Contextual factors in lexical processing: the case of French Liaison

Mireille Babineau, Rushen Shi & André Achim

To cite this article: Mireille Babineau, Rushen Shi & André Achim (2017) Contextual factors in lexical processing: the case of French Liaison, Language, Cognition and Neuroscience, 32:4, 457-470, DOI: 10.1080/23273798.2016.1239022

To link to this article: http://dx.doi.org/10.1080/23273798.2016.1239022
McQueen, Cutler, & Butterfield, 1997) state that listeners might compete for recognition. Results showed a dominant effect of syntactic category, with a general bias for vowel-initial interpretation when targets followed a determiner. The use of specific liaison acoustic cues for disambiguation was found for /z/ and /n/ only in adjective context. Liaison frequency and onset probability had no clear influence. Thus, the contextual knowledge of liaison-causing words is crucial for lexical recognition. These findings are consistent with the predictions of the hierarchy proposed by Mattys, White, and Melhorn (2005).

1. Introduction

Spoken word recognition is a complex process that involves the use of acoustic information in the speech signal along with listener’s higher-level knowledge. Lexically ambiguous cases provide an ideal opportunity for studying how various factors interact during lexical processing. In such cases, listeners face a greater challenge than usual for selecting and recognizing the intended word from competing candidates. For instance, ambiguity can arise due to resyllabification. Recognising the word ash after hearing pink ash can be hard for infants (Mattys & Juszczyk, 2001), since the form cash surfaces and competes with the word ash. In this example, the misalignment of the word ash with the syllable produces the ambiguity. With more exposure and experience with disambiguating acoustic cues, English adult listeners no longer show difficulty identifying the words in near-homophonous phrases involving resyllabification such as no notion versus known ocean (e.g. Nakatani & Dukes, 1977). However, they still show some delays in recognising words that are misaligned with the syllable (e.g. mint in min.tayf in Culter & Norris, 1988; lac in zu.glac in Dumay, Frauenfelder, & Content, 2002; melk in mel.koos in Vroomen, van Zon, & de Gelder, 1996). Several lexical access theories (e.g. Syllable Onset Segmentation Heuristics (SOSH); Content, Dumay, & Frauenfelder, 2000; Possible Word Constraint (PSW); Norris, McQueen, Cutler, & Butterfield, 1997) state that listeners are more inclined to segment speech based on the alignment of word and syllable boundaries. Based on this lower-level syllable bias, misalignment generates a processing cost. In French, misalignment due to liaison, a frequent resyllabification phenomenon, can be particularly hard for processing.

Liaison is a phonological process involving the surfacing of an underlying consonant between a liaison-causing word and a vowel-initial word, e.g. a /z/ between les [le] (i.e. Word 1) and amis [ami] (i.e. Word 2), [le.zami] (“the friends”). The liaison consonant is referred to as underlying since it does not surface when Word 1 is utterance-final or when a consonant-initial word follows it (e.g. les [le] and pommes [pɔm] as [le. pɔm], “the apples”). Thus, the underlying consonant surfaces only in liaison cases and behaves as the onset consonant of the subsequent vowel-initial word. Consequently, the word boundary and the syllable boundary are misaligned in liaison. In homophonous sequences such as un air (“a melody”) and un nerf (“a nerve”), the misalignment in the former liaison case produces a surface form identical to the latter non-liaison case, both [œ.nɛʁ], and the two possible words (air and nerf) might compete for recognition.

Liaison occurs frequently in French. According to a corpus study, it appears approximately once every 16 words in adult speech (Boë & Tubach, 1992). Some
liaison consonants surface more frequently than others. The consonants /z/ (e.g. surfacing between les [le] and amis [ami], [lez.ami] “the friends”), /n/ (e.g. un ami [œ.nami] “a friend”) and /t/ (e.g. petit ami [pati.tami] “small friend/boyfriend”) represent about 99% of liaison cases in French (e.g. Boë & Tubach, 1992; Durand & Lyche, 2008; Mallet, 2008). The consonants /r/ (e.g. between premier and ami, [premjer.ami] “first friend”), /p/ (e.g. between trop and unis, [tro.pyni] “too close”), and /g/ (e.g. between long and hommage, [lɔ̃.gɔ.mɑ̃] “long tribute”) represent less than 1% of all liaison cases. Various accounts of liaison have been given in linguistic theories (for a detailed discussion, see Côté, 2005, 2011). According to one of these accounts (e.g. Encrevé, 1988), which is the classical view, the triggering of liaison is linked to Word 1, that is, the surfaced consonant is the underlying coda of Word 1. Furthermore, a high-frequency Word 1 (especially function words) has a greater chance of triggering liaison than a low-frequency Word 1 (e.g. Fougeron, Goldman, Dart, Guélat, & Jeager, 2001; Fougeron, Goldman, & Frauenfelder, 2001). Previous studies focused on the production of liaison cases and the contexts in which they surface. The following sections discuss lower-level and higher-level processes that may be involved in perceiving liaison cases.

1.1. Acoustic factors

It has been suggested that lower-level processing of specific acoustic cues can guide listeners’ interpretation of Word 2 in liaison, by potentially disambiguating between homophonous sequences (e.g. un air [œ.nɛʁ] “a melody” and un nerf [œ.nɛʁ] “a nerve”). Studies reporting the acoustic cues linked to liaison productions in European French have shown significant differences between liaison consonants and their consonant-initial counterparts (e.g. Gaskell, Spinelli, & Meunier, 2002; Spinelli, McQueen, & Cutler, 2003; Tremblay, 2011), though other studies found inconsistent differences for some pivotal consonants (e.g. Tremblay & Spinelli, 2013) or no overall significant differences (e.g. Nguyen, Wauquier, Lancia, & Tuller, 2007; Yersin-Besson & Grosjean, 1996). For instance, Spinelli et al. (2003) measured the length of liaison consonants versus their consonant-initial homophonous counterparts (e.g. der nier oignon “last onion” vs. der nier rognon “last kidney”). They reported an average 17% shortening of the target consonants in liaison contexts (/tr/, /p/, /tr/, /g/, and /n/) relative to consonant-initial contexts. Yersin-Besson & Grosjean (1996) also used homophonous pairs, but did not seem to find strong durational cues. They reported an average 10% shortening of the target consonants in liaison contexts (/n/, /tr/, /tr/, /z/), which was not tested for significance. In Tremblay & Spinelli (2013), differentiating durational cues were found for /z/ and /n/, but less consistently for /tr/.

Since subtle disambiguating durational cues were found in most of the studies, many researchers have explored if listeners perceived and used such cues in lexical processing. A priming study by Spinelli, McQueen, and Cutler (2003) investigated lexical activation involving liaison cases. Subjects performed a lexical decision task upon seeing a target (e.g. oignon “onion”) on a computer screen immediately after hearing a sentence containing either the intended target (e.g. C’est le dernier oignon, [sɛ.lɔ̃.dɛʁɔ̃n.œʁɔ̃] “It is the last onion”) or the counterpart (e.g. C’est le dernier rognon, [sɛ.lɔ̃.dɛʁɔ̃n.œʁɔ̃] “It is the last kidney”). Listeners were thus faced with two possible interpretations (e.g. oignon or rognon) upon hearing either sentence. Their results showed that the unintended word (e.g. rognon) was weakly activated, and that the intended word (e.g. oignon) was significantly more activated. The authors thus claimed that the surfacing of an underlying liaison consonant did not impede the activation of the intended vowel-initial word, and they interpreted their results as evidence supporting the use of liaison-related acoustic cues.

Tremblay and Spinelli (2014b) also showed the use of disambiguating acoustic cues in an online task. They tested listeners’ online recognition of /n/, /z/, and /t/ liaison cases with non-homophonic pairs. The task involved the simultaneous presentation of four pictures associated with known words on the screen for a brief period of time, and then their reappearance with the auditory stimulus (e.g. petit abri “small shelter”). Subjects clicked on the target that they heard. Eye movements were measured from the onset of the pivotal consonant (e.g. the surfaced liaison consonant /t/ in petit /t/abri). Targets were only ambiguous at their onset, for example, /t/abri [tabri] vs. tableau [tablo] “board” following a liaison-causing Word 1. The authors manipulated the V-C-V portion of the stimuli by cross-splicing. Native French listeners were faster in their recognition of the target words for which the spliced portion was from another recording of the same word-onset condition than in their recognition of the targets for which the spliced portion was from the reverse word-onset condition, indicating that they were sensitive to those acoustic cues. Sensitivity to consonant durational difference between liaison- versus consonant-initial cases was also shown for /t/ and /z/ during online processing in Tremblay and Spinelli (2014a).

Nevertheless, sensitivity to liaison-related acoustic cues was not found in some other studies using different
methods. For instance, Shoemaker and Birdsong (2008) used a forced-choice identification task to investigate listeners’ interpretation of ambiguous liaison cases. Using some of the stimuli from Spinelli et al. (2003), they reported an overall identification rate close to the chance level (i.e. 50%) and no correlation between the length of the consonant and the interpretations of ambiguous homophonous sequences (e.g. aucun air, aucun nerf). That is, longer consonants did not trigger more consonant-initial interpretations. Thus, the acoustic differences present in the stimuli were not used for disambiguation. Uncertain interpretations were also observed in Yersin-Besson and Grosjean (1996). In that study subjects heard an ambiguous utterance (e.g. un œuf [œ.nœf] “an egg”) in each trial and had to decide which of the written utterances (e.g. un œuf “an egg”, un neuf “a nine”) they heard. Their choices were random, showing that they were not able to correctly perceive the intended Word 2 in the utterance.

A recent study by Shoemaker (2014) examined the effect of duration cues on listeners’ discrimination and identification of liaison-ambiguous cases. The pivotal consonants were instrumentally manipulated for creating three degrees of length (i.e. shortened liaison consonant, baseline, lengthened onset-consonant). Listeners showed discrimination of ambiguous pairs, such as un air vs. un nerf, only when they had durations differing by two standard deviations. Thus, only extreme acoustic differences seem to be perceptually salient enough to yield correct responses. In the forced-choice identification task, subjects were also influenced by the manipulated duration cues: Shortened consonants yielded more vowel-initial interpretations (i.e. liaison), and lengthened consonants yielded more consonant-initial interpretations.

Taken together, the findings in the literature are mixed with respect to listeners’ use of acoustic cues for disambiguating homophonous sequences involving liaison. It is possible that the low saliency/reliability of acoustic-phonetic cues to liaison in French may be responsible for their limited use in listeners’ interpretation. These results are consistent with the idea of the hierarchy of word segmentation cues proposed by Mattys and colleagues (e.g. Mattys & Melhorn, 2007; Mattys, Melhorn, & White, 2007; Mattys, White, & Melhorn, 2005; White, Melhorn, & Mattys, 2010). Under certain testing conditions listeners can use the available acoustic cues, for example, when cues involve large differences (Shoemaker, 2014) or when online processing of such cues are measured (e.g. Spinelli et al., 2003; Tremblay & Spinelli, 2014a). However, listeners did not correctly interpret the intended forms in offline tasks using naturally produced cues (e.g. Shoemaker & Birdsong, 2008; Yersin-Besson & Grosjean, 1996). Therefore, whether listeners can use acoustical cues to liaison consonants seems to depend on specific stimuli/testing conditions. Furthermore, the presence of cues could potentially vary for particular liaison consonants.

1.2. Liaison contextual effects

It has been proposed that knowing the phonological make-up of Word 1 influences the processing of Word 2 in liaison. Spinelli, Cutler, and McQueen (2002) showed that the recognition of vowel-initial words was impeded in illegal liaison contexts where a consonant was artificially added as the consonant onset of Word 2 (e.g. demi /t/agneau “half lamb”), but not in legal liaison contexts (e.g. petit agneau [pati.ta.tø] “little lamb”). That is, upon hearing petit agneau, the underlying liaison consonant /t/ of petit was automatically processed as belonging to petit, and the activation of agneau was not impeded. The activation of agneau was impeded in demi /t/agneau since /t/ is not related to the preceding word demi.

Gaskell, Spinelli, and Meunier (2002) reported that the presence of a liaison does not produce any cost on the activation of the following vowel-initial word, despite the mismatch between the target and the surface form. For example, in a priming task vowel-initial words in liaison cases (e.g. un généreux italien, [œ.ʒene.œ.zitalj] “a generous Italian”) were as easy to recognise as vowel-initial candidates that do not undergo liaison (e.g. un chapeau italien, [œ.ʃapo.italj] “an Italian hat”). Furthermore, in their word monitoring task liaison context even facilitated the access of the following vowel-initial word. The authors interpreted their results as suggesting that listeners were aware of the underlying liaison consonant that can surface after Word 1 and used that knowledge to easily access Word 2. However, caution should be applied in interpreting listeners’ responses in liaison (e.g. un généreux italien) versus non-liaison (e.g. un chapeau italien) cases since the latter included two consecutive vowels, which may pose segmentation difficulties of their own (see discussion in Tremblay and Spinelli, 2013).

In Dejean de la Bâtie and Bradley (1995)’s monitoring task, listeners showed an inhibition effect. That is, the monitoring of /t/-initial words was slower in petit tableau “small board” than in vrai tableau “real board”. The adjective petit has an underlying coda /t/ that can only surface before a vowel-initial word (e.g. petit ami, [pati.tami]). Thus, the knowledge of this underlying /t/ in petit affected subjects’ processing of petit tableau, even though tableau is inherently consonant-initial.
Taken together, these studies seem to suggest that listeners are aware of the underlying consonant of Word 1, and that the processing of the onset of Word 2 can be affected by this knowledge.

1.3. Onset probability

In work on spoken word recognition more generally, studies on the processing of non-words show an effect of phonotactic probability (e.g. Vitevitch & Luce, 1998, 2005), a type of higher-level knowledge. Phonotactic probability was measured by the frequency of occurrence of a segment at a particular word position and the probability of co-occurrence of segments. They found that a higher phonotactic probability yielded a greater likelihood that participants processed novel target words as belonging to an existing group of lexical items sharing that particular phonotactic pattern. Participants showed facilitation in their interpretation and processing speed of those items. Vitevitch, Luce, Charles-Luce, and Kemmerer (1997) also found a facilitative effect for targets with high syllable phonotactic probabilities in comparison to those with low syllable phonotactic probabilities.

The role of onset probability in the processing of liaison-ambiguous cases has hardly been investigated. In liaison, the underlying coda consonant of Word 1 (e.g. /zl/, /zn/, /zt/, and /zl/) becomes the syllable onset of the following vowel-initial Word 2. The extent to which these consonants are processed as word-initial consonants of Word 2 may be related to the number of words with these onsets in the lexicon and their general probability of occurrence. For example, there are more /zn/-initial words than /zl/-initial words in French (Beauchemin, Martel, & Théoret, 1992). In a liaison-licensing context, ambiguous Word 2 pseudo-nouns involving these two consonants might then lead to more consonant-initial interpretations for the former than for the latter cases.

Recent studies by Tremblay and Spinelli (2013, 2014a) using a visual-world eye-tracking task examined the use of onset probability in the interpretation of transitory ambiguous cases linked to liaison. In the presence of a lexical competitor, subjects in Tremblay and Spinelli (2013) were more biased towards the consonant-initial competitor relative to the vowel-initial competitor when the stimuli contained the pivotal consonants /t/ and /n/, which have higher probability onsets than /zl/. The opposite effect was observed with the pivotal consonant /zl/, which yielded more fixations to the vowel-initial competitors. That is, the probability of the pivotal consonant as a word-onset biased listeners’ attention (i.e. eye movements) towards a vowel-initial competitor for /zl/ (lower onset probability) and towards a consonant-initial competitor for /zn/ and /zt/ (higher onset probability). We note that liaison cases with /zl/ are more frequent than with /zn/ in European French (e.g. Mallet, 2008), which likely contributed to listeners’ biases in Tremblay and Spinelli (2013). Tremblay and Spinelli (2014a) tested /zl/ and /zt/, and they found an overall bias towards consonant-initial targets over vowel-initial words only for /zt/.

1.4. The present study

The present study aimed at investigating lower-level and higher-level processes in the perception of liaison cases. An offline segmentation task was designed to examine the effects of liaison-related acoustic cues, onset probability and contextual knowledge (liaison frequency, syntactic category of Word 1) on lexical processing involving liaisons and their ambiguous counterparts. Each trial presented a noun phrase, and listeners were asked to say the last word as fast and as accurately as possible. Their responses therefore served as an indication of their interpretation of the last word. To control for possible effects of lexical frequency and semantic plausibility, we used pseudo-nouns, which formed noun phrases with preceding real French words. The pseudo-nouns were vowel-initial with a liaison consonant surfacing as the onset of the noun (e.g. un /zn/onche “an onche”) and the consonant-counterparts (e.g. un nonche “a nonche”). The segmentation of these lexically ambiguous phrases was investigated. Listeners in previous liaison studies (e.g. Shoemaker & Birdsong, 2008; Yersin-Besson & Grosjean, 1996) did not correctly interpret the intended real nouns in offline tasks. However, could acoustic cues to liaison play an important role in a segmentation task that controlled for lexical frequency and semantic factors?

The interaction between the factors of liaison contextual knowledge (i.e. the frequency of the different liaison consonants and the syntactic category of the Word 1) and acoustic cues were not considered in previous studies. Hence, the possible variation of performance linked to consonant frequency as liaison or the syntactic context in which these pivotal consonants appeared has never been tested. In light of recent online studies (Tremblay & Spinelli, 2013; 2014a) showing an effect of higher-level influence (i.e. onset probability and liaison frequency) on the processing of the pivotal consonant, we investigated how these factors as well as the syntactic category of Word 1 and acoustic cues may interact in listeners’ processing of liaison-related cases.

In our study we examined onset probability separately from liaison frequency (i.e. the frequencies of occurrence
of liaison consonants). This was not possible in Tremblay and Spinelli’s study (2013) since both factors predicted the same pattern of results in European French. Recent work showed that the frequencies of liaison consonants in Laurentian French (i.e. Canadian French) are not the same as those in European French (Côté, 2013). In European French, /z/ is the most frequent liaison consonant, followed by /n/, and then followed by /t/ (e.g. Durand & Lyche, 2008; Mallet, 2008). In Laurentian French, /z/ and /n/ liaison have similar frequencies, both more frequent than the /t/ liaison (Côté, 2013). Therefore, based on liaison frequency, the two contexts (i.e. /z/ and /n/) should yield similarly high vowel-initial responses (i.e. high liaison interpretation). These cases differ in their onset probability, with the pivotal consonant /n/ (i.e. 86 nouns with these onsets in the spoken corpus of Beauchemin, Martel, & Théoret, 1992, total token frequency 1766) being more frequent than the pivotal consonant /z/ (i.e. 10 nouns, total token frequency of 35), predicting less vowel-initial responses for the former than the latter. Moreover, to separate these influences, we investigated pivotal consonants sharing the same onset probability but differing in liaison frequency in our task. This was possible since the onset probabilities of /r/ and /t/ are comparable in Laurentian French (361 versus 347 nouns, Beauchemin, Martel, & Théoret, 1992), thus predicting similarly high consonant-initial interpretations for Word 2 in /r/ and /t/ cases. We note, however, that the number of occurrence (i.e. total token frequency) of /t/-initial nouns (i.e. 7810) is higher than /r/-initial nouns (i.e. 4386). Based on liaison frequency, cases involving the pivotal consonant /t/ should yield more vowel-initial responses than the ones involving the pivotal consonant /r/. Furthermore, all cases for this comparison (onset probability versus liaison frequency) were phrases containing prenominal adjectives, which enabled us to control for the factor of the syntactic category of Word 1.

No study has yet investigated the potential effect of the syntactic category of liaison-causing Word 1. The highest occurrence of liaison /z/ and /n/ stems from the fact that these consonants surface after highly frequent determiners. Côté (2013) reported that most realised liaison comes from function word contexts, including Determiner + Noun sequence (e.g. un /n/ami “a friend”, des /z/ amis “the friends”) at 26% and Pronoun + Verb sequences (e.g. on /n/aim “we love”, ils /z/ aiment “they love”) at 35% of all liaison cases in Laurentian French. Cases involving adjectives accounted for less than 9% of all liaison cases, with the plural sequence Adjective + Noun (i.e. linked to the pivotal consonant /z/) accounting for 8%, and the singular Adjective + Noun sequence (i.e. linked to the pivotal consonant /n/, /t/, and /r/) only accounting for 0.7%. Hence, most of the previous studies in the literature focused on liaison cases occurring less than 10% of all liaison cases in the language, that is, following adjectives (e.g. Spinelli et al., 2003; Tremblay, 2011; Tremblay & Spinelli, 2013, 2014a, 2014b). Furthermore, some studies used both determiners and adjectives without taking into account the potential syntactic category factor (e.g. Shoemaker, 2014; Yersin-Besson & Grosjean, 1996). In our study, the general liaison frequency was controlled for cases involving /n/ and /z/, allowing us to assess the effect of syntactic category of Word 1 (i.e. adjective versus determiner) on lexical processing.

2. Method

2.1. Participants

Forty-eight native Quebec-French-speaking adults participated in this experiment. Four additional participants were tested but were not included in the results due to many missing data and/or equipment problems. Participants were paid for their participation.

2.2. Stimuli

A total of 40 NP including pseudo-nouns were created (see Appendix A). These NPs had a Det + N or Det + Adj + N structure. The target pseudo-nouns were made of one, two or three syllables. Four types of liaison contexts (i.e. /z/, /n/, /t/, /r/) preceded the targets (i.e. the phrase-final pseudo-noun). A total of 12 vowel-initial pseudo nouns were used, along with their consonant-initial counterpart. For instance, the vowel-initial pseudo-noun oigue had four consonant-initial counterparts: noigue, zoigue, toigue, and roigue). Appendix A shows the overall target stimuli that we created: half of the target NPs contained vowel-initial pseudo-nouns in each of the four liaison contexts, and the other half contained the corresponding consonant-initial pseudo-nouns (ambiguous non-liasons, e.g. un noigue). The four columns of Appendix A show the four liaison contexts and the respective pseudo-noun pairings. The exact preceding contextual words varied, and the paired consonant-initial pseudo-nouns varied accordingly. That is, ambiguous homophonous pairs of the pseudo-nouns each containing a vowel-initial and a consonant-initial target were created (e.g. liaison: un /n/ oigue, non-liaison un noigue), and each vowel-initial pseudo-noun was applied across multiple liaison consonants.

All contextual words preceding the targets were liaison-causing words, that is, Word 1, and they were
paired with the targets (i.e. Word 2) randomly. Four contextual words were associated with the /n/ liaison consonant (i.e. two determiners: un [œ] “a”, mon [mɔ̃] “my”, and two adjectives: aucun [okœ] “no”, bon [bo] “good”), four with the /z/ liaison consonant (i.e. two determiners: ses [se] “his/hers/these”, mes [me] “my”, and two adjectives: gros [ɡʁɔ̃] “big”, beaux [bo] “beautiful”), two with the /t/ liaison consonant (i.e. premier [pʁemje] “first”, dernier [dəʁnje] “last”), and two with the /r/ liaison consonant (i.e. petit [pɔt] “small/little”, grand [ɡʁɑ̃] “tall/big”). These underlying consonants only surface when preceding vowel-initial words. For instance, if un (“a”) preceded the pseudo-noun onche, the underlying /n/ surfaces: un onche [œ.nɔ̃].

Filler NPs containing real nouns and pseudo-nouns with various onsets were used for the purpose of making the task more variable and preventing listeners from building any strategies. Some fillers were liaison cases (for example, un petit éléphant “a small elephant”) or liaison-ambiguous cases (for example, dernier appel “last call”, dernier rappel “last reminder”). Other fillers were not related to liaison (e.g. un râteau “a rake”, un cousin “a cousin”). Additional NPs containing real nouns and pseudo-nouns were created and used for practice trials.

The phrases were recorded in a sound-attenuated booth by a female native Quebec-French speaker who was unaware of the goals of the study. She read a printed list of the stimuli NPs including target liaison phrases (e.g. un onche) and consonant-initial counterparts (e.g. un nonche), which were mixed with many unambiguous filler NPs in French with a variety of onset consonants. Multiple tokens were recorded. If she did not produce the liaison consonant for any liaison-intended phrase, she was told explicitly to do so. To prepare for the final stimuli, one exemplar of each phrase was randomly chosen.

2.3. Design

In an implicit segmentation task listeners heard NPs and were asked to repeat the last word as fast and as accurately as possible. A total of 24 practice trials were first presented to the participants, familiarising them with the task. The stimuli used for the practice trials were different from those used for the experimental task. Since some practice trials presented liaison cases (e.g. dernier éveil, “last awakening”) and liaison-ambiguous cases (e.g. dernier réveil “last alarm clock”), they served as implicit indication to the subjects that they may encounter liaison ambiguity in the subsequent test stimuli. Following each practice trial, the experimenter indicated to the subject if he or she was correct in his/her response.

There were 344 phrases for this task, including pseudo-noun targets as well as fillers. These stimuli were separated into four sets, so that each group of 12 participants was tested with 86 NPs. Participants were randomly divided into the four groups. Each group heard on average 10 target pairs of vowel-initial pseudo-nouns in liaison cases (e.g. un petit onche [œ.pɔt.tiʃ]) and their consonant-initial counterparts (e.g. un petit tonche [œ.pɔt.tiʃ]). Thus, among the 86 phrases, 18–22 phrases contained targets, and the remaining were fillers. All groups heard the same vowel-initial pseudo-nouns, but in one of four different liaison contexts that are ambiguous (e.g. un onche for one group, ses onches for another, etc.). That is, for a particular ambiguous target pair, each group only heard it in one liaison context. For example, one group heard un onche and also un nonche (i.e. both surfaces as [œ.nɔʃ]), whereas another group heard ses onches and ses zonches (i.e. both surfaces as [se.zɔʃ]). The pairs were separated by an average of 34 other stimulus phrases. Thus, each group was tested with all four liaison contexts, but with different vowel-initial targets (and their consonant-initial counterparts) for different contexts. These manipulations were necessary for avoiding giving different contextual cues to the same vowel-initial target. As an illustration, Appendix B shows the target NPs that were presented to the four groups of participants.

Different factors known to affect spoken word recognition were investigated. One factor was the acoustic cues related to liaison disambiguation. If listeners’ interpretations were guided by any possible naturally produced disambiguating acoustic cues in the stimuli, the intended forms should be perceived correctly. The vowel-initial targets should yield vowel-initial responses during the segmentation task. For example, participants should repeat onches upon hearing ses onches, even though the surface form of the phrase is [se.zɔʃ]. Consonant-initial tokens should yield consonant-initial interpretations (e.g. zonches for ses zonches).

Two experimental designs were embedded in our study: cases with adjectives involving four pivotal consonants (/z/, /n/, /t/, /r/), and cases with adjectives versus determiners involving the pivotal consonants /z/ and /n/. With the adjective-only cases, we tested the role of liaison frequency, along with the role of onset probability on the parsing of a potential liaison consonant. Our first hypothesis was that those pivotal consonants that are highly frequent liaison cases should yield more vowel-initial responses. The factor of liaison frequency predicted high vowel-initial responses for /z/ and /n/, less for /t/, and lowest for /r/. We also predicted that upon
hearing a pseudo-noun target sharing a high-probability onset consonant with many real words from the lexicon, listeners’ interpretation of the target in the segmentation task should have a consonant-initial bias, and that both consonant-initial and liaison targets of an ambiguous pair would show a consonant-initial bias (e.g. rèque interpretation for both le dernier èque and le dernier rèque). Conversely, pseudo-nouns sharing an onset with a small number of real words in the lexicon, that is, low-probability onsets, should yield more vowel-initial responses (e.g. onche interpretation for both les gros oigues and les gros zoigues). The onset probabilities predicted high consonant-initial responses for /t/ and /r/, less for /n/, and the lowest for /z/.

With the second design, we investigated if the syntactic category of Word 1 (adjective vs determiner) had an effect on listeners’ interpretation. The effect of the syntactic category of Word 1 has never been tested in previous studies. Table 1 presents a summary of each of the factors tested in our study.

2.2.1. Acoustic analysis

Several measurements were performed on the ambiguous phrases involving vowel-initial pseudo-nouns and their consonant-initial counterparts by a researcher who had prior training on acoustical analysis. The researcher was blind to the purpose of the study and to the elicitation condition for each token. She analysed the duration based on both the waveform and the spectrogram. For each pivotal consonant, the boundary was placed at the rightmost edge of the periodicity of the preceding vowel and the leftmost edge of periodicity of the following vowel. The beginning and the end of vowel periodicity determined the duration of the vowels. The mean segmental durations and standard deviation (SDs) for the pivotal consonant (C), the preceding (V1) and the following vowel (V2) are presented in Table 2, along with the VOT for the pivotal consonant /t/ and the mean intensity for all pivotal consonants and V2. Many measures showed no significant difference. The measures that showed significant or near-significant differences are discussed below (p < .1).

Previous studies on acoustic cues to liaison focused primarily on consonant durational differences (e.g. Spinelli et al., 2003; Tremblay & Spinelli, 2014a, 2014b). The presence of other acoustic cues (i.e. V1) was also found in several studies (e.g. Spinelli et al., 2003). We inquired whether our stimuli contained durational cues. As shown in Table 2, liaison consonants are shorter than word-initial consonants, though these differences did not reach significance for all contexts. Repeated-measure ANOVAs were performed for both /z/ and /n/ cases separately in order to investigate if distinguishing acoustics cues were present, and if they varied depending on the syntactic category of the Word 1 (determiner vs. adjective). For /z/, a marginally significant main effect of the Intended Form was found on the length of V1, F(1,10) = 4.254, p = .066, but no main effect of the Syntactic Category was observed (F(1,10) = .731, p = .371). Crucially, no interaction between the two factors was found (F(1,10) = 1.11, p = .317). There was a main effect of the Intended Form on the length of the consonant, F(1,10) = 5.011, p = .049, with no main effect of the Syntactic Category (F(1,10) = 2.648, p = .135). No interaction was found between these two factors,

\[ \text{Table 2. Mean durations (in ms) and standard deviations of the surfacing consonant (C), the preceding (V1) and the following vowel (V2), as well as the intensity (in dB) of the surfacing consonant and the VOT for the /t/ liaison-ambiguous phrases in the experiment.} \]

\[
\begin{array}{cccc|ccc}
\text{Pivotal consonant} & \text{Acoustic cues strength} & \text{Liaison frequency} & \text{Onset probability} & \text{Syntactic category} \\
\hline
/z/ & * & high & low & Adj vs. Det \\
/n/ & * & high & moderate & Adj vs. Det \\
/t/ & * & moderate & high & Adj \\
/r/ & ns & low & high & Adj \\
\hline
\end{array}
\]

\[ p < .05. \]

\[ **p < .01. \]
For /n/, a marginally significant main effect of the Intended Form was found on the length of V1, \( F(1,10) = 4.697, p = .055 \), as well as a main effect of the Syntactic Category (\( F(1,10) = 9.72, p = .011 \)). Crucially, there was no interaction between the two factors (\( F(1,10) = .077, p = .787 \)). A main effect of the Intended Form was found on the length of the pivotal consonant, \( F(1,10) = 15.731, p = .003 \). No main effect of the Syntactic Category was observed (\( F(1,10) = 0.121 p = .735 \)) nor an interaction between the two factors (\( F(1,10) = 0.041, p = .843 \)). A main effect of the Intended Form was found on the whole V1/n/V2 sequence, \( F(1,10) = 9.862, p = .011 \), with no main effect of the Syntactic Category (\( F(1,10) = 0.395, p = .544 \)). There was no interaction between the two factors (\( F(1,10) = 0.559, p = .472 \)). Hence, in all comparisons with /z/ and /n/, no interaction between Syntactic Category and Intended Form was observed, which shows that similar acoustic cues were present following determiners and adjectives.

Individual paired-sample t-tests were conducted for /t/ and /r/, comparing ambiguous phrasal pairs of targets from Det + Adj + N contexts. For /t/, a shortening of the preceding vowel was marginally significance, \( t(9) = 1.908, p = .089 \), and the V1/t/V2 was significantly shorter in liaison than in non-liaison cases, \( t(9) = 2.942, p = .016 \). For /r/, none of the acoustic measurements reached significance (\( p > .1 \)). We note that there were only six pairs for /r/, thus more variability was present in /r/ cases than in the other comparisons. Note that for all pivotal consonants, none of the intensity measures was significant.

Overall, the acoustic cues to liaison present in our stimuli were similar to those found in previous study. For instance, strong durational cues were found for /z/ and /n/, but less consistently for /t/ in Tremblay and Spinelli (2013).

### 2.3. Procedure

The program E-Prime was used for the experiment. Participants were tested individually in a quiet room in a session lasting approximately 20 min. The stimuli were presented at a comfortable sound level through two loudspeakers (Sony – model SRS-A60) positioned on each side of the subject. During the practice trials, the participants adjusted the volume to a comfortable level if necessary. Headphones were not used in order to avoid any interference with participants’ production responses and to allow them to hear the feedback from the experimenter (during the practice trials). The experimenter read the instructions to the participant. They were also presented on the computer screen. When the participant pressed on the space bar, the instructions were replaced with a grey background, and a trial began. Each participant first took part in practice trials including phrases containing nouns and pseudo-nouns that were different from those presented in the experiment. Feedback was given by the experimenter. The practice with feedback was designed to expose listeners to liaison ambiguity with real nouns and pseudo-nouns, so that they could be aware of the possibility of hearing vowel-initial tokens in liaison cases and consonant-initial counterparts in ambiguous non-liaison cases.

Participants were instructed that they would hear phrases each containing a real noun or a pseudo-noun, and that they needed to repeat the last word they heard (i.e. the noun) as fast as possible. Their responses were recorded by an audio-recorder. The recording was necessary for later coding by a researcher blind to the condition. If participants gave more than one response for a trial, the first response was coded as the answer. Vowel-initial responses were coded as 1, and consonant-initial responses were coded as 0. Participants made a small number of production errors, such as converting a pseudo-noun into a similar-sounding real noun (e.g. producing rêveur “dreamer” instead of the pseudo-noun rimeur upon hearing le dernier rimeur). Such cases were coded as missing values.

### 3. Results

Vowel-initial responses for vowel-initial targets in liaison cases (e.g. responding onche upon hearing un petit onche) and for consonant-initial counterparts in ambiguous non-liaison cases (e.g. responding onche upon hearing un petit tonche) were coded. Several logit mixed-effects models were conducted on listeners’ vowel-initial responses (i.e. 1 = vowel-initial response, 0 = consonant-initial response). These analyses were done with R (R Core Team, 2015) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). The effect of the Intended Form (coded as +.5 = vowel-initial intended, −.5 = consonant-initial intended) was investigated in all these models and entered in the random effect structure. In each model, we aimed at using a maximal random effect (i.e. MRE) structure (as discussed in Barr, Levy, Scheepers, & Tily, 2013), that is, with by-subject and by-items random intercepts and slopes. However, we will only report the maximal converging models. Hence, some models had a simplified random effects (i.e. SRE) structure which did not allow correlation between the random slope and the random intercept. Note that random slopes were important for
the model since participants heard target pairs of vowel-initial pseudo-nouns in liaison cases (e.g. un petit onche [œ.pɔti.tɔʃ]) and their consonant-initial counterparts (e.g. un petit tonche [œ.pɔti.tɔʃ]), which had some subtle disambiguating acoustic cues related to the intended form.

### 3.1. Contexts involving adjectives

As shown in Figure 1, listeners displayed higher proportions of vowel-initial responses for liaison cases than for consonant-initial ambiguous cases involving /z/ and /n/ following an adjective Word 1, whereas the proportions of vowel-initial responses for the two intended contexts were comparable for cases involving /t/ and /r/. Two separate models were performed, one for the /t/ and /r/ comparison with a MRE structure for Participants and Items, and the other for the /n/ and /z/ comparison with a SRE structure for Participants and for Items. Note that one pivotal consonant was coded as -.5 and the other as +.5 in each comparison (i.e. first comparison: /r/ = -.5 and /t/ = +.5; second comparison: /n/ = -.5 and /z/ = +.5). Each model compared specific pairs in which one of the factors (onset probability, liaison frequency) was controlled (see Table 3).

On the one hand, the pivotal consonants /r/ and /t/ differed in their liaison frequency, but are both highly probable onsets. This pair enabled us to test the effect of liaison frequency on listeners’ segmentation. Results clearly show that listeners’ segmentation was not affected by liaison frequency (i.e. /t/ being more frequent than /r/ as a liaison consonant), since the effect of Pivotal Consonant is not significant. On the other hand, the pivotal consonants /z/ and /n/ are both highly frequent liaison consonants, but differ in their onset probabilities.

This pair enabled us to test the effect of onset probability. The effect of Pivotal Consonant was again not significant. The Intended Form was significant for this model involving the high-frequency liaison cases (i.e. /z/ and /n/). These results indicate a tendency for more vowel-initial responses when the intended form was truly vowel-initial only when the pseudo-nouns followed /n/ and /z/. This finding can be linked to the fact that stronger liaison-related acoustic cues were present for /n/ and /z/, which may have helped listeners interpret the intended Word 2 more easily. With weaker acoustic cues, /t/ cases yielded mixed responses, as did /r/ cases.

Thus, for adjectives, neither liaison frequency nor onset probability had an impact on listeners’ interpretation. The factor of liaison frequency predicted less vowel-initial responses for /r/ than for /t/, whereas onset probabilities predicted less vowel-initial responses for /n/ than for /z/ (refer to Table 1). Our results showed no general bias towards less vowel-initial interpretations with adjectives involving /n/, /z/, /t/, and /r/. Only the presence of strong liaison-related acoustic cues for /n/ and /z/ had an impact on listeners’ interpretation.2

### 3.2. Contexts involving adjectives versus determiners

As shown in Figure 2, listeners displayed higher proportions of vowel-initial responses for ambiguous cases involving /z/ or /n/ after a determiner than after an adjective, regardless of the intended target. A logit mixed-effects model on all listeners’ responses and with a SRE structure for Participants and for Items (i.e. maximal converging model) was performed. A significant effect of Syntactic Category (i.e. coded as determiner = −.5 and adjective = +.5) was found (see Table 4). The Intended Form was not significant, but a significant interaction between the Intended Form and Syntactic Category

#### Table 3. Logit mixed-effects models on vowel-initial responses for adjective contexts with intended form and pivotal consonant as the fixed factors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate (SE)</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liaison frequency</td>
<td>(Intercept)</td>
<td>−0.34 (0.59)</td>
<td>−0.57</td>
</tr>
<tr>
<td>(I/t vs /r/)</td>
<td>Intended form</td>
<td>0.11 (0.30)</td>
<td>0.38</td>
</tr>
<tr>
<td>(vowel-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pivotal consonant</td>
<td>Intended form</td>
<td>0.55 (1.16)</td>
<td>0.47</td>
</tr>
<tr>
<td>(pivotal consonant)</td>
<td>(pivotal consonant)</td>
<td>0.09 (0.59)</td>
<td>0.15</td>
</tr>
<tr>
<td>Onset probability</td>
<td>(Intercept)</td>
<td>−0.54 (0.49)</td>
<td>−1.10</td>
</tr>
<tr>
<td>(I/z vs /n/)</td>
<td>Intended form</td>
<td>1.39 (0.44)</td>
<td>3.15</td>
</tr>
<tr>
<td>(vowel-initial)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pivotal consonant</td>
<td>Intended form</td>
<td>−0.43 (0.96)</td>
<td>−0.45</td>
</tr>
<tr>
<td>(pivotal consonant)</td>
<td>(pivotal consonant)</td>
<td>−0.12 (0.84)</td>
<td>−0.14</td>
</tr>
</tbody>
</table>
was found. Hence, a significant tendency for less vowel-initial responses was obtained for cases involving adjectives than for those involving determiners.

Logit mixed-effects models were performed separately for the different syntactic categories (i.e. determiner and adjective). Note that the model testing adjectives was the same as the one reported in Table 3. Models that converged had different structures: the one involving determiners had a MRE structure for Participants and a SRE structure for Items, and the one involving adjectives had a SRE structure for Participants and for Items. In both models, cases involving /n/ were coded as −.5 and those involving /z/ were coded as +.5. The models revealed a significant impact of Intended Form for cases involving adjectives, but not for cases involving determiners (see Table 5). In both models, no effect of Pivotal Consonant was obtained; hence similar responses were obtained for both /z/ and /n/.

Taken together, the results indicate that listeners’ responses tended to correspond to the speaker’s intended pseudo-noun forms only in the context of adjectives as Word 1 and only for the pivotal consonants /z/ and /n/, but not for /t/ and /r/. Even though strong liaison-related acoustic cues were present for the /z/ and /n/ cases involving determiners as Word 1, listeners did not interpret the targets the way they were intended by the speaker, and they instead showed an overall vowel-initial bias.

4. Discussion and conclusions

Different factors in spoken word processing were investigated with a segmentation task involving pseudo-nouns in liaison and ambiguous non-liaison contexts. Stimuli included phonetically ambiguous cases (e.g. *un onche, un nonche*, both [œ.ⁿɔ.ʃ]). As in previous offline studies (e.g. Shoemaker & Birdsong, 2008; Yersin-Besson & Grosjean, 1996), listeners in our experiment showed confusion in some contexts and were not able to interpret the intended target correctly. In particular, /t/ and /r/ responses were near the chance level for both liaison and ambiguous non-liaison cases. For /z/ and /n/, however, our results showed the use of acoustic cues in certain contexts. In particular, although strong acoustic cues were present in both syntactic contexts, listeners used them when /z/ and /n/ followed an adjective, but failed to do so when the two consonants followed a determiner.

Acoustic cues related to liaison have not been previously documented in Quebec French. The speaker in our study produced shorter pivotal consonants in liaison-initial cases than in consonant-initial cases (see the stimuli measures in Table 2), although the difference was only statistically significant for /n/ and /z/. Shortening of the vowel preceding the pivotal consonant was also found for /n/ and /z/ and /t/. Even though only one speaker produced our stimuli, the acoustic cues were similar to the ones reported in studies using European French (e.g. Spinelli et al., 2003; Tremblay & Spinelli, 2013). Whereas many studies have reported the use of the specific acoustic cues which signals the correct form in online processing of liaison-ambiguous cases (e.g. Spinelli et al., 2003; Tremblay & Spinelli, 2014a), our study is the first offline study using natural speech that showed listeners’ use of acoustic cues for liaison interpretation (see the use of acoustical cues in instrumentally manipulated speech: Shoemaker, 2014).
strong acoustic cues were present (i.e. /z/ and /n/ cases), our listeners were successful in interpreting the intended target in the context of an adjective as Word 1. Although some acoustic cues for /t/ were present, listeners’ interpretations of /t/ cases were mixed for both liaison- and consonant-initial cases. Cases with /t/ also yielded similarly mixed results, as these cases did not provide significant acoustic cues at all.

Our study can be considered in the larger context of the existing literature on listeners’ use of disambiguating acoustic cues for speech recognition in different languages. For instance, in lexical-embedding cases (e.g. ham and hamster in English), segmental lengthening (i.e. longer in monosyllabic words) can be a useful disambiguating cue for online lexical interpretation (Salverda, Dahan, & McQueen, 2003). Listeners are also sensitive to subtle differences in consonant length during lexical processing in various languages (e.g. English: Gow & Gordon, 1995; Dutch: Shatzman & McQueen, 2006; Italian: Tagliapietra & McQueen, 2010). Tuinman, Mitterer, and Cutler (2012) found that English listeners can use the acoustic-phonetic cues related to the intrusive /r/ in their lexical selection, for example, saw roads versus saw /r/odes. In general, listeners’ responses in those studies were likely driven by the presence of distinct acoustic cues. In contrast, acoustic cues in liaison-ambiguous cases are overall weaker. Nevertheless, listeners in our experiment showed some evidence of using acoustic cues to interpret liaison ambiguity for pivotal consonants with relatively strong acoustic cues (i.e. /z/ and /n/).

Mattys and colleagues (e.g. Mattys & Melhorn, 2007; Mattys, Melhorn, & White, 2007; Mattys, White, & Melhorn, 2005; White, Melhorn, & Mattys, 2010) have shown that word segmentation cues can be put in a hierarchy, with lexical, syntactic, semantic, and contextual cues dominating lower-level cues such as phonotactic and acoustic cues. According to their view, segmentation cues have different weights for listeners. In our study we found that the syntactic category context influenced listeners’ use of liaison-related acoustic cues. Listeners used acoustic cues in the context of adjectives, but not in the context of determiners. The lack of use of acoustic cues in determiner context may be due to the more dominant influence of the category of function words: the greater occurrences of liaison with determiners. Liaison occurs predominantly in function word contexts, with an estimated total of 60–90% of all liaison occurrences; and Determiner + Noun sequences account for 26% of liaison production, whereas Adjective + Noun sequences account for less than 9% (Côté, 2013). Furthermore, based on a European French corpus, Mallet (2008) reported that potential liaison cases were consistently realised following determiners such as mes and ses (both 100%), whereas Adjective + Noun sequences had more variable rate of realisation (e.g. petit: 75%, grand: 55.56%, gros: 50%). The effect of syntactic category observed in our study can be due to the high frequency of function words (i.e. Determiner + Noun sequences) and a high number of liaison realisations for /z/ and /n/ in function word contexts. Liaison realisation is closely related to the frequency of Word 1, as low-frequency adjectives have more variable liaison realisations (e.g. Fougeron, Goldman, Dart, Guélat, & Jeager, 2001; Fougeron, Goldman, & Frauenfelder, 2001).

Given these facts, the lack of use of the acoustic cues related to liaison in the context of determiners is particularly interesting. Listeners did not use acoustic cues to interpret liaison ambiguity in the context of frequent function words. They instead showed a bias towards an overall vowel-initial interpretation regardless of the intended target. This bias indicates an effect of high- level knowledge in French-speaking listeners, that is, interpreting liaison (i.e. vowel-initial Word 2) as being more likely upon hearing pseudo-nouns following function words, for which most liaison cases occur and liaison realisation is obligatory. In contrast, when pseudo-nouns followed adjectives, listeners relied on the strong acoustic cues in the pivotal consonants /z/ and /n/ to interpret the intended targets. Our results are thus compatible with the idea of relative cue weights discussed in the work of Mattys and colleagues (e.g. Mattys, Melhorn, & White, 2007; Mattys, White, & Melhorn, 2005).

Taken together, among the factors that we examined, syntactic category showed a dominant effect on listeners’ interpretations, acoustic cues related to liaison had an effect only in cases where the cues were strongly present and where adjectives were Word 1. The overall liaison frequency (without the consideration of syntactic categories of Word 1) had no clear influence, since the two pivotal consonants with the highest frequency (i.e. /z/ and /n/) did not show a vowel-initial bias when the factor of syntactic category was balanced. The onset probability had no influence either, since the two pivotal consonants with the highest onset probabilities (i.e. /r/ and /t/) did not show a consonant-initial bias. Therefore, the effect of onset probability/ liaison frequency observed in online tasks (e.g. Tremblay & Spinelli, 2013) was not found with our offline task. The higher-level effect (i.e. syntactic category) that we showed is compatible with spoken word recognition models (e.g. Cohort: Marslen-Wilson, 1990; TRACE: McClelland & Elman, 1986; Shortlist: Norris, 1994; Neighbourhood Activation Model: Luce & Pisoni, 1998). All these models
acknowledge that higher-level knowledge can affect recognition, even though they differ with respect to the exact processing stage at which contextual influence occurs. Our study did not test the specific timing of contextual influences since our measures were offline. What we demonstrated was the influence of a higher-level factor during processing of ambiguous contexts.

In our study we showed how the syntactic category of Word 1 plays a major role in spoken word recognition of ambiguous misalignment cases. Our participants showed high vowel-initial interpretations in the context of determiners, although sub-syllabic vowel-initial responses are disfavoured in lexical access theories (e.g. SOSH: Content, Dumay, & Frauenfelder, 2000; PSW: Norris, McQueen, Cutler, & Butterfield, 1997). Based on those theories, listeners are more inclined to segment speech based on the onset of the syllable. Misalignment generates a processing cost according to SOSH. For instance, in Dumay, Frauenfelder, and Content (2002), listeners had significantly slower reaction times and more errors in a word-spotting experiment when the word (e.g. lac) had the onset misaligned with the syllable (e.g. zu glac) than when it was aligned (e.g. zun lac). The effect was not present when the offset of the word was misaligned with the syllable (e.g. la cluf) versus when it was aligned (e.g. lac tuf). Nevertheless, Fougeron, Frauenfelder, and Content (1999) showed that the insertion of a consonant with a morphemic status (e.g. l’ , a form of “the”) before a vowel-initial word (e.g. acrobate) does not impede its access, whereas the insertion of a consonant without a morphemic status (e.g. a /g/ before acrobate in gacrobate) did slow it down (see also Hanulikova, McQueen, & Mitterer, 2010). Thus, the higher-level knowledge about the consonant surfacing as the onset of the vowel-initial word influenced listeners’ processing in those studies. Likewise, our listeners showed a dominant influence of context, that is, liaisons occurring frequently with determiners (such as /z/ and /n/) leading to a vowel-initial bias for the subsequent word. We note that our participants produced /z/-initial words when an unambiguous context supported it (e.g. responding zarlet upon hearing un zarlet), suggesting that their vowel-initial bias in liaison and liaison-ambiguous context was not due to a general dis-preference for /z/ as a word onset following a determiner. That is, our listeners automatically processed liaison consonants as part of Word 1 and use that knowledge to process the subsequent word. This sensitivity to the phonological information related to the preceding word is a manifestation of higher-level knowledge. In summary, our study demonstrates that higher-level knowledge is strong, and it can affect spoken word recognition.

Notes

1. The initial design of our study was meant to test the resyllabification phenomenon globally. Therefore, our stimuli included both liaison and enchaînement, which together yielded a balanced number of target pairs across participant groups (i.e. each 12 pairs). Enchaînement is another type of resyllabification, which occurs when a word with an overt coda consonant is resyllabified with the following vowel-initial word (for example, the resyllabication of /d/ in cold ice in English, /k/ in chaque enfant in French). We later decided to only analyse the results of the liaison pairs, as it is unclear if enchaînement involves somewhat different processes. The focus on liaison pairs allowed us to test our hypotheses in a cleaner way and to link our results directly with the numerous studies that have investigated the case of liaison literature. Since we only had a few enchaînement phrases, the number of liaison phrases was almost equally balanced across groups (9 pairs for Group 1, 10 for Groups 2 and 3, and 11 for Group 4).

2. We note that among the /n/ stimuli, one un bon + N pair was produced with a natural distinctive variation of the vowel quality in liaison context (i.e. oral vowel for bon from un bon ourain) versus in consonant-initial context (i.e. nasal vowel for bon from un bon naurain). The two other pairs (i.e. un bon eque/nèque, un bon oigue/ noigue) did not contain this variation (i.e. the nasal vowel did not change into an oral vowel, as it could be expected in a liaison context). We did the same logit mixed-effects model analyses above by only excluding the two pairs without the natural cues, then by only excluding the pair containing the natural cues. The same results reported above were obtained (i.e. the effect of the Intended Form was significant, p < .05). This finding is consistent with the fact that listeners’ responses were likely affected by acoustic cues other than vowel quality (as mentioned in the Acoustic analysis section).

3. For example, when they heard the filler pseudo-noun zarlet preceded by the determiner un (which has an underlying /n/), subjects were predominantly correct (91%) in interpreting the pseudo-noun zarlet.

Acknowledgments

Parts of this study were presented at the 6th International Conference on the Mental Lexicon and at the joint meeting of the 21st International Congress on Acoustics and the 165th Meeting of the Acoustical Society of America.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This research was supported by SSHRC, NSERC, and CFI grants to the second author, and a FQRNT Ph.D. scholarship to the first author.
References


