic and synchronic intricacies and complexities of the distribution of both liaison types. Within the usage-based framework of /r/-liaison proposed here, it is irrelevant to ask whether linking and intrusive /r/ are inserted, deleted or floating, or what their underlying forms are. Rather, it is suggested that the /r/-liaison use is based on the existence of exemplars, i.e. categories formed from tokens of experience which may come in various sizes (syllables, syllabic sequences, words, word combinations, etc.). Therefore, any theoretical account of /r/-liaison excluding historical, usage-based and other functional factors from consideration runs the risk of being not only incomplete, but also unnatural.
5. Conclusion

This paper was concerned with the patterning and distribution of /r/-liaison in Standard British English. To ascertain the degree of occurrence of [ɻ] and Ø in /r/-liaison use, the following predictors were tested: Preceding vowel, Following vowel, Neighbouring /r/, Stress, Word type, Vowel type frequency, Collocability, Word combination frequency, Word 1 frequency, Word 2 frequency, and Speech rate. The strength of the influence of the individual factors was tested by means of a mixed-model logistic regression analysis, with Speaker, Word 1 and Word 2 used as random intercepts.

The results of the analysis have shown that the realization of both liaison types can be explained substantially through the influence of 4 predictors, in particular, (a) Collocability or Word combination frequency, (b) Following vowel, (c) Vowel type frequency, and (d) Stress. This also indicates that linking and intrusive /r/ are based on the same V-to-V resolution strategy, and are therefore, in usage-based and phonetic terms, the same phenomenon. Whether the differences between the productivity of the two types are caused by orthographic and/or social pressures, as had been previously suggested, remains to be seen.

It has been concluded that /r/-liaison can be explained as an interplay of diachronic change and synchronic language variability shaped not only by phonetic and grammatical factors, but also by cognitive and usage-based determinants. The distribution of [ɻ] and Ø in /r/-liaison realization can be modelled in relation to the existing exemplars – strong, easily accessible representations containing specific phonetic detail.

Acknowledgements
The author would like to thank both anonymous reviewers for their useful comments and criticisms. A special thanks goes to Daniel E. Johnson and Bodo Winter for their expert statistical advice. A word of gratitude is also due to Peter Blight for his careful reading of the proofs.
References


