FRENCH LIAISON: LINGUISTIC AND SOCIOLINGUISTIC INFLUENCES ON SPEECH PERCEPTION

DISSERTATION

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By

Robin Guillaume Dautricourt, B.A., M.A.

Graduate Program in Linguistics

The Ohio State University

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Dissertation Committee:
Professor Shari R. Speer, Advisor
Professor Mary E. Beckman
Professor Mark A. Pitt
Abstract

French liaison is a phonological process that takes place when an otherwise silent word-final consonant is pronounced before a following vowel-initial word. It is a process that has been evolving for centuries, and whose patterns of realization are influenced by a wide range of interacting linguistic and social factors. French speakers therefore not only have to adapt their lexical identification processes to words ending in liaison consonants, but they also have to learn the rules which govern when they could pronounce the liaison consonants, and when they should expect them to be pronounced by other speakers. This dissertation begins by establishing a comprehensive understanding of liaison production with a focus on the linguistic and social factors that influence its present day usage. The challenges which liaison presents to theories of word segmentation and speech perception are then established, followed by the presentation of a series of psycholinguistic experiments that manipulate some of the most salient factors that are known to influence liaison production (e.g. syntactic context, liaison consonant identity, speaker age, and speaker social class). The first experiment investigates the effects of liaison in four different environments, and not only provides evidence that liaison consonants can facilitate word recognition of the following vowel-initial word, but that this effect is more likely to take place in contexts where liaison consonants are more likely to occur in production. A series of three experiments then use auditory stimuli from a corpus of radio
interviews and visual stimuli consisting of photographed individuals in order to explore the influences of age and social class on the perception of liaison. Ultimately, the hypothesis that listeners’ expectations of speakers’ social identities can influence speech perception is put to the test using a cross-modal priming paradigm.
Dedicated to

My daughter, Annalise Rose Dautricourt, to your first smiles,

My son, Daniel Victor Dautricourt, to your first words,

My wife, Safiya Lyles Dautricourt, to our love.
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Vita

September 11, 1977 .................................Born – Châteauroux, France

1999................................................................B.A. Linguistics, University of California

San Diego

2005.............................................................M.A. Linguistics, The Ohio State University

Fields of Study

Major Field: Linguistics

Specialization: Psycholinguistics
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1. The Linguistics of Liaison

1.1 Introduction

While the white spaces between the letters on this page make it easy for the reader to identify word boundaries, there are no completely reliable acoustic cues which allow the listener to segment continuous streams of speech into sequences of words (Lehiste, 1972; Nakatani & Dukes, 1977). Yet, listeners are somehow able to effortlessly map the fluid acoustic signal onto discrete lexical representations in order to extract meaning from spoken utterances.

Theories of auditory word recognition address lexical segmentation from multiple perspectives. One approach is to emphasize the role of identifying word boundaries in order to then derive competing lexical hypotheses at word onsets. Linguistic units such as the phoneme or the syllable, as well as language-specific rhythms, are some of the important cues that listeners can use to identify word boundaries. Another approach assumes that word boundaries emerge from competing lexical hypotheses which are activated at any time, regardless of their location in the speech stream. That is, the sequence of competing lexical items which best match the acoustic signal is what determines the word boundaries. One way or another, listeners ultimately decipher word boundaries and lexical representations by making use of a vast array of linguistic and extra-linguistic cues ranging from subphonemic information to social context.
The focus of this thesis is French liaison, a phonological process that takes place at word boundaries and which presents interesting challenges to theories of word segmentation and speech perception. It is a process that has been evolving for centuries, and whose patterns of realization are influenced by a wide range of interacting linguistic and social factors. Liaison takes place when an otherwise silent word-final consonant is pronounced before a following vowel-initial word. For example, the final -s is not pronounced in the word *les* [le] ‘the’ when the word is spoken in isolation or when followed by a consonant-initial word (e.g. *parents* [paʁɑ̃] ‘parents’), as in the phrase *les parents* [le.pɑʁɑ̃] ‘the parents’. However, the final -s is pronounced as [z] when followed by a vowel-initial word (e.g. *enfants* [ɑ̃.fɑ̃] ‘children’), as in the phrase *les enfants* [le.zɑ̃.fɑ̃] ‘the children’.

<table>
<thead>
<tr>
<th>Context</th>
<th>Phrase</th>
<th>Pronunciation</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Les</em>, in isolation</td>
<td><em>Les</em></td>
<td>[le]</td>
<td>‘the’</td>
</tr>
<tr>
<td><em>Les</em>, followed by C</td>
<td><em>Les parents</em></td>
<td>[le.pɑʁɑ̃]</td>
<td>‘the parents’</td>
</tr>
<tr>
<td><em>Les</em>, followed by V</td>
<td><em>Les enfants</em></td>
<td>[le.zɑ̃.fɑ̃]</td>
<td>‘the children’</td>
</tr>
</tbody>
</table>

Table 1.1: Examples of liaison

While all native and fluent speakers of French will apply this example of the liaison rule, there are many contexts in which the realization of the liaison consonant is licensed but in practice may or may not be pronounced by these same speakers. French speakers therefore not only have to adapt their lexical identification processes to words such as *les* (since the liaison consonant is sometimes pronounced and other times not),

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1 Syllable boundaries will be denoted by ‘.’ throughout, and liaison consonants will be underlined for clarity.
but they also have to learn the rules which govern when they could pronounce the liaison consonants, and when they should expect them to be pronounced by other speakers. As we’ll soon discover, these so-called rules are very complex and their application varies by speaker and by context.

This thesis has three primary objectives, the first of which is to establish a comprehensive understanding of liaison production, from its historical origins to its present day usage. In particular, emphasis is placed on identifying the primary linguistic and sociolinguistic factors which influence the likelihood that liaison consonants are produced. The second objective is to report on a series of psycholinguistic experiments that explore how the presence or absence of liaison consonants impacts word recognition for French listeners. These experiments manipulate some of the most salient linguistic and sociolinguistic factors that are known to influence liaison production (e.g. syntactic context, liaison consonant identity, speaker age and social class), in order to evaluate their role in speech perception. The third objective of this thesis is to relate the experimental results back to the observations regarding liaison production and to theories of word recognition.

Chapter 1 reviews the approaches that have been used to study liaison production, as well as the factors which influence the realization of liaison in spoken French. Section 1.2 provides a brief description of the phonetically conditioned sound changes in Middle French that have led to the current state of the liaison process today. In section 1.3, the traditional grammarian approach of categorizing liaison environments into obligatory, optional, and prohibited contexts is introduced. The phonological and syntactic theories
that are based on the traditional descriptions of liaison are then discussed in section 1.4. The different types of corpus studies that have reported on liaison use are presented in section 1.5, along with an assessment of how well their quantitative results support the impressionistic hypotheses of the traditional grammarians. Following the chapter summary in section 1.6, a thesis outline is presented in section 1.7.

1.2 Historical context

1.2.1 Liaison as a result of diachronic change

The synchronic variation in French liaison today is linked to a more general historical process ofphonetically conditioned syllable-final consonant deletion. Starting around the 12th century, and extending throughout the period of Middle French, consonants were deleted word-internally and word-finally (first in preconsonantal position and then in prepausal position), such that only consonants in prevocalic position were pronounced (Tranel, 1987). Final consonants which were pronounced before vowel-initial words underwent the process of enchâînement, or forward resyllabification, meaning that they were pronounced as the initial segment of the following syllable. This resyllabification process caused phrases of spoken Middle French to be characterized by strings of open (consonant-vowel) syllables, as described in L’esclarcissement de la langue françoys, composed in the 16th century by Jehan Palsgrave, 1530:

*And here upon it ryseth why the frenche tong semeth so short and sodayne in pronounsyng; they joine the consonants of the wordes that go before to the vowels of the wordes following in redyng and speking without any pausyng… as though*
fyve or syx wordes or sometyme more made but one worde: whiche thyng, though it make that tong more hard to be atteyned, yet it maketh it more pleasant to the eare. (cited in Delattre, 1955)

Many of the factors which have historically influenced the pronunciation of word-final consonants in French continue to play an important role in the language. For instance, some word-final consonants are pronounced in isolation, but are deleted when followed by a consonant-initial word (e.g. chef [ʃɛf] ‘chef’ and dix [dis] ‘ten’, but chef d’oeuvre [ʃɛ.divœvʁ] ‘masterpiece’ and dix pages [di.pas] ‘ten pages’). By contrast, liaison takes place when otherwise silent word-final consonants are pronounced before a following vowel-initial word. For example, the second t in the word petit ‘little’ is not pronounced when the word is spoken in isolation or when followed by a consonant-initial word, as in the phrase petit frère [pœ.ti.frɛʁ] ‘little brother’. However, the t is pronounced when followed by a vowel-initial word, as in the phrase petit éléphant [pœ.ti.te.le.fɔ̃] ‘little elephant’. Interestingly, these two processes are complementary in that they both encourage open consonant-vowel syllables across word boundaries.

Liaison could be viewed as a mechanism for avoiding consecutive vowels, known as hiatus, in the French language. Indeed, liaison consonants occur in contexts which would otherwise result in hiatus. The role of the liaison consonant could then be interpreted as a means of clarifying the syllable and word edge and promoting a perceptually clear consonant-vowel sequence at the word onset. However, while this may in part be true, Martinet (1988) reminds us that hiatus is not uncommon in French, and gives the example il va à Avignon, ‘he’s going to Avignon’, which includes three consecutive instances of the same vowel across three words: /il va a avinjɔ̃/. Martinet also
points out that liaison can take place even when hiatus would not otherwise have occurred, such as in the phrase *les belles infidèles*, ‘the beautiful infidels’, pronounced as /le bel zɛfɛl/.

Though the consonant deletion process in Middle French affected all consonants and was widespread throughout the language, this phonetically driven process did not affect the French language uniformly. For instance, not all consonants began the deletion process at the same time, and monosyllabic words resisted the dropping of final consonants more strongly than did polysyllabic words (Fouché, 1961:666-680). Alternations in pronunciations were common and consonant-final words or morphemes that frequently occurred in prevocalic constructions were more likely to retain their final consonants. Liaison consonants survived the general consonant deletion process in Middle French by virtue of having been conserved through pairs of words which were and continue to be closely linked.

The history of the use of the liaison consonant /z/ in the 3\textsuperscript{rd} person plural pronoun *ils* exemplifies the alternations in pronunciation forms which resulted from the more general deletion process (Delattre, 1955). The written form of the 3\textsuperscript{rd} person plural pronoun during the 13\textsuperscript{th} century was *il*, and was it pronounced [il] before vowels but [i] before consonants. In the 14\textsuperscript{th} century an -s was added by analogy to nouns spelled with an -s in the nominative plural form, resulting in *ils*, the spelling which is still used today. During the 16\textsuperscript{th} century the pronunciation of *ils ont* ‘they have’ was either [i.1ɔ̃] or [i.zɔ̃], and by the end of the 17\textsuperscript{th} century, [i.zɔ̃] had become the more frequent pronunciation in the upper classes. It is a combination of pressures which have led the phrase *ils ont* to be
pronounced in Modern French as either [i.zɔ̃] or as [il.zɔ̃] (but no longer as [i.lɔ̃]). That is, while the phonetically conditioned sound change is the driving force behind the consonant deletion process, the consonant insertion by analogy to the orthography of plural nouns has spread due to lexical diffusion. The liaison consonant /z/ continues to act as an important plural marker in the language today, in the majority of plural determiners, adjectives, and nouns.

Social pressures constitute another important factor that has historically influenced the likelihood that liaison consonants are realized in speech. For example, Fouché (1961:664) explained that non-educated Parisians in the 16th century (i.e. speakers of ‘la langue vulgaire’) were dropping the final -r in words like mestier, papier, and resveur, and dropping the final -p in beaucoup, while grammarians such as Palsgrave, Du Wés, and Sylvius were advising educated people to pronounce their final consonants before pauses. During the 18th century, grammarians continued to condemn the vulgar dropping of final consonants, such as the final -r in tiroir ‘drawer’ (Walter, 1988:99). The increase in literacy and spelling reforms also played a role in the maintenance of ‘proper’ pronunciations, and some final consonants such as -r might not have survived had they disappeared in the written form (Cohen, 1987:225). Speakers’ awareness of the presence or absence of liaison continues to be an important social marker of register and prestige. The variation in realization of liaison consonants clearly does not occur randomly but is instead a process that speakers must learn to use appropriately. Knowledge of when to apply liaison not only marks you as a native or non-
native speaker of the language, but can also serve as an important marker of social identity.

The combination of influences which have affected the French language over the years has led to an interesting state of liaison because 1) liaison appears to be synchronically optional like a sound change in progress, and yet 2) liaison seems to have remained stable over a long period of time. Perhaps the balance of this stable yet optional process has been maintained by virtue of opposing factors that are more or less in balance. That is, it seems that the phonetically-conditioned sound change that results in phonetic pressure to delete word-final consonants has been tempered by social, orthographic, and morphological pressures to retain the very same consonants. The various linguistic and sociolinguistic factors which continue to influence the realization of liaison today will be explored in more detail in the upcoming sections. First, however, the set of liaison consonants will be described, as well as the distributional patterns of consonants and vowels at the edges of words in French.

1.2.2 Liaison consonants and word boundary patterns

While there are only five remaining consonants that can act as liaison consonants\(^2\), liaison is still a very active process in spoken French. More than one

\(^2\) Some sources will cite a sixth liaison consonant /k/ (e.g. Bergen, 2001; Booij & De Jong, 1987), but as Booij & De Jong point out, /k/ liaison is limited to the word long ‘long’, as in the phrase un long espoir [œ̃lɔ̃kɛspwar], ‘a long hope’. Liaison with /p/ is included among the 5 liaison consonants, though it only occurs with the words beaucoup ‘a lot’, and trop ‘too (much)’. 
orthographic representation can be associated with a liaison consonant (L Cons), as illustrated on the following page.

<table>
<thead>
<tr>
<th>L Cons Letter</th>
<th>Example</th>
<th>Transcription</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>/z/</td>
<td>‘s’ mes amis</td>
<td>[me.香味]</td>
<td>‘my friends’</td>
</tr>
<tr>
<td></td>
<td>‘x’ deux enfants</td>
<td>[dø.香味]</td>
<td>‘two children’</td>
</tr>
<tr>
<td></td>
<td>‘z’ venez ici</td>
<td>[香味.zi.香味]</td>
<td>‘come here’</td>
</tr>
<tr>
<td>/t/</td>
<td>‘t’ petit oiseau</td>
<td>[特香味.twa.zo]</td>
<td>‘small bird’</td>
</tr>
<tr>
<td></td>
<td>‘d’ grand avion</td>
<td>[grand.香味.vj3]</td>
<td>‘large airplane’</td>
</tr>
<tr>
<td>/r/</td>
<td>‘r’ premier étage</td>
<td>[premier.香味.tet]</td>
<td>‘first floor’</td>
</tr>
<tr>
<td>/n/</td>
<td>‘n’ bon article</td>
<td>[good.香味.tikl]</td>
<td>‘good article’</td>
</tr>
<tr>
<td>/p/</td>
<td>‘p’ trop aimable</td>
<td>[too.香味.mabl]</td>
<td>‘too kind’</td>
</tr>
</tbody>
</table>

Table 1.2: Examples of liaison by orthographic letter

It should be noted that when /t/ liaison consonants are produced there can be an accompanying change in vowel quality. Taking the examples above, the word premier in isolation is pronounced [premier.香味.mje], but when the liaison consonant /t/ is realized and resyllabified to the following vowel-initial syllable, the final vowel of premier shifts from [e] to [ɛ]. This change in vowel quality often happens in words that end in ‘er’, though this is not always the case. Most notably, verbs in the infinitive form that end in ‘er’ will maintain the [e] even if /t/ liaison takes place.

When /n/ liaison takes place, the word-final nasal vowel generally denasalizes. For example, the words bon ‘good’ and certain ‘some’ are pronounced [bɔ] and [sεʁ.tɛ] in isolation, but their final vowels are denasalized if /n/ liaison is realized, resulting in the final vowels [ɔ] and [ɛ]. There are some exceptions, however, including un ‘one’ or aucun ‘none’, which are realized as and [tɛ] and [o.kɛ] regardless of whether or not the liaison consonant occurs (e.g. aucun homme, [o.kɛ.nɔm], ‘no man’).
Liaison consonants vary greatly in terms of their frequency of occurrence in liaison contexts, as well as in their likelihood of actually being pronounced as liaison consonants. In order to provide a very rough sense of how often the primary requirements for a liaison environment are met (i.e. a word ending in a liaison consonant that is silent when the word is said in isolation, followed by a vowel-initial word), as well as an appreciation for the idiosyncrasy of each liaison consonant, here is a brief analysis of the relevant letters and phonemes which appear in word-initial and word-final position in French.

The corpus selected for analyzing the distribution of word boundary letters and phonemes in French is Lexique 2, a lexical database of the French language which contains roughly 129,000 word types coded by relevant information such as orthography, pronunciation, grammatical class, grammatical gender, and frequency (New, Pallier, Ferrand, & Matos, 2001). This resource was selected because its classification scheme greatly facilitated the analysis of both the orthographic and phonemic distributions at word edges in the French language. Also, Lexique 2 is a fairly large database that was recently assembled and which provides two different word frequency measures. The first frequency value is derived from a contemporary corpus of literary texts called Frantext, and the second is the number of web pages containing each word from a search of 15 million web pages using Fastsearch.

The first important observation to make from the analysis of initial and final segments of words in the Lexique 2 corpus is that the last letter of a word in French is not a good predictor of the last phoneme in that word. Table 1.3 illustrates the distribution of
final consonants (CV letter vs. CV phoneme\(^3\)) across the entire Lexique 2 corpus of 129,000 words and reveals that the legacy of historical deletion of final consonants in French has led to a current state in which there is substantial mismatch between orthographic and phonemic representation\(^4\). Knowledge of the French spelling system is obviously crucial in order to determine which words have latent liaison consonants, and furthermore to know the identity of that consonant (i.e. /z/ vs. /t/, /n/, etc.).

<table>
<thead>
<tr>
<th></th>
<th>C Phoneme</th>
<th>V Phoneme</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Letter</td>
<td>20.6%</td>
<td>46.6%</td>
<td>67.2%</td>
</tr>
<tr>
<td>V Letter</td>
<td>13.5%</td>
<td>19.3%</td>
<td>32.8%</td>
</tr>
<tr>
<td>Total</td>
<td>34.1%</td>
<td>65.9%</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.3: Word-final consonants in French: CV letters vs. CV phonemes

In order to illustrate how often word-final consonants correspond to liaison consonants, Table 1.4 provides the count of words ending in each of the orthographic consonants which correspond to a liaison consonant.

<table>
<thead>
<tr>
<th>Word-Final Orthographic Consonant</th>
<th>s</th>
<th>x</th>
<th>z</th>
<th>t</th>
<th>d</th>
<th>r</th>
<th>n</th>
<th>p</th>
<th>Other C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>42640</td>
<td>1210</td>
<td>2763</td>
<td>25872</td>
<td>468</td>
<td>7166</td>
<td>4068</td>
<td>73</td>
<td>2431</td>
</tr>
<tr>
<td>%</td>
<td>49.2</td>
<td>1.4</td>
<td>3.2</td>
<td>29.8</td>
<td>0.5</td>
<td>8.3</td>
<td>4.7</td>
<td>0.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 1.4: Distributions of orthographic consonants in word-final position

\(^3\) Glides /j/ and /w/ were classified as vowels in this analysis, as well as in all subsequent analyses.

\(^4\) The same table was generated using the 1000 words with the highest Frantext frequencies, and again using the 1000 words with the highest web search frequencies, in order to ensure that the relationship between orthographic and phonemic CV segments of the entire corpus were not skewed by the inclusion of a majority of very low frequency words. The patterns exhibited by the two top-1000 word frequency analyses were largely consistent with that of the entire 129,000 word corpus.
As shown in Table 1.4, the word-final letters that correspond to potential liaison consonants (i.e. s, x, z, t, d, r, n, p) account for over 97% of the words ending in an orthographic consonant in the Lexique 2 corpus. Note in particular that over 50% of the words end in a consonant associated with potential /z/ liaison (i.e. s, x, z), and that over 30% end in a consonant associated with potential /t/ liaison (i.e. t, d). The correlation between the final orthographic consonants and the last phonemes in those words is given in Table 1.5, below. This matrix indicates that a relatively small percentage of word-final orthographic consonants are actually pronounced as their spelling might suggest to the naïve reader. For example, only 3.5% of words ending in the letter ‘s’ end in /s/, and only 2% of words ending in the letter ‘t’ end in /t/. See Appendix A for a more detailed version of this table.

<table>
<thead>
<tr>
<th>Last Phone In Word</th>
<th>s</th>
<th>x</th>
<th>z</th>
<th>t</th>
<th>d</th>
<th>r</th>
<th>n</th>
<th>p</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>/d/</td>
<td>1.4%</td>
<td>0%</td>
<td>0%</td>
<td>0.5%</td>
<td>11.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>/t/</td>
<td>5.2%</td>
<td>0%</td>
<td>0%</td>
<td>2.0%</td>
<td>0.2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>/n/</td>
<td>3.0%</td>
<td>0%</td>
<td>0%</td>
<td>1.3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3.0%</td>
<td>0%</td>
</tr>
<tr>
<td>/p/</td>
<td>0.4%</td>
<td>0%</td>
<td>0%</td>
<td>0.2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>78.1%</td>
<td>0%</td>
</tr>
<tr>
<td>/s/</td>
<td>8.7%</td>
<td>0%</td>
<td>0%</td>
<td>8.6%</td>
<td>59.6%</td>
<td>31.8%</td>
<td>0%</td>
<td>0%</td>
<td>0.4%</td>
</tr>
<tr>
<td>/z/</td>
<td>3.5%</td>
<td>6.4%</td>
<td>0.5%</td>
<td>2.8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Other C</td>
<td>12.3%</td>
<td>0.1%</td>
<td>0.4%</td>
<td>2.0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>88.2%</td>
</tr>
<tr>
<td>Vowel</td>
<td>61.3%</td>
<td>93.6%</td>
<td>99.0%</td>
<td>81.1%</td>
<td>28.4%</td>
<td>68.2%</td>
<td>97.0%</td>
<td>21.9%</td>
<td>8.3%</td>
</tr>
<tr>
<td>Total Count</td>
<td>42640</td>
<td>1210</td>
<td>2763</td>
<td>25872</td>
<td>468</td>
<td>7166</td>
<td>4068</td>
<td>73</td>
<td>2431</td>
</tr>
</tbody>
</table>

Table 1.5: Pronunciations of orthographic consonants in word-final position
In contrast to word-final segments, the orthographic consonants and vowels which occur word-initially are excellent predictors of word-initial consonant and vowel phonemes in the pronunciation of the citation forms of French words.

<table>
<thead>
<tr>
<th></th>
<th>C Phoneme</th>
<th>V Phoneme</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Letter</td>
<td>74.1%</td>
<td>1.4%</td>
<td>75.5%</td>
</tr>
<tr>
<td>V Letter</td>
<td>0.0%</td>
<td>24.5%</td>
<td>24.5%</td>
</tr>
<tr>
<td>Total</td>
<td>74.1%</td>
<td>25.9%</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.6: Word-initial consonants in French; letters vs. phonemes

The analysis of letters and phonemes at word edges in the French language suggest that the two primary conditions required to license the realization of a liaison consonant are frequently met. The first condition, that the liaison word ends in a liaison consonant that is silent when the word is said in isolation, occurs frequently because 1) roughly two thirds of words end in an orthographic consonant, 2) over 97% of these consonants are liaison consonants, and 3) the vast majority of these consonants are pronounced as something other than the liaison consonant in isolation. The second condition, that the liaison word is followed by a vowel-initial word, is satisfied in that roughly a quarter of French words begin with a vowel. The point of this frequency analysis has been to make some very general observations about consonants and vowels at word edges in the French language, in order to establish that the minimal requirements to license the liaison context is productive. However, the degree to which these observations are a simplification of the likelihood of liaison cannot be overstated.
The remaining sections of this chapter focus on the linguistic and sociolinguistic factors which influence the likelihood that liaison consonants are pronounced. First, the traditional grammarian approach to studying the liaison phenomenon will be introduced. Next, some of the theoretical approaches which attempt to predict liaison production based on the grammarians’ descriptive accounts will be reviewed. Finally, the various forms of liaison corpora which have been reported will be discussed. Together, these approaches illustrate the dynamic nature of the interacting factors which characterize the synchronic variation in liaison production.

1.3 Descriptive approaches to French liaison

1.3.1 Introduction

French liaison has been studied in fine detail by grammarians, and it is on the basis of their descriptions that linguistic theories have attempted to account for liaison production. The traditional approach undertaken by grammarians has been to provide detailed examples of the contexts in which liaison is produced. The realization of liaison has long been classified into three categories, in which the pronunciation of the liaison consonant is considered obligatory, optional, or prohibited. Support for these categories consists of lists of words and phrases, as well as anecdotal evidence, which are classified according to the likelihood of liaison, based on the authors’ impressions rather than on quantitative data. Descriptions of factors which influence liaison rates include the phonetic environment of the liaison consonant, syntactic relationships and cohesion.
between words, nasalization, $h$-aspiré words, and phonostylistics. The purpose of this section is not to reproduce in detail the descriptions provided by traditional approaches, but rather to identify the main factors which consistently appear in these studies, in order to identify the challenges faced by theoretical frameworks which attempt to account for liaison production. In addition, the categorization of liaison environments into obligatory, optional, and prohibited liaison will play a significant part in the design of the word recognition experiments presented in Chapter 3.

1.3.2 Categorization of obligatory, optional, and prohibited liaisons

Traditional approaches to the study of liaison consistently categorize liaison environments in terms of whether liaison is obligatory, optional, or prohibited (Delattre, 1947, Léon, Bhatt, & Baligand, 1992, Armstrong, 1964, Capelovici, 1992). All environments first satisfy the basic phonological constraint that in order for liaison to be licensed, the first word must end in a latent consonant and the second word must begin with a vowel. Once this condition has been fulfilled, the syntactic cohesion between the two words determines whether liaison is obligatory, optional, or prohibited. The stronger the cohesion, the more likely liaison is to occur. Syntax and prosody also constrain the realization of liaison, as the two words must not only belong to the same syntactic phrase but also to the same rhythmic group. Liaison only rarely occurs across syntactic or rhythmic groups. In addition to addressing phonological and syntactic constraints, traditional classifications of liaison typically include some discussion of the role of speech style (from informal to formal) on liaison use. In simplified terms, speech in
which only obligatory liaisons are produced is associated with an informal style, whereas
the pronunciation of optional liaisons is associated with a more formal style. Prohibited
liaisons are never produced in any style.

Obligatory liaison occurs (a) after determiners, (b) between personal pronouns
and verbs, (c) between verbs and personal pronouns, (d) between prenominal adjectives
and nouns, (e) after monosyllabic prepositions, and (f) after monosyllabic adverbs. This
is by no means an exhaustive list of the obligatory liaison environments, but it does give
an indication of the types of syntactic contexts which fall under this category. A list of
examples corresponding to each environment is provided by Delattre (1947).

(a) vos [z] enfants ‘your children’, les [z] autres ‘the others’, un [n] ami ‘a friend’
(b) nous [z] avons ‘we have’, ils [z] ont ‘they have’
(c) vient [t]-elle ‘is she coming?’, parlons [z]-en ‘let’s talk about it’, allons [z]-y
   ‘let’s go’
(d) un grand [t] arbre ‘a big tree’, de grands [z] amis ‘close friends’, au premier [r]
   étage ‘on the first floor’, un bon [n] ami ‘a good friend’
(e) sous [z] un arbre ‘under a tree’, en [n] hiver ‘in winter’
(f) très [z] utile ‘very useful’, trop [p] aimable ‘too kind’

Table 1.7: Examples of obligatory liaison

Liaison is prohibited (g) after singular nouns, (h) after proper nouns, (i) after
polysyllabic conjunctions, (j) after the conjunction et, and (k) before h-aspiré. Again, a
list of examples is provided by Delattre (1947).

16
(g) *un soldat/anglais*5 ‘an English soldier’, *le camion/arrive* ‘the truck is arriving’
(h) *Louis/appele* ‘Louis is calling’, *Paris/aussi* ‘Paris too’
(i) *alors/on va ‘so we’re going’, cependant/on l’accusait ‘meanwhile we accused him’
(j) *lui et/elle ‘him and her’, et/on l’a fait ‘and we did it’, et/avec moi ‘and with me’
(k) *des/héros ‘some heroes’, en/haut ‘above’

Table 1.8: Examples of prohibited liaison

While syntactic constraints determine many of the obligatory and prohibited liaison environments, the last two environments listed above (j, k) illustrate that phonological rules can block liaison. For instance, liaison is blocked by words whose final orthographic consonants are mute and by definition never pronounced (e.g. as with the conjunction *et ‘and’, and the adjectives court ‘short’, fort ‘strong’, and lourd ‘heavy’). Words which begin with an *h*-aspiré are another example of a phonological rule that can block the application of liaison. Orthographically, the letter *h* is used to represent both *h*-aspiré consonants (of Germanic origin) as well as non-*h*-aspiré consonants (of Latinate origin). Although all *h*’s are silent, word-initial *h*-aspiré consonants pattern phonologically like other consonants in that they block liaison, whereas non-*h*-aspiré consonants pattern phonologically like vowels in that they license liaison. Thus liaison is prohibited before words which begin with *h*-aspiré (e.g. *les/haricots* ‘the string beans’, *les/hérissons* ‘the hedgehogs’, and *les/hiboux* ‘the owls’), but is obligatory following the plural determiner *les* when the next word begins with non-*h*-aspiré (e.g. *les [z] hommes* ‘the men’, *les [z] hôpitaux* ‘the hospitals’, and *les [z] horloges* ‘the clocks’).

Optional liaisons are the most difficult to describe because liaison is more likely in some optional environments than in others, and because there are a wide variety of

5 The symbol ‘/’ indicates the absence of liaison.
factors which influence the likelihood of their realization. Delattre (1955) identifies syntax, phonetics, prosody, historical factors, and speech style as the factors which most influence the realization of optional liaison, and makes the following predictions: Syntax governs the likelihood of liaison based on the degree of cohesion between the two words. Phonetics influences liaison rates such that liaison is more likely a) if the first word ends in a vowel than if it ends in one or more consonants, and b) between two identical vowels than two different vowels. Prosody influences liaison use such that liaison is less likely a) in longer words or phrases, b) in questions than in declaratives, and c) when the initial syllable of the second word is stressed for contrast or emphasis. Historical factors include the differentiation between the two types of $h$-initial words, whose licensing of liaison is not influenced by syntactic or additional phonetic constraints. Another historical process is the nasalization of vowels, which occurred as a consequence of final consonant deletion during the period of Middle French. Liaison is blocked from occurring after nouns which end in nasal vowels, such as *maison* [me.zɔ̃] ‘house’. Delattre singles out speech style as having the most influence on speakers’ use of liaison, such that liaison is more likely in more careful or formal speech. In order to illustrate the range in the realization of optional liaison, Delattre developed the following hierarchy based on a scale of 1 to 10, where a 10 indicates cases of obligatory liaison.
| 1. Conjunction + clause | il regardait [t] et parlait ‘he was looking and talking’ |
| 2. Noun + verb | les enfants [z] iront ‘the children will go’ |
| 3. Pronoun + verb | les autres [z] iront ‘the others will go’ |
| 4. Verb + object | vous devez [z] aller ‘you should go’ |
| 5. Noun + adjective | des enfants [z] allemands ‘some German children’ |
| 6. Auxiliary + infinitive | vous devez [z] aller ‘you should go’ |
| 7. Auxiliary + past participle | ils ont [t] été ‘they have been’ |
| 8. Preposition + its complement | sous [z] un lit ‘under a bed’ |
| 9. Adverb + adjective or verb | tellement [t] agréable ‘so nice’ |
| 10. Determiner + noun | des [z] amis ‘some friends’ |

Table 1.9: Syntactic hierarchy of liaison likelihood

One year later, Delattre (1956) revised his hierarchy of optional liaison according to the following six levels: très fréquente ‘very frequent’, assez fréquente ‘rather frequent’, mi-fréquente ‘half-frequent’, peu fréquente ‘not frequent’, rare ‘rare’, and très rare ‘very rare’.

A review of traditional approaches to the study of liaison would not be complete without mentioning the groupes figés ‘fixed phrases’ in which liaison is either obligatory or prohibited. It is interesting to note that virtually all descriptive works on liaison make reference to these exceptional cases, but that due to the large number of exceptions, no two sources provide the same set of examples (e.g. Delattre, 1947:156; Moisset, 2000:147; Mastromonaco, 2000:18). Frequently cited examples of obligatory liaison in fixed phrases include Il était [t] une fois ‘once upon a time’, petit [t] à petit ‘little by little’, Mesdames [z] et Messieurs ‘Ladies and gentlemen’, avant [t]-hier ‘the day before yesterday’, c’est [t] à dire ‘that is to say’, pas [z] encore ‘not yet’, Nations [z] Unies ‘United Nations’, États [z]-Unis ‘United States’, and Jeux [z] Olympiques ‘Olympic
Games’. Fixed expressions in which liaison is prohibited include *de part/en part* ‘straight through’, *corps/à corps* ‘hand-to-hand (combat)’, and *à tord et à travers* ‘wildly’.

1.3.3 Summary

The traditional approaches to French liaison generate highly detailed descriptions of the environments in which liaison is considered obligatory, optional, or prohibited. These categories, as well as the extensive lists of examples which accompany them, can be useful for French language learners. However, these descriptions do not provide generalizations or rules which summarize or predict the realization of liaison. Theoretical rule-based approaches which attempt to account for French liaison have based their hypotheses largely on the impressionistic descriptions and categories proposed by the traditional grammarians. Formal accounts of liaison have focused on the phonological aspects of resyllabification, the syntactic bases for the liaison phenomenon, as well as the prosodic phrases within which liaison can occur. The next section provides a brief overview of some of these theoretical approaches to French liaison.
1.4 Theoretical approaches to French liaison

1.4.1 Phonological approaches to French liaison

Phonologists attempt to provide formal representations in order to predict the use of liaison according to the obligatory, optional, and prohibited categories established by traditional grammarians. Phonological approaches to French liaison differ in their analyses of liaison consonants, which are pronounced before vowels but are silent before consonants and pauses. The linear approach interprets liaison consonants as deleted segments, the concrete approach considers the liaison consonants to be epenthetic, and the non-linear approach characterizes liaison consonants as floating segments that attach themselves to following empty onsets. Each approach has its strengths, yet no approach adequately accounts for the variation.

The linear approach is based on generative abstract phonology, and assumes that underlying representations of words contain word-final liaison consonants. These consonants are deleted in their surface forms by means of a deletion rule, when followed by a consonant-initial word. Some of the major contributors to this linear approach include Dell (1970, 1973), Schane (1968, 1974), and Selkirk (1972). Mastromonaco (2000) points out various problems with this approach, including a) a failure to differentiate fixed final consonants that are always phonetically realized from liaison consonants which delete before consonant-initial words, b) a failure to predict when liaison will occur in optional liaison environments, c) a failure to generalize the liaison process with other resyllabification phenomena in French, and d) a failure to incorporate
the syntactic processes which influence the realization of liaison (Mastromonaco, 2000: 37-40).

The concrete approach to analyzing French liaison does not assume any underlying word-final consonants, but instead attempts to insert liaison consonants into the appropriate contexts via epenthetic rules. Major contributions to this approach include Klausenburger (1974, 1977, 1978a, 1978b, 1984) and Tranel (1981, 1986, 1990). The epenthetic approach has numerous advantages over the deletion approach, but the concrete approach has its own challenges. For instance, insertion rules must be postulated for individual cases in order to account for those words which have obligatory liaison and those words which don’t. The primary difficulty in this approach is that there is no way to predict the appropriate liaison consonant (e.g. /t/ or /z/ or /n/, etc.) for epenthesis. The concrete approach does not effectively generalize consonant deletion.

The non-linear approach is based on a multi-linear representation of syllable structure in which liaison segments are present underlingly in the form of floating consonants. When the appropriate syntactic conditions are met, these consonants are realized in the surface structure by attaching themselves to the following empty onset. Some of the main contributors to this approach include Clements and Keyser (1983), Tranel (1986, 1990), Encrevé (1983, 1988), Hyman (1985), and Wetzels (1986). Since three-dimensional phonology incorporates syllable structure into its analysis, it is better equipped than the linear and concrete approaches when it comes to handling the phonological properties that influence liaison. However, while the non-linear approach doesn’t need to posit deletion or insertion rules, it does not adequately distinguish the
contexts in which an empty onset permits a floating liaison consonant to attach itself (e.g. *dans [z] une heure* ‘in an hour’) from the contexts in which this is not allowed to happen (e.g. *pendant/une heure* ‘for an hour’).

In summary, none of the phonological approaches are able to effectively and/or comprehensively predict the use of liaison. The linear and concrete approaches assume an underlying lexical representation which either contains a liaison consonant or not, but neither approach is able to accurately predict when liaison consonants are realized in the surface form by means of deletion or insertion rules. The advantage of the non-linear approach is that syllable structure and phonological properties are built into the analysis, yet determining the contexts in which floating consonants are anchored to empty onsets remains a familiar problem. Various factors which are known to influence liaison production remain unaddressed by these phonological approaches.

1.4.2 Syntactic approaches to French liaison

A liaison consonant requires a following empty onset in order to attach itself to the following word, and phonological theories acknowledge that liaison is not only conditioned by segmental context, but it is also governed by syntactic properties. However, it is difficult to establish the “close syntactic relationship” which is necessary in order for liaison to occur. Some of the attempts to formally account for the syntactic conditions for liaison have been addressed by X-bar syntax, c-command, and government.
In X-bar syntax, word boundaries are units in the phonological string which define a domain. Milner (1967), Schane (1974), and Selkirk (1972, 1977) propose that the number of word boundaries between two words determines whether or not liaison will be produced. That is, liaison is produced before a single word boundary (represented by the symbol ‘#’), but not before a double word boundary (‘##’). Based on the notion of the phonological word in Chomsky and Halle’s (1968) *The Sound Pattern of English* (SPE), word boundaries are inserted before and after each string which is dominated by a major category (e.g. lexical categories noun, verb, and adjective). Determiners alone are not phonological words (i.e. not lexical categories), but they can form phonological words with a following noun. This formulation predicts that liaison will occur between a determiner and a noun because they are only separated by a single word boundary (e.g. *les # enfants*), but that liaison will not occur between a noun and a following adjective because these two are separated by a double word boundary (e.g. *les # enfants ## intelligents*). Since this analysis is adequate for obligatory liaison but not optional liaison (i.e. recall that liaison is obligatory after determiners, but optional between plural nouns and adjectives), syntactic rules in X’ were modified such that they would be sensitive to style. For example, Selkirk (1972) proposed readjustment rules in order to account for the realization of optional liaison in different speech styles such as casual speech, careful speech, and reading/lecture. Despite Selkirk’s attempt to integrate speech style into the syntactic account of liaison, the insertion or deletion of word boundaries (‘#’) according to speech style appear to be no more than arbitrary rules formulated based on the
descriptive (and *didactic*, not empirical) analyses presented by traditional grammarians such as Delattre.

In addition to Selkirk’s (1972) account of liaison using X’ theory, syntactic approaches have also been undertaken using c-command (e.g. Kaisse, 1985; Prunet, 1987) and government (e.g. Bennett, 1991). Neither approach provides an adequate account for liaison production. In particular, these theories are not able to handle the differences in liaison rates after certain verbs but not others, or after mono- vs. polysyllabic prepositions or adverbs (for a more complete discussion, see Mastromonaco, 2000).

1.4.3 Summary

Neither phonological nor syntactic theories are able to account for liaison production, and both are especially challenged by the variation in optional liaison environments. Whether a liaison consonant is taken to be present (floating or not) in the underlying structure but sometimes deleted in surface form, or absent in underlying structure but sometimes inserted in surface form, the theory is still faced with the problem of accurately predicting when the liaison consonant is realized. Phonological approaches are best equipped to address sublexical influences such as constraints imposed by neighboring segments, while syntactic theories focus on using the strength of the word boundary in order to predict liaison. What all of these theories have in common is that they aim to simplify the liaison process into a few elegant derivational rules. This approach will never succeed, however, so long as liaison production continues to be
influenced by a complex interaction of phonological, morphological, syntactic, prosodic, and social factors. The first step in developing a more effective model to account for the liaison process should be to abandon the traditional grammarians’ classification of liaison into obligatory, optional, and prohibited categories. These groupings may be helpful for students who are trying to learn when to pronounce liaison consonants and when not to, as was originally intended by grammarians, but they will only misguide any theory which takes them too seriously. An alternative approach for a theoretical model which predicts liaison production would be to dynamically incorporate all relevant linguistic and sociolinguistic factors such that the weight of each factor is appropriately shifted according to their influence on liaison occurrence. Such a model can only be entertained once the impact of each factor on the likelihood of liaison occurrence – as well as the interactions between factors – has been evaluated and quantified. The next section reviews the types of speech corpora that have been used to investigate the use of liaison, and highlights some of the results which illustrate the variability in the use of liaison.

1.5 Quantitative studies of French liaison production

1.5.1 Review of liaison corpus studies

While traditional approaches to French liaison consist largely of impressionistic descriptions, and theoretical approaches aim to predict the occurrence of liaison according to the traditional obligatory, optional, and prohibited categories, the quantitative observations from corpus studies of French liaison clearly demonstrate that
liaison production cannot be adequately characterized by the traditional three-way
distinction (Malécot, 1975; Ashby, 1981). For example, sometimes liaison isn’t realized
in obligatory liaison environments but is realized in prohibited environments.
Furthermore, the use of the term ‘optional liaison’ suggests random alternations, when in
fact the realization of liaison is consistently more likely in some optional contexts than in
others. “Because of the complex nature of the variability in liaison usage, neither
traditional grammars nor intuitions can be used as empirical evidence: the direct study of
liaison in natural speech by means of corpora is an absolute requirement for gaining an
insight into the constraints upon its usage” (Booij & De Jong, 1987:1015).

The traditional grammarian approach to liaison focused primarily on
generalizations about the use of liaison in formal and proper speech, while the empirical
data reported in studies of liaison speech corpora provide valuable insights into type and
token counts of liaison and non-liaison realizations across a wider variety of speech
styles. For example, the corpora used for investigations of liaison have included speech
from French radio broadcasts (Ågren, 1973; Blount, 1989), radio and television
performances by French political and union leaders (Léon, 1971; Encrevé, 1983),
informal and semi-structured interviews (De Jong, 1994; Green & Hintze, 1990),
conversations by Parisians (Malécot, 1975), combinations of spontaneous speech and
read speech (Bannert, 1998; Kovac, 1979; Lucci, 1983; Moisset, 2000), spontaneous
task-oriented speech (Boula de Mareüil & Adda-Decker, 2002), read sentences (Morin &
Kaye, 1982; Sampson, 2001), and read newspaper speech (Boula de Mareüil & Adda-
Decker, 2002; Boula de Mareüil, Adda-Decker, & Gendner, 2003). Corpus studies such
as these not only provide empirical bases on which theoretical accounts can be evaluated and refined, but they also highlight the importance of formally acknowledging the wide variety of linguistic and extra-linguistic factors which influence the realization of liaison in spoken French.

1.5.2 Corpus evidence for the influence of linguistic factors on liaison realization

The highly variable nature in data source, method of collection, and focus of analysis across liaison corpus studies add yet one more element of complexity to the pursuit of understanding the liaison phenomenon. However, this variety is precisely the ingredient which is required in order to evaluate the degree to which liaison production actually conforms to the alleged obligatory – optional – prohibited categories. The objective of this section is to synthesize the empirical evidence which has been reported in liaison corpus studies as the basis for evaluating the influence of syntactic environment, lexical properties, and consonant identity on liaison production.

1.5.2.1 Syntactic environment

Corpus studies indicate that while the rate of liaison in obligatory environments is generally high, speakers clearly do not produce liaison categorically in these contexts. The liaison rate after articles occurred 99.9% of the time in De Jong’s (1994) corpus, and 99.5% of the time in Malécot’s (1975) corpus. Liaison rates drop slightly after monosyllabic prepositions (Malécot: 98.8%, De Jong: 91.2%), and drop further after
monosyllabic adverbs (De Jong: 92%, Malécot: 63.1%). De Jong reports a 94.3% rate of liaison between prenominal adjectives and nouns.

The rate of liaison in optional environments tends to be low yet highly variable. Liaison rates are high after adjectives which include those in prenominal position (Malécot: 93.2%), but low after adjectives that aren’t followed by a noun (Moisset, 2000: 20%). Liaison rates are low after nouns (Malécot: 2%, Moisset: 16%), although more frequent between plural nouns and adjectives (Ågren, 1973: 26%). Liaison rates are also low after verbs (Malécot: 5.2%, Moisset: 12%), and especially low after infinitives (Malécot: 0.9%).

Few studies report on liaison rates in prohibited environments. Malécot reported 0% liaison after singular nouns and 0% liaison after proper nouns, though the sample size in this study was relatively small (n=9 and n=13, respectively).

1.5.2.2 Lexical properties

Quantitative studies of liaison clearly demonstrate that various lexical properties play an important role in determining the likelihood of liaison production. For instance, liaison is more likely in monosyllabic words than polysyllabic words (De Jong, 1994; Ågren, 1973). Moisset (2000) reports a liaison rate of 25% after monosyllabic words, but only 5% after polysyllabic words. Liaison occurs more often after high frequency words.
(e.g. *très* [z] *attentif* ‘very attentive’) than after low frequency words—(e.g. *trop* [p] *attentif* ‘too attentive’) (Booij & De Jong, 1987; Bybee, 2001). For example, liaison occurred 75.5% of the time in frequent words from the BREF corpus, but only 18.1% of the time in rare words. (Boula de Mareüil & Adda-Decker, 2002). Liaison is also more likely to occur in high frequency bigrams—(e.g. *ils entrent* ‘they enter’) than in low frequency bigrams (e.g. *les gens entrent* ‘the people enter’), and in some cases those high frequency constructions may be at least partially *lexicalized* (Bybee, 2001).

The influence of word frequency on the rate of liaison production is well illustrated by Ågren’s (1973:33) report of liaison rates for the different inflections of the auxiliary verb *être* ‘to be’, reproduced below. First, it is important to note that the rate of liaison varies dramatically according to the inflection. The liaison rate gradually decreases from the nearly categorical [t] after *est* (97%), all the way down to the infrequent use of [z] following *j’étais* (21%). This observation is crucial because it significantly weakens the argument that liaison use can be categorized as obligatory, optional, or prohibited according to the syntactic environment. That is, while the liaison rate after *est* is comparable to the reported rates in obligatory contexts (see determiners, monosyllabic prepositions/adverbs, and prenominal adjectives, above), liaison after *suis* only occurs half as often, and yet the two verb forms can occur in exactly the same

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6 In these examples, *très* is the 92nd most frequent word in the Lexique corpus whereas *trop* is the 366nd most frequent word. The former occurs 1027.1 times per million in the literary *frantext* source, and 134179 times per million in *fastsearch* web pages, and the latter occurs 559.68 and 51574.1 times per million in the same sources, respectively.

7 The bigrams in question are groups of two words in the French language. The probability of a given bigram is equivalent to the probability $P()$ of a word $W_n$ given the preceding word $W_{n-1}$, or the co-occurrence of the two words $P(W_{n-1}, W_n)$ divided by the probability of the preceding word. That is, $P(W_n|W_{n-1}) = P(W_{n-1}, W_n) / P(W_{n-1})$.  

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syntactic frames (e.g. *il est énervé* ‘he is annoyed’ vs. *je suis énervé* ‘I am annoyed’). The second observation of Ågren’s data is that the percentage of liaison is correlated with the token frequency of the verb form. In other words, the more frequent the verb form is, the more likely liaison will occur.

<table>
<thead>
<tr>
<th>Forms of the verb <em>être</em></th>
<th>L</th>
<th>NL</th>
<th>Total</th>
<th>% Liaison</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>est</em> (3rd Sg. Pres. Ind.)</td>
<td>2,591</td>
<td>77</td>
<td>2,668</td>
<td>97%</td>
</tr>
<tr>
<td><em>sont</em> (3rd Pl. Pres. Ind.)</td>
<td>242</td>
<td>38</td>
<td>280</td>
<td>86%</td>
</tr>
<tr>
<td><em>étant</em> (Pres. Part.)</td>
<td>22</td>
<td>7</td>
<td>29</td>
<td>76%</td>
</tr>
<tr>
<td><em>était</em> (3rd Sg. Impf.)</td>
<td>272</td>
<td>95</td>
<td>367</td>
<td>75%</td>
</tr>
<tr>
<td><em>êtes</em> (2nd Pres. Ind.)</td>
<td>24</td>
<td>10</td>
<td>34</td>
<td>71%</td>
</tr>
<tr>
<td><em>étaient</em> (3rd Pl. Impf.)</td>
<td>36</td>
<td>21</td>
<td>57</td>
<td>63%</td>
</tr>
<tr>
<td><em>sommes</em> (1st Pl. Pres. Ind.)</td>
<td>43</td>
<td>31</td>
<td>74</td>
<td>58%</td>
</tr>
<tr>
<td><em>suis</em> (1st Sg. Pres. Ind.)</td>
<td>65</td>
<td>74</td>
<td>139</td>
<td>47%</td>
</tr>
<tr>
<td><em>serait</em> (3rd Sg. Fut.)</td>
<td>17</td>
<td>24</td>
<td>41</td>
<td>41.4%</td>
</tr>
<tr>
<td><em>soit</em> (3rd Sg. Pres. Subj.)</td>
<td>22</td>
<td>32</td>
<td>54</td>
<td>40.7%</td>
</tr>
<tr>
<td><em>j’étais</em> (1st Sg. Impf.)</td>
<td>6</td>
<td>23</td>
<td>21</td>
<td>21%</td>
</tr>
</tbody>
</table>

Table 1.10: Ågren's liaison rates for the forms of the verb *être*

1.5.2.3 Liaison consonant identity

The realization of liaison varies greatly according to consonant identity. The most frequent liaison consonants are /z/, /t/, and /n/; liaison with /t/ and /p/ is very rare. Based on 20 hours of adult speech, Boë & Tubach (1992) reported that 99.7% of all liaisons produced were accounted for by /z/ (50.5%), /t/ (30.4%), and /n/ (18.9%).

Liaison with /z/ is very frequent due to its prevalence as a plural marker for determiners, adjectives, and nouns. For instance, /z/ liaison occurs systematically after plural determiners (i.e. *les, mes, tes, ces*) and variably between plural nouns and adjectives (e.g. *les [z] enfants [z] intelligents* ‘the intelligent children’). Green and Hintze (1990:83) claim that this liaison type is synchronically the most productive in Modern
French. While /z/ liaison is often used as a plural marker, liaison with /t/ is especially associated with verbs conjugated in the 3rd person. Thus, verb forms which end in [t] tend to have a higher rate of liaison than verb forms of equivalent frequency which end in [z] (Bybee, 2001:350). Liaison with /t/ occurs in a wider variety of environments than /z/, and consequently its range of realization is greater than that of /z/ (Moisset, 2000; Lucci, 1983).

Liaison rates vary according to context. Based on a corpus of speech in five different contexts (spontaneous, conference, reading, interview, and conversation), Lucci (1983) reported that /t/ liaison varied from 34% to 65%, while /z/ liaison varied from 15% to 43%. Context influences the rate of liaison for each consonant according to the types of constructions in which those consonants can occur. For instance, Chevrot & Fayol (2001:773) point out that “the optional liaisons which are often produced in formal situations involve /t/ or /z/, whereas the /n/ liaisons which are normally obligatory are present in all situations.” Table 1.11 includes data from three major corpora of liaison, and indicates the percentage of liaison occurrence per consonant, as well as the number of tokens per consonant.

<table>
<thead>
<tr>
<th></th>
<th>/t/</th>
<th>/z/</th>
<th>/n/</th>
<th>/r/</th>
<th>/p/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisset (2000)</td>
<td>22% (5,550)</td>
<td>15% (5,019)</td>
<td>75% (122)</td>
<td>1% (738)</td>
<td>41% (37)</td>
</tr>
<tr>
<td>Malécot (1975)</td>
<td>52.4% (1,173)</td>
<td>60.5% (2,447)</td>
<td>94.4% (769)</td>
<td>50% (4)</td>
<td>25% (8)</td>
</tr>
<tr>
<td>Encrevé (1983)</td>
<td>72%</td>
<td>39.8%</td>
<td></td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.11: Liaison rates per consonant
From the table above, it is clear that both the number of liaison tokens and the rate of liaison differ widely according to the liaison consonant. Discrepancies across the different corpora reflect not only differences in the sources of the data, but also differences in the selection of liaison contexts. For instance, Malécot’s (1975) data is based on obligatory and optional liaisons, while Moisset (2000) and Encrevé (1983) only report on optional liaison.

1.5.2.4 Summary

Corpus studies of liaison make it abundantly clear that liaison is a highly variable process, and the influence of linguistic factors alone illustrate that the classification of liaison environments into obligatory, optional, and prohibited categories is a gross oversimplification. Although traditional grammarians suggested that liaison use varies according to speech style, and some theoretical accounts of liaison have attempted to integrate these different levels into their frameworks (e.g. Selkirk, 1972), corpus data on liaison production suggest that speech style not only interacts with linguistic factors, but also with a variety of social factors. This interaction, along with the contribution of other sociolinguistic factors on liaison production is reviewed in the next section.

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Encrevé (1983) does not provide liaison rates for /n/ or /p/.
1.5.3 Corpus evidence for the influence of sociolinguistic factors on liaison realization

In addition to the linguistic factors which influence the realization of liaison, there are a number of social factors which have also been linked to the liaison phenomenon. These include speech register, social class, and age, each of which will be examined in more detail below by presenting results from corpus studies which highlight the relationship between variation in liaison use and the corresponding social factor.

Speech register is frequently linked with liaison in traditional studies of liaison production. Delattre (1955) argued that speech style is the factor which most strongly influences the realization of optional liaison, and identified four different levels of style (casual, careful, conference, and read verses). Liaison rates are predicted to rise along with an increase in formality. Corpus studies which compare liaison rates across contexts which vary in their degree of formality support Delattre’s claim. For instance, liaison rates have been reported to increase from informal to formal unscripted speech (Bannert, 1998), as well as from the reading of short passages (formal) to the reading of word-lists (very formal) (Kovac, 1979; De Jong, Poll, & Woudman, 1981; see also Booij & De Jong, 1987; Sampson, 2001). Similarly, Moisset (2000) found that liaison rates increased across three different levels of style (vernacular speech, formal speech, and reading style), while Lucci (1983) reported that liaison rates increased across four different situational contexts of increasing formality (conversations, interviews, conference talks, and reading of texts). Variation in liaison according to style has also been demonstrated in corpora based on the speech of radio announcers (Blount, 1989; Ågren, 1973) and politicians (Encrevé, 1983).
Studies by Booij and De Jong (1987), De Jong (1988), and Moisset (2000) all report gradual increases in the use of liaison from lower to higher socio-economic classes. It is not surprising, therefore, that of the 21 politicians in Encrevé’s (1988) study, the one who produced the least liaison had working class roots and was the leader of the French communist party, whereas the individual who produced the highest proportion of optional liaison was a member of the prestigious French Academy. Speakers can adjust their liaison use according to the social context of the discourse, however, and are perhaps most inclined to do so in order to distinguish or assimilate themselves to other speakers. For instance, while Francois Mitterand produced liaisons in optional contexts 80% of the time in his inaugural presidential address, optional liaisons only occurred 54% of the time when he was in a televised debate with Valéry Giscard d’Estaing (Encrevé, 1988). In contrast to the example of a highly-educated member of an upper social class who tones-down his liaison usage in order to appeal to his broad audience, Sampson (2001) reports an example of linguistic insecurity on the part of an individual who is aware that their liaison use does not typically conform to that of “proper” French. In his production study of /n/ liaison, Sampson reports that a subject experienced a “general feeling of tension between the spontaneous tendency to use ZERO-liaison in the various sequences and the desire somehow to conform to ‘correct’ pronunciation by using a distinct liaising form”. Corpus studies of liaison therefore not only demonstrate that liaison use generally increases from lower to higher socio-economic classes, but also that speakers have an awareness of this correlation and may adjust their liaison use according to the speech community with which they wish to be associated.
In their review of liaison in five corpora, Booij and De Jong (1987) reported that older speakers produced more liaison than younger speakers. This pattern was also found in studies by Malécot (1975), De Jong (1988), and Moisset (2000). De Jong’s findings suggest that the use of liaison may indeed be decreasing in the language overall, as some of the contexts which were once considered obligatory are now considered optional. Perhaps the age effect reflects a diachronic shift in liaison usage across all speaker populations, as characterized by a gradual loss in the use of liaison over time. It may also be that French speakers produce more liaison as they grow older, in a phenomenon called ‘age grading’. The use of liaison has been linked with the speaker’s level of education, and is associated with “proper” French, both of which suggest that at least some speakers may produce more liaison as they grow older, become more educated, and are surrounded by other members of higher classes in society.

Corpus studies do not provide any clear support for an effect of speaker gender on the use of liaison. While some studies report a higher rate of liaison in the speech of women (Booij & De Jong, 1987), and some report a higher rate of liaison in the speech of men (Bannert, 1998; Léon and Tennant, 1990), other studies report no gender difference in the use of liaison (Moisset, 2000).

The significance of social factors on liaison use is clearly demonstrated through liaison corpus studies. Whether the corpus data is analyzed according to different speech styles (e.g. casual conversation, formal interview, reading word lists, etc.) or speaker identity (e.g. age, level of education, social class status, etc.), the results indicate that liaison is an important social marker for speakers of French. In addition to modeling the
influences of linguistic factors such as phonological and syntactic environments, a theory of liaison production must also integrate the impact of the social context on the realization of liaison.

1.6 Chapter summary

The liaison phenomenon is one of several processes which results in resyllabification across word boundaries in spoken French. Although liaison is linked to a general historic process of phonetically conditioned consonant deletion, the use of alternating spoken forms have also long been influenced by social factors such as speech register, social class, and age. Three of the primary approaches to investigating liaison production are descriptive, theoretical, and quantitative. While the descriptive approach simplifies the liaison phenomenon into three categories – obligatory, optional, and prohibited –, theoretical attempts to model liaison production are challenged because “no adequate theory about liaison can be developed without taking into account its fundamentally variable nature” (Booij and De Jong, 1987:1015). Quantitative studies based on a diverse range of speech corpora confirm the variability in liaison use as it interacts with a wide variety of linguistic and sociolinguistic factors.

1.7 Thesis Outline

The review of liaison production in Chapter 1 provides the foundation for this study, whose ultimate objective is to explore the relationship between speech production
and speech perception. To this end, the liaison process in French is an excellent and exciting phenomenon, since the rich variety of interacting linguistic and sociolinguistic factors which influence the likelihood of liaison occurrence are in turn well-motivated candidates for factors whose perceptual impacts on liaison can be experimentally tested. What makes liaison a particularly interesting process for this type of investigation is that French speakers are aware – to a certain extent – that there are rules which govern the “proper” use of liaison, and that their application of those rules has a direct impact on the perception of their social identity. The four experiments reported in the subsequent chapters of this thesis investigate the following perceptual effects on liaison: 1) the effects of linguistic factors (syntactic environment and consonant identity) on word recognition, 2) the strength of the associations between liaison use and speaker identity (speaker age and social class), and 3) the effects of social factors (speaker age and social class) on word recognition. The investigation of these effects utilized different sources of auditory and visual stimuli, as well as a variety of methodological approaches.

Chapter 2 discusses the theoretical implications for resyllabification in word recognition, and in particular reviews evidence for how French liaison impacts speech perception. Chapter 3 presents the results from Experiment 1, a word recognition experiment which investigates the perceptual effects of liaison and non-liaison variants in contexts ranging from obligatory to prohibited liaison. Chapters 4, 5 and 6 then shift the focus of study to a sequence of 3 experiments that explore how the socially marked use of liaison influences listeners’ perception of speaker identity, and how listeners’ sociolinguistic expectations can impact language processing. Chapter 4 presents
Experiment 2, in which participants estimate the ages and social class levels of individuals in photographs, and transcribe a series of phrases containing liaison. Chapter 5 presents Experiment 3, in which participants first listen to liaison phrases and estimate the speakers’ ages and social class levels of individuals shown in photographs, and then listen to liaison phrases and select the speakers from a set of individual portraits. Chapter 6 presents Experiment 4, which explores how the listener’s expectations of the speaker’s social identity impacts word recognition, using a cross-modal priming paradigm that leverages the stimuli and results from the two previous experiments. Chapter 7 concludes the thesis with a general discussion of the relationship between liaison production and liaison perception, the impact of socially marked speech variants on word recognition, and the theories which aim to account for the perception results.
2. Processing Liaison in Auditory Word Recognition

2.1 Introduction

When French liaison takes place, the latent consonant at the end of the liaison word is pronounced and resyllabified to the onset of the following word. For example, if the final consonant *petit* is pronounced when followed by the word *éléphant*, the sequence *petit éléphant* ‘little elephant’ is realized as [pœ.ti.te.le.fã]. This resyllabification results in a misalignment of syllable and word boundaries, because the [t] is the final segment of the first word and yet also the initial segment of the syllable which begins the following word. The misalignments of word and syllable boundaries which result from liaison are generally predicted to be problematic, since most theories of word recognition emphasize the role of the syllable in the segmentation process of French. However, while experimental results suggest that liaison can be perceptually problematic for young children and non-native speakers, there is evidence that adult native speakers of French develop effective strategies for coping with the liaison phenomenon.

This chapter explores how the liaison phenomenon in spoken French affects speech processing in auditory word recognition. In section 2.2, resyllabification processes in spoken French are described, with an emphasis on the liaison phenomenon. Section 2.3 explores how language-specific rhythm-based segmentation strategies and connectionist models address word recognition, and examines the predictions which these approaches
have for the processing effects of liaison. Section 2.4 presents the results from experimental studies on the perceptual effects of French resyllabification, and of liaison in particular. Section 2.5 provides a chapter summary.

2.2 Resyllabification in spoken French

Resyllabification of consonants across word boundaries takes place when the final consonant of one word is pronounced as the initial consonant of the following word. Resyllabification occurs frequently in spoken French, and results from common processes such as enchaînement, elision, and liaison. Enchaînement is the process by which a word-final consonant which is always pronounced (e.g. the [k] of *chaque* [ʃak] ‘each’) is followed by a vowel-initial word (e.g. *avion* [a.vjõ] ‘aircraft’), resulting in the resyllabification of the word-final consonant to the onset of the following word (i.e. *chaque avion* [ʃa.kə.vjõ]9 ‘each aircraft’). Elision takes place when the final vowel of a word is deleted, thereby allowing the preceding consonant to resyllabify to the onset of the following vowel-initial word (e.g. *le* [lə] + *avion* [a.vjõ] is pronounced as *l’avion* [la.vjõ] ‘the aircraft’). Elision occurs frequently with function words such as *le*, *ne*, and *te* (e.g. *l’eau* ‘the water’, *t’appelle* ‘call yourself’, and *n’aime* ‘do not like’). Liaison takes place when an otherwise silent word-final consonant is pronounced before a following vowel-initial word. For example, the final -r is not pronounced in the word *premier* [prə.mje] ‘first’ when the word is spoken in isolation or when followed by a consonant-initial word (e.g. *mot* [mo] ‘word’), as in the phrase *premier mot* [prə.mje.mo] ‘first

9 The symbol ‘.’ indicates a syllable boundary.
word’. However, the final -r is pronounced when followed by a vowel-initial word (e.g. 
*homme* [ɔm] ‘man’), as in the phrase *premier homme* [prɔ.mjɛ.ɔm] ‘first man’.

Resyllabification across word boundaries presents an interesting challenge for theories of speech perception because of the difficulties it poses for segmenting the speech stream into words. That is, the resyllabified liaison segment is likely to cause a temporary ambiguity in the identity of the initial segment of the following word. For instance, as the speech signal unfolds in the phrase *petit éléphant* ‘small elephant’, the second /t/ in *petit* could either be the resyllabified final consonant of *petit* (followed by a vowel-initial word), or the initial consonant of a word like *téléphone*. The assumption is that the liaison segment causes the listener to look up both /t/-initial words and vowel-initial words, and that the ambiguity of the word’s initial segment will only be resolved as the rest of the word is heard. In extreme cases, the ambiguity can result in homophonous pairs such as *premier homme* ‘first man’ and *premier rhum* ‘first rum’.

**Question:** Quel est le *premier homme* du monde?  
“Who is the first man in the world?”

**Answer:** Le *rhum* de la Jamaïque.  
“Rum from Jamaica”

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10 Philipot (1914:138)
2.3 Theoretical implications of French liaison on auditory word recognition

2.3.1 Language-specific rhythm-based segmentation strategies; SOSH

One approach to understanding speech perception has been to investigate how listeners use linguistic units such as the phoneme or the syllable in order to map the acoustic speech signal to lexical representations in memory. Mehler, Dommergues, Frauenfelder, & Seguí (1981) conducted a seminal study which has had a major impact on speech perception research, and which has motivated decades of cross-linguistic follow-up studies. French students were presented with auditory stimuli of lists of unrelated French words, and were required to monitor for word-initial CV or CVC syllable sequences such as /pa/ or /pal/. Responses were faster when there was a match between the target and the initial syllable of the stimulus word (e.g. /pa/ in [pa][lace] or /pal/ in [pal][mier]), than when there was a mismatch (e.g. /pal/ in [pa][lace] or /pa/ in [pal][mier]). The authors suggested that “the syllable constitutes a unit of speech processing” and that “syllabic segments could well serve as accessing units” (Mehler et al., 1981; pp.303-304).

Mehler et. al’s (1981) study was replicated with English and French listeners in order to test whether the syllable effect could be generalized across languages (Cutler, Mehler, Norris, & Seguí, 1986). While the syllable structure is considered to be relatively clear in French (e.g. the syllabification of the word palace in French is [pa][lace]), this is not the case in English (e.g. the /l/ of palace in English is ambisyllabic: [pa][lace]). Cutler et al.’s (1986) replication of Mehler et al.’s (1981) study indicated that French listeners
used a clear syllabification strategy when listening to French materials, and when listening to English materials. English listeners, on the other hand, didn’t show a syllable effect when listening to materials in either language. The authors concluded that French listeners make use of a syllable segmentation strategy while English listeners do not, as a result of the phonological differences between the French and English languages. Furthermore, “the general processing model would remain language-universal, with the language-specific variations being predictable from the phonological structure of each language” (Cutler et. al, 1986; p.397).

English is a stress-language in which strong syllables (containing full vowels) contrast with weak syllables (containing reduced vowels). The Metrical Segmentation Strategy (MSS) claims that lexical attempts are initiated at the onset of strong syllables (Cutler & Carter, 1987), given that words in English typically begin with strong syllables (e.g. based on a transcribed corpus of natural speech in English approximately 75% of strong syllables occurred at word onsets, and 90% of content words began with strong syllables). Some of the original support for the MSS comes from experiments in which listeners are slower to detect words which are embedded at the beginning of nonsense bisyllabic strings when the strings consists of two strong syllables as opposed to a strong syllable followed by a weak syllable (Cutler & Norris, 1988). For example, *mint* is detected more slowly in *mintayve* than in *mintesh*, presumably because in the first case the activation of *mint* competes with the activation of a lexical hypothesis initiated at the onset of the strong syllable *tayve*, resulting in lexical candidates that overlap on the segment */t/.* On the other hand, since the second syllable of *mintesh* is a weak syllable, no
lexical attempt is initiated at its onset, and there is no competition to interfere with the activation of mint. Further support for the MSS came from a study on both spontaneously and experimentally elicited misperceptions in which erroneous word boundary insertions and deletions revealed listeners’ tendencies to assume that content words began with strong syllables (Cutler & Butterfield, 1992).

Evidence for the use of a speech segmentation strategy based on the syllable in French (Mehler et al., 1981) but not in English (Cutler et al., 1986), and based on stress in English (Cutler & Carter, 1987; Cutler & Norris, 1988) has motivated further cross-linguistic studies which suggest that the basic segmentation strategies used for word recognition are language-specific. It is generally agreed that languages differ according to their metrical structure, and that this rhythmic pattern guides or determines the most efficient parsing strategy for that language. Furthermore, listeners apply to foreign-language input the segmentation procedures which work efficiently with their native language, whether or not the procedures suit the foreign input. Speakers of syllable-timed languages such as French, Spanish, and Catalan use syllable information in speech segmentation (Mehler, Dommergues, Frauenfelder, & Seguí, 1981; Cutler, Mehler, Norris, & Seguí, 1986; Pallier, Sebastián-Gallés, Felguera, Christophe, & Mehler, 1993; Sebastián-Gallés, Dupoux, Seguí, & Mehler, 1992; Mehler, Dupoux, & Seguí, 1990; Seguí, Dupoux, & Mehler, 1990; Seguí, Frauenfelder, & Mehler, 1981; Content, Kearns, & Frauenfelder, 2001; Dumay, Frauenfelder, & Content, 2002). Speakers of stress-timed languages such as English, German, and Dutch segment speech at the onset of strong syllables, but not at the onset of weak syllables (Cutler & Norris, 1988; Cutler &
Butterfield, 1992; Cutler & Carter, 1987; McQueen, Norris, & Cutler, 1994; Norris, McQueen, & Cutler, 1995; Vroomen & de Gelder, 1995; Vroomen, van Zon, & de Gelder, 1996). Speakers of the mora-timed language Japanese use moraic information in segmentation (Otake, Hatano, Cutler, & Mehler, 1993; Cutler & Otake, 1994; McQueen, Otake, & Cutler, 2001). In order to reconcile the perceptual differences exhibited by speakers of different languages, a universal model of speech perception must account for the experimental evidence which indicates that language-specific segmentation strategies are based on the rhythmic properties of the listener’s language.

We now return to the role of the syllable in speech perception of French, in order to address the theoretical implications which resyllabification processes such as liaison have on word recognition. Based on the evidence for French listeners’ use of the syllable in speech processing, Mehler, Dupoux, & Seguí (1990) suggested that “speech is segmented into elementary units that roughly correspond to the syllable” and that “syllabic frames are recognized by a bank of syllabic analyzers” (Mehler et al., 1990, p255). According to this view, the syllable is a unit of classification in speech perception and lexical access, and the acoustic speech signal consists of consecutive sequences of syllables which are aligned such that the offset of one syllable corresponds to the onset of the following syllable.

The Syllable Onset Segmentation Heuristic (SOSH) departs from the view that the syllable is a unit of classification for French, and proposes instead that listeners rely on syllable onsets for speech segmentation (Frauenfelder & Content, 1999; Content, Dumay, & Frauenfelder, 2000; Content, Kearns, & Frauenfelder, 2001; Content,
Meunier, Kearns, & Frauenfelder, 2001; Dumay, Frauenfelder, & Content, 2002).

According to SOSH, the process of locating syllable offsets and syllable onsets constitutes separate operations, and the segmentation of syllable onsets is given priority when there is a conflict in resolving the location of word boundaries. Since syllable onsets regularly align with word onsets, a syllable onset segmentation strategy is taken to be an efficient heuristic by which lexical searches are initiated at syllable onsets.

Misalignments between syllable and word onsets are considered problematic for word recognition, because SOSH relies not only on a regular syllabic structure, but also on the regular alignment of syllable and word onsets. Such misalignments not only take place in polysyllabic words (e.g. only the first syllable of *éléphant* aligns with a word onset), but also occur frequently in spoken French as a result of resyllabification across word boundaries. In the case of liaison, as the speech signal unfolds in a phrase such as *petit éléphant*, the second /t/ in *petit* is resyllabified to the onset of *éléphant*, and thus (according to SOSH) a lexical search is initiated at the onset of the nonword *téléphant*. The activation of /t/-initial words (e.g. *téléphone*) then compete with the activation of vowel-initial words, and so SOSH predicts a delay in the recognition of the correct vowel-initial word (*éléphant*). In order for the speech recognition system to cope with the liaison process, Content, Dumay, & Frauenfelder (2000) suggest that listeners’ sensitivity to subphonemic differences between resyllabified liaison consonants and word-initial consonants (e.g. consonant duration) may serve as crucial word boundary cues in the segmentation process.
The emphasis which SOSH places on the role of syllable onsets in segmentation does not necessarily restrict its application to syllable-timed languages such as French. Recall that for stress-timed languages such as English, the MSS predicts the initiation of lexical searches at the onsets of strong syllables only, in contrast to weak syllables which are unstressed and contain reduced vowels (Cutler & Norris, 1988). Given the absence of an analogous vowel reduction process in French, all syllables are assumed to be strong, and thus SOSH and MSS make equivalent predictions as to the role of strong syllables, in speech segmentation, despite the differences in the metrical characteristics of French and English. The development and testing of segmentation strategies such as MSS and SOSH is very helpful for both understanding how speech perception of speakers is influenced by language-specific metrical structures, as well as for exploring the language-universal processes of human speech perception.

2.3.2 Competition-based connectionist models; PWC in Shortlist

The approach to speech processing which we have reviewed thus far assumes that an explicit segmentation strategy is required in order to initiate lexical hypotheses, and that listeners develop effective segmentation strategies based on knowledge of the metrical structure of their particular language (whether based on syllabic or moraic structure, or on stress patterns). The approach which will be discussed in this section contrasts with these theories in that speech processing is viewed instead in terms of competing lexical hypotheses, such that lexical segmentation emerges from word recognition. In connectionist models such as TRACE (McClelland & Elman, 1986) and
Shortlist (Norris, 1994), what is most important is the overall goodness of fit between a given stretch of acoustic signal and competing lexical representations. Lexical hypotheses are activated at any time, regardless of their location in the speech stream. For example, in the sequence [ðәsɪlɪbalzrol], lexical candidates such as *syllable* and *role* will compete for activation with similar candidates such as *silly*, *balls*, and *roe*\(^\text{11}\). In general, the activation of lexical hypotheses which are consistent with the speech signal is boosted, while the activation of candidates which are inconsistent or overlapping is reduced. Although there is consensus that the speech input activates competing lexical hypotheses which ultimately result in the selection of lexical representations in memory, the TRACE and Shortlist models differ in the means by which activation and competition processes take place and are resolved.

TRACE is a highly interactive model that consists of three processing levels corresponding to features, phonemes, and words. The connections between these levels are excitatory while the connections within these levels are inhibitory, and activation levels rise (or fall) as the model confirms (or denies) the match between the stimulus input and the nodes at each processing level. The TRACE model has been very influential because the specificity of its architecture has made it possible to perform simulations which can be compared to the results of a broad range of psycholinguistic experiments. However, there are a number of drawbacks to the TRACE model which make it rather inelegant and computationally expensive. For example, all words in the TRACE vocabulary are simultaneously considered as candidates for any given stretch of

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\(^{11}\) Example taken from Cutler, McQueen, Norris, & Somejuan (2001)
speech, which results in a very large number of overlapping candidates whose nodes are connected with inhibitory links. Since repetitions of these nodes and links are copied over successive time slices of the auditory input, this architecture is not only computationally inefficient but perhaps also psychologically unrealistic.

Shortlist is an attractive alternative to the TRACE model, because its selection of lexical candidates is more plausible, and because it is better able to account for lexical segmentation in continuous speech. The Shortlist model consists of two stages, which separate the process of generating candidate words from the process of competition. The first stage consists of a lexical search for candidates which are consistent with the acoustic signal, resulting in a small set of word candidates (i.e. the “shortlist”). In the second stage the candidates are entered into an interactive network in which overlapping words inhibit each other in proportion to the number of overlapping phonemes. In other words, the initial bottom-up selection of the most appropriate candidates ensures that the competition network remains small, and lexical segmentation emerges from the activation of candidate words with the best degree of fit to the speech input.

Although Shortlist doesn’t explicitly recognize the syllable as a sublexical unit, it is not incompatible with theories such as MSS and SOSH. Shortlist can exploit knowledge of language-specific rhythmic patterns in order to locate likely word boundaries, thereby facilitating the process of mapping competing lexical representations to the acoustic signal. For instance, Norris, McQueen, & Cutler (1995) implemented the original formulation of the MSS (i.e. that lexical hypotheses are initiated at the onset of strong syllables) into the Shortlist model in a straightforward way by boosting the
activation of candidates which were aligned with strong syllables, and by reducing the activation of candidates which were misaligned with strong syllables. Simulations which incorporated the MSS into the Shortlist model supported previous experimental results. Norris et al. (1995) suggested that metrically based segmentation strategies for other languages such as French and Japanese could also be successfully implemented into the Shortlist model in a similar way.

The competition stage in Shortlist makes use of procedures that allow for potential competitors to be quickly rejected. The Possible Word Constraint (PWC) is an example of such a procedure, and has been implemented in the Shortlist model by penalizing a candidate word if the residue between the edge of that candidate word and a “known” boundary consists of a string which does not constitute a possible word in that language (Norris, McQueen, Cutler, & Butterfield, 1997). Known boundaries are considered to be likely word boundaries, as determined by language-specific properties such as rhythm and phonotactics. The original evidence for the PWC came from an experiment in which listeners were required to detect real words which were embedded in nonsense strings. Words were more difficult to detect when the residue of the nonsense string was a single consonant than when it was a syllable. For example, listeners found it more difficult to detect sea in seash than in seashub, and more difficult to detect apple in fapple than in vuffapple. Note that while none of the residues (i.e. sh, shub, f, vuff) constitute actual words in English, shub and vuff could be words while sh and f could not. Shortlist’s ability to simulate experimental results improved after the implementation of
the PWC. In addition, Norris et al. (1997) presented successful simulations of prior studies on metrical segmentation effects (e.g. including Cutler & Norris, 1988).

Since French is a syllable-timed language, word boundaries are likely to occur at syllable onsets. The PWC therefore predicts that a misalignment between a syllable onset (a “known” boundary) and a word onset will result in a processing cost, as in the case of the sequence petit éléphant, which is realized as [pœ.ti.ţe.le.fã]. Recognition of the word petit is not problematic, since it is identified as [pœ.ti], as if the latent consonant hadn’t surfaced. Recognition of the word éléphant, however, is penalized by the PWC because the consonant [t] is left stranded after the identification of [e.le.fã]. In order for the speech recognition system to handle liaison, Norris et al. (1997) suggest that:

“...The liaison process is highly systematic in a way that should allow the PWC penalty to be disabled in contexts where liaison is likely. A simple solution would be to turn off the PWC when the first word was identified and the initial consonant of the following syllable was that word’s latent consonant... Note that the plausibility of disabling the PWC in liaison contexts is supported by the fact that the set of environments in which liaison can occur is very restricted in French.” (Norris et al., 1997, p237).

The PWC handling of liaison is not altogether convincing on at least two counts. First, the suggestion that turning off the PWC when the first word is identified and the initial consonant of the following syllable is that word’s latent consonant is probably not such a simple solution. When you consider that /t/ is both a frequent liaison consonant
and also a relatively frequent word-initial consonant\textsuperscript{12}, it may not be immediately clear whether the \[t\] following \textit{petit} is the latent liaison consonant followed by \textit{éléphant}, or the onset of \textit{téléphone}. Second, while the environments in which liaison can occur are restricted to words ending in liaison consonants followed by vowel-initial words, these sequences are not altogether rare\textsuperscript{13}, and furthermore the likelihood of liaison in those environments is probabilistic in nature and therefore perhaps not trivial for the PWC to predict.

2.3.3 Summary

Two different approaches to word recognition have been reviewed, and their predictions for the implications of the liaison process in French have been stated. The first approach emphasizes the role of segmenting the speech signal by identifying word boundaries so that lexical hypotheses can be initiated at word onsets. According to this view, different languages have different segmentation strategies which are based on language-specific rhythm. The second approach focuses on competition between candidate words, such that lexical segmentation emerges from word recognition. Different word candidates compete for activation, and those which would result in stranded consonants are penalized. The two approaches are not incompatible, however, as

\textsuperscript{12} Based on the 1000 most frequent words in the Lexique 2 corpus, the letter ‘t’ is the second most frequent consonant (after ‘s’) to appear in word-final position, accounting for 13\% of word-final letters. The \(/t/\) is silent in isolation for 93\% of these words, making it a frequent candidate as a liaison consonant. In word-initial position, the letter ‘t’ and phoneme \(/t/\) each account for 5.5\% of the most frequent 1000 French words.

\textsuperscript{13} See section 1.2.2 for a review of the distribution of words ending in liaison consonants and vowel-initial words in the French language.
we have seen that the Shortlist model can successfully implement knowledge of language-specific properties of rhythmic structure in order to identify likely word boundaries.

The language-specific segmentation strategy proposed by SOSH and the language-universal competition constraint proposed by PWC make similar predictions for the perceptual effects of liaison in spoken French. That is, the two approaches predict that the misalignment between syllable and word onsets will cause processing delays. Such misalignments result from resyllabification of liaison consonants, such as when the final consonant of *petit* resyllabifies to the onset of *éléphant* in the sequence *petit éléphant*. Both SOSH and PWC predict that the recognition of the word *éléphant* will be delayed; SOSH because a lexical search will begin at [te.le.fâ], and PWC because recognition of *éléphant* is penalized for stranding the consonant [t]. We now turn to experimental evidence of the perceptual effects of resyllabification in French, and in particular to the effects of liaison on word recognition.

2.4 Perceptual effects of French liaison

2.4.1 Liaison and child language acquisition

Evidence that liaison affects speech perception can be observed in speech errors involving liaison consonants (Desrochers, 1994). The consonants /z/, /t/, and /n/ account for over 99% of liaisons produced by adults (Boë & Tubach, 1992), and liaison errors occur frequently enough that there are in fact separate terms for errors involving each of
these three particular consonants (these are called *velours, cuirs*, and *pataquès*, respectively). Errors in liaison use are especially common in the speech of children and adult non-native speakers. These errors generally consist of liaison insertions (where there shouldn’t be a liaison consonant), deletions (where a liaison consonant should occur), and substitutions (where the wrong liaison consonant is applied). Adult speakers who produce any of these “dangerous liaisons” immediately reveal themselves as non-native speakers of French.

An illustration of the types of errors which children make is helpful in establishing the link between liaison speech errors and speech perception. In a corpus of errors based on the speech of Sophie, a young girl between the ages of 2;1 and 3;6, Chevrot & Fayol (2001) found 665 cases of phoneme substitution and addition at word boundaries, involving the segments /z/, /t/, /n/, and /l/. For example, while a /z/ liaison is expected in the sequence *trois ours* ‘three bears’, Sophie instead substituted the incorrect liaison segment /n/, resulting in the sequence [twawuʁs]. In the sequence *papa ours* ‘daddy bear’, an intervocalic context where liaison is not expected in the speech of adults, Sophie added an /n/ segment, resulting in the sequence [pa.pauʁs]. Sophie’s addition errors weren’t restricted to /n/, however, as demonstrated by her pronunciation of the word *orage* ‘thunderstorm’ with an initial /n/, /z/, and /l/, all on the same day. The origin of a vowel-initial word such as *ours* being erroneously produced with an initial /z/, /t/, or /n/ becomes clear when you consider that these liaison consonants all obligatorily resyllabify to the onset of *ours* in phrases such as *les ours* [le.zuʁs] ‘the bears’, *petit ours* [pœ.ti.uʁs] ‘little bear’, and *un ours* [œ̃uʁs] ‘a/one bear’. Indeed, hearing the word *ours*
without a resyllabifying consonant was probably the exception for Sophie, given the syntax of almost obligatory definiteness marking and the strong tendency for determiners in French to end in liaison consonants (e.g. *les, des, mes, cet*, etc). A simple explanation for young Sophie’s errors is precisely the hypothesis advanced by theories such as SOSH, which is that syllable onsets constitute good alignment points for word segmentation, and that syllable and word misalignment are consequently problematic. That is, the frequent resyllabification of liaison across word boundaries presents such a word segmentation challenge for young learners of French that the resyllabified consonant is sometimes taken to be the first segment of the second word, rather than the latent consonant of the first word. Nevertheless, young French children eventually develop mature language abilities, and learn to distinguish resyllabified consonants from consonant-initial words with ease. While it is clear that speech perception strategies evolve as young learners of French learn to correctly produce and perceive liaison consonants, it is not clear how these strategies develop, nor how the word recognition system of adult native speakers of French copes with the liaison phenomenon.

2.4.2 Liaison and second language acquisition

Non-native adult learners of French face the daunting task of learning to apply liaison in the proper contexts, and although guides to French pronunciation often include a section which attempts to simplify the liaison ‘rules’, the advice is often far from comforting. Consider the following suggestion:
“The learner is advised to study the question of liaison in a more interesting and profitable way than by learning lists. He should read aloud a large number of reliable phonetic texts, noting specially the cases where liaison is or is not made. He should train himself to listen carefully to educated French speakers, noting the presence or absence of liaison forms and the effect of difference in style... Cases where the liaison form is optional are extremely numerous. If the learner uses liaison forms whenever they are optional he will certainly be criticized by even pedantic French speakers for using too many. If he uses none of them he will be criticized for using too few.” (Armstrong, 1964, p.162, 165)

A comparison of the segmentation abilities of non-native adult listeners of French to those of native listeners of French provides important insights into the development of strategies which listeners use to cope with the liaison process (Dejean de la Bâtie & Bradley, 1995). In two phoneme monitoring experiments, participants were required to detect /t/-initial words in potential liaison phrases (e.g. excellent tableau ‘excellent painting’, excellent acteur ‘excellent actor’) and in non-liaison phrases (e.g. vrai tableau ‘real painting’, vrai acteur ‘real actor’). In the first experiment, reaction times of both non-native and native speakers of French were longer in response to potential liaison phrases as opposed to non-liaison phrases. Relative to their native counterparts, learners of French had overall longer reaction times and higher error rates, particularly to the potential liaison items. The delayed segmentation process in the potential liaison environment suggests that when listeners identify potential liaison consonants, they anticipate a following vowel-initial word\textsuperscript{14}. In the second experiment, the neutral context C’est un ‘it’s a’ which preceded the adjective+noun phrases in the first experiment was replaced by biasing context phrases which were semantically related to the particular

\textsuperscript{14} Based on the 129,000 entries in the Lexique corpus, 24.5% of French words begin with an orthographic vowel, and 24.4% of words begin with a letter that corresponds to a liaison consonant (9.1% ‘r’, 9% ‘p’, 4.7% ‘t’, 1.4% ‘n’, and 0.2% ‘z’).
adjective+noun constructions (e.g. the biasing context for the noun phrase *excellent/mauvais acteur* ‘excellent/bad actor’ was a phrase containing the word *film* ‘film’). While reaction time responses for both groups again revealed a numerical advantage of non-liaison sentences over potential liaison sentences, this difference was only significant for non-native listeners. Thus, the segmentation strategies of non-native listeners were not as effective as those used by native listeners, who were able to use contextual cues in order to locate word boundaries in potential liaison and non-liaison sentences.

2.4.3 Homophonous phrases and acoustic cues

Although very uncommon in normal conversational speech, cases of potential liaison are especially problematic when they result in phrases such as *dernier oignon* ‘last onion’, which is homophonous with the phrase *dernier rognon* ‘last kidney’. Stridfeldt (2003) found that Swedish learners of French were not able to discriminate between homophonous phrases such as *un avas - un navas, les avas - les zavas*, or *premier uveur - premier ruveur*, in which the second word was always a non-word. These participants, who studied French at the introductory level, tended to segment both phrases as containing a liaison segment. This was especially true for phrases containing */n/* and */z/* consonants, but also for those containing */t/* consonants. However, learners were sometimes able to discriminate between phrases containing a */t/* consonant, such as *petit uveur - petit tuveur*. Despite their difficulties in discriminating between homophonous phrases, Stridfeldt suggests that the Swedish learners’ strategy of expecting liaison in
ambiguous phrases might be an overall effective strategy, since more words in French begin with vowels than with the consonants /n/, /z/, /r/, or /t/. As it turns out, the type frequency of vowel-initial words in French is roughly equivalent to the type frequency of words beginning with liaison consonants, each representing roughly 25% of the French words in the Lexique 2 corpus.

In a related cross-modal priming study, native speakers of French made visual lexical decisions to vowel-initial or consonant-initial targets (e.g. oignon ‘onion’, or rognon ‘kidney’), following the auditory presentation of homophonous phrases such as C’est le dernier oignon/rognon, ‘It’s the last onion/kidney’ (Spinelli, McQueen, & Cutler, 2003). Facilitation was reported for both types of targets when they matched the speaker’s intended segmentation, and weaker facilitation was reported when there was a mismatch between target and the intended segmentation. In addition, liaison consonants were found to be overall shorter in duration than the corresponding word-initial consonants. Spinelli et al. (2003) argued that liaison is not problematic for the recognition of vowel-initial words, because speakers provide sufficient subphonemic cues with which French listeners can effectively segment continuous speech.

Further evidence that phonological resyllabification processes do not hinder word recognition in spoken French was found using a cross-modal priming paradigm, in which consonants resyllabified as a consequence of liaison (e.g. /t/ in un fervent idéaliste ‘a fervent idealist’) did not incur any processing cost to the activation of the following vowel-initial word (i.e. idéaliste, ‘idealist’) in a lexical decision task (Gaskell, Spinelli, & Meunier, 2002). Results from a word monitoring experiment, and to a lesser extent a
sequence monitoring experiment, supported these results and even provided evidence that liaison may actually facilitate word recognition. Although Gaskell et al. (2002) also found that resyllabified segments were overall shorter than the equivalent word-initial consonants, they argued that acoustic information about consonant durations can only be used probabilistically, and that listeners are likely to use a combination of cues, including acoustic and lexical information, in order to resolve resyllabification.

2.5 Chapter summary

The studies which investigate the effects of liaison on word recognition indicate that the resyllabification of liaison consonants to following vowel-initial words results in segmentation difficulties for learners of French, but not for native adult speakers of French. These results run counter to the predictions made by syllable-based segmentation strategies, which state that the misalignment of syllable and word onsets is problematic for word recognition. If anything, experimental evidence indicates that it is not liaison that delays the segmentation process, but rather potential liaison. That is, the response delays to word-initial /t/ in potential liaison sequences (e.g. excellent tableau) relative to non-liaison sequences (e.g. vrai tableau) observed in non-native and native speakers of French (Dejean de la Bâtie & Bradley, 1995) can be interpreted as a strategy by which ambiguous consonants are treated by default as liaison consonants. In other words, the misalignment of syllable and word onsets might actually increase the activation of vowel-initial words, while decreasing the activation of consonant-initial words. This is consistent with Gaskell, Spinelli, & Meunier (2002), who found that recognition of
vowel-initial words was facilitated by the resyllabification of liaison consonants, relative to syllable-aligned words.

The strategies which native speakers of French use to resolve resyllabification are likely to include the sources of information identified in previous studies: subphonemic differences between resyllabified liaison consonants and word-initial consonants (Spinelli et al., 2003; Gaskell et al., 2002; Dejean de la Bâtie, 1993), semantic context (Dejean de la Bâtie & Bradley, 1995), and lexical information (Gaskell et al., 2002). Yet, listeners undoubtedly make use of additional cues which perception studies of liaison have not yet addressed. In particular, while these studies have all treated liaison as an obligatory phonological process, the rate of liaison ranges dramatically in spontaneous French discourse. Production studies of liaison have focused on the wide variety of environments in which the likelihood of liaison ranges from obligatory to optional to prohibited, as well as on the combination of both linguistic and sociolinguistic factors which influence the likelihood of liaison in a given environment. A better understanding of the factors which influence liaison production may in turn reveal important insights into the additional factors which may impact the effects of liaison on word recognition.
3. French Liaison and Word Recognition: Experiment 1

3.1 Introduction

The likelihood that a given liaison consonant will be pronounced is probabilistic in nature, based on a variety of linguistic and sociolinguistic factors, yet very few of these known factors have been explored in experiments which evaluate the impact of liaison consonants on word recognition. In particular, despite the emphasis in liaison production studies on the categorization of liaison into obligatory, optional, and prohibited environments, perception studies have thus far always treated liaison as an obligatory phonological process. For instance, the studies by Dejean de la Bâtie & Bradley (1995), Stridfeldt (2003), Gaskell et al. (2002), and Spinelli et al. (2003) all used stimuli in which the liaison environment consisted of a prenominal adjective followed by the modified noun, an environment in which liaison is considered to be obligatory (e.g. Delattre, 1956). However, the impact of liaison on word recognition is likely to vary according to the probability of liaison production, as listeners’ expectations of liaison production in optional and prohibited contexts will differ from the expectations in obligatory contexts.

This chapter presents Experiment 1, in which the impact of liaison on word recognition is explored by comparing the presence of liaison to the absence of liaison in multiple environments that span the obligatory – optional – prohibited continuum. Liaison rates reported from a survey of liaison corpus studies served as the basis for
selecting four different liaison environments in which liaison is considered obligatory (i.e. between a prenominal adjective and a noun), optional but infrequent (i.e. between a plural noun and an adjective), optional but rare (i.e. between a plural noun and a verb), and prohibited (i.e. between a singular noun and an adjective).

Two separate experiments were conducted such that each would investigate two different liaison environments. This approach, rather than combining all four environments into a single experiment, reduced the likelihood that participants would notice unusual usage of liaison over the course of the experiment. That is, since the experimental target trials would consist of a balanced set of auditory stimuli in which the liaison consonant was either produced or not, participants would hear both types of phrases in environments where on one extreme liaison is considered obligatory and on the other extreme liaison is considered prohibited.

The cued shadowing paradigm is used for both Experiment 1a and Experiment 1b. This experimental paradigm, which has been used successfully to study the effects of frequency and phonetic structure (for a review see Bates & Liu, 1996), requires participants to listen to short phrases and to repeat the last word that they hear as quickly and as accurately as possible. In Experiment 1a, participants listen to short phrases such as *Les clients impatients* ‘the impatient clients’ (i.e. optional but infrequent liaison), or *le client impatient* ‘the impatient client’ (i.e. prohibited liaison), while in Experiment 1b, participants listen to short phrases such as *un affreux accident* ‘an awful accident’ (i.e. obligatory liaison), or *les tensions accumulent* ‘the tensions accumulate’ (i.e. optional but
rare liaison). Each phrase is pronounced either with or without liaison between the last two words\(^{15}\).

In phrases containing a liaison consonant which is pronounced prior to the final word (e.g. *les clients impatients*), listeners have to resolve the misalignment between the syllable level (i.e. [les][cli][ent][zim][pa][tients]) and word level (i.e. [les][clientz][impatients]), whereas in phrases pronounced without the liaison consonant, there is no misalignment between syllable level (i.e. [les][cli][ents][im][pa][tients]) and word level (i.e. [les][clients][impatients]). For each of the four conditions, the amount of time required to initiate the repetition of the last word is measured, and the time to repeat vowel-initial words preceded by a liaison consonant are compared to those not preceded by a liaison consonant.

It is anticipated that repetition times will indicate that listeners are sensitive to the presence or absence of the liaison consonant, as well as to the environment in which liaison is or is not produced. In particular, the more likely liaison is to occur in a given environment, the shorter the response times to liaison pronunciations are predicted to be, relative to pronunciations without liaison. Conversely, the less likely liaison is to occur in a given environment, the longer the response times to liaison pronunciations are expected to be, relative to pronunciations without liaison. In other words, it is hypothesized that liaison is not a process which either is or is not problematic for word recognition. Rather, the presence or absence of liaison is predicted to either facilitate or inhibit word

\(^{15}\) Note that the words *client(s)*, *affreux*, and *tension(s)* are all pronounced with final vowels in isolation or before consonant-initial words, although they end orthographically with consonants.
recognition, depending on whether or not the realized pronunciation matches the listener’s expectation of liaison use.

3.2 Experiment 1a

3.2.1 Liaison environments: optional but infrequent; prohibited

Experiment 1a tested the effects of liaison on word recognition in two conditions, one in which the use of liaison is optional and the other in which it is prohibited. The stimuli in both conditions consisted of noun+adjective sequences, either in plural or in singular. Plural noun+adjective sequences are frequently used as examples of optional liaison (see e.g. Delattre, 1947; Morin & Kaye, 1982; Bybee, 2001), while liaison is considered to be prohibited in singular noun+adjective sequences (Delattre, 1947; Tranel, 1987). Delattre (1955) observed that the realization of liaison is governed in part by degree of syntactic cohesion, such that the greater the strength of the union between two words, the more likely liaison is to occur in that environment. Delattre proposed a hierarchy of liaison usage based on a 10 point scale, where 10 indicated the strongest and 1 indicated the weakest degree of union. Along this scale, Delattre ranked noun+adjective sequences with a 5, noting that these sequences should be ranked with a 1 when in the singular form. Delattre (1956) later reworked his hierarchy into 6 levels (“very frequent”, “pretty frequent”, “somewhat frequent”, “not very frequent”, “rare”, and “very rare”), and identified plural noun+adjective sequences in conversational speech as ranging from “not very frequent” to “rare”. However, Delattre noted that liaison in this environment is
affected by style, such that it is “pretty frequent” in careful speech and even “very frequent” in read speech. Liaison in singular noun+adjective sequences, on the other hand, was identified as “rare” with the liaison consonant /z/ or /t/, even though liaison in this environment is considered to be prohibited in formal instruction. Delattre’s rankings and observations give an impression of liaison rates in both plural and singular noun+adjective environments, as well as an indication of some the factors which might cause these rates to vary, both of which can be evaluated by the results of analyses of liaison in corpus studies.

Based on a corpus which consisted of roughly forty hours of conversational speech recorded from 134 radio programs during 1960-1961, Ågren (1973) reported that liaison occurred in 26% of 639 plural noun+adjective sequences. The rate of liaison was 42% in radio programs identified with careful speech, but only 14% in programs identified with casual speech, thus supporting Delattre’s claim that liaison in this environment is sensitive to style. In a study on stylistic variation of optional liaison of 14 middle class Parisians, Moisset (2000) reported a 16% rate of liaison after 510 nouns. While Moisset suggests that this rate is lower than Ågren’s 26% because Ågren restricted his analysis to plural nouns, the comparison is also made more difficult in that Moisset’s reported liaison rate after nouns is not restricted to following adjectives. In a study based on 50 half-hour conversations with middle-class Parisians, Malécot (1975) reported only a 2% rate of liaison after 166 plural nouns, and a 0% rate of liaison after 9 singular nouns. Again, the low incidence of liaison in the case of plural nouns may be due to the inclusion of all following contexts, and/or to a relatively low data sample. Malécot
divides liaison environments into four categories, and includes liaison after plural nouns in the category described as ‘rare in conversation but optional in elocution’. Liaison after singular nouns was included in the category described as universally forbidden. Despite the variation in the reported rates of liaison across the different corpus studies, these results overall support the initial claims made by Delattre (1955, 1956).

For the purposes of the present study, liaison in plural noun+adjective sequences is considered optional but infrequent, while liaison in singular noun+adjective sequences is considered prohibited. Since listeners are familiar with the alternating use of liaison in the plural noun+adjective environment, the repetition times of the vowel-initial adjectives following the liaison environment are not expected to differ significantly according to the presence or absence of liaison. However, since listeners rarely if ever hear liaison in singular noun+adjective sequences, the repetition times for the adjectives immediately following the unexpected liaison consonant are expected to be longer than for the equivalent phrases in which liaison is not produced.

3.2.2 Method

3.2.2.1 Participants

Sixteen paid native French speakers took part in Experiment 1a. Twelve of the participants were students from the Université de Nantes, France, and were studying abroad for one academic quarter at The Ohio State University in Columbus, Ohio. Four participants were students at the Ohio State University, and had been living in the United
States less than five years. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

3.2.2.2 Materials and design.

Forty-eight vowel-initial adjectives containing three syllables served as experimental targets, and each target adjective was paired with a consonant-initial and vowel-final noun containing two-syllables. The plural noun+adjective sequences consisted of the definite plural determiner *les* followed by a noun (e.g. *questions*) followed by the target adjective (e.g. *indirectes*). The singular noun+adjective sequences consisted of a definite singular determiner *le* or *la* followed by a noun (e.g. *question*) followed by the target adjective (e.g. *indirecte*). Thus, four versions of each of the 48 target phrases were constructed, since both plural and singular noun+adjective sequences were read with and without the liaison consonant /z/ between the noun and the adjective. See Table 3.1 for examples of Experiment 1a target stimuli, Appendix B for the complete list of target stimuli, and Appendix C for the complete list of filler stimuli.
### Table 3.1: Example stimuli for Experiment 1a

<table>
<thead>
<tr>
<th>Condition</th>
<th>Spoken Phrase</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plural Noun+Adjective</td>
<td><em>les questions indirectes</em></td>
<td>‘the indirect questions’</td>
</tr>
<tr>
<td>Liaison</td>
<td>[le.kes.tjo.zed.dei.ket]</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td><em>les questions indirectes</em></td>
<td>‘the indirect questions’</td>
</tr>
<tr>
<td></td>
<td>[le.kes.tjo.zed.dei.ket]</td>
<td></td>
</tr>
<tr>
<td>Singular Noun+Adjective</td>
<td><em>la question indirecte</em></td>
<td>‘the indirect question’</td>
</tr>
<tr>
<td>Liaison</td>
<td>[la.kes.tjo.zed.dei.ket]</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td><em>la question indirecte</em></td>
<td>‘the indirect question’</td>
</tr>
<tr>
<td></td>
<td>[la.kes.tjo.zed.dei.ket]</td>
<td></td>
</tr>
</tbody>
</table>

Lexical and segmental properties, which are known to influence the realization of liaison and/or word recognition, were controlled in the selection of the stimuli words. Nouns and adjectives were selected from the BRULEX database, which provides Log10 lexical frequencies out of 100 million words in a text corpus, in order to maintain a consistent range of high frequency words. The mean frequencies of the penultimate and ultimate words in the target phrases were 358 and 332, and the standard deviations were 51 and 31, respectively. The number of syllables in the selected nouns and adjectives was held constant because both word length and word frequency have been shown to influence the rate of liaison (Booij & De Jong, 1987; Boula de Mareüil & Adda-Decker, 2002; De Jong, 1994; Moisset, 2000; Bybee, 2001), as well as influence auditory lexical access in word repetition tasks (Andonova, D’Amico, Devescovi, & Bates, 2004). Finally, only vowel-final nouns were selected, given the claim that liaison is more likely to occur following vowel-final words than consonant-final words (Delattre, 1955, 1956).

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16 Although the two liaison environments tested in Experiment 1a are singular noun + adjective and plural noun + adjective, BRULEX does not provide different frequency information for singular vs. plural forms.
In addition to the 48 target sequences, 96 filler phrases were also constructed. While target phrases were always 3 words long, filler phrases varied in length (24 phrases of 3-word length, 36 phrases of 5-word length, and 36 phrases of 7-word length) so that the overall phrase length was not predictable in the experiment. Similarly, while the last word in target sequences was always a vowel-initial adjective consisting of 3 syllables, the last word in filler utterances varied in its initial segment (vowel or consonant), grammatical category (24 adjectives, 36 nouns, and 36 verbs), and length (ranging from 1 to 4 syllables).

To further mask the target phrases, 24 of the filler phrases began with sequences that were very similar to those in the plural and singular noun+adjective target utterances (i.e. a determiner followed by a bisyllabic noun followed by a 3-syllable vowel-initial adjective, with liaison occurring half of the time between the noun and adjective). However, each of these filler phrases was longer than the target phrases (half of them contained 5 words and the other half contained 7 words), such that the last word of the phrase (i.e. the word that the participant would repeat) was not in a liaison environment. Finally, since a fourth of the target phrases presented to participants contained a liaison consonant in an environment where liaison is considered prohibited (i.e. between a singular noun and adjective), these 24 filler phrases (a fourth of all filler phrases) also contained errors. Half of these errors involved gender disagreement (e.g. the feminine determiner *la* was placed before the masculine noun *lapin*, ‘rabbit’), while half of the errors involved number disagreement (e.g. the singular determiner *le* was placed before the plural noun *chevaux*, ‘horses’). These errors were included in order to distract
participants from noticing potentially questionable uses of liaison, which could lead to their conscious attention to liaison realizations throughout the experiment and thereby influence their word repetition performance.

Although the phrase length of the target and filler stimuli was carefully controlled, the original sentences from which these stimuli were extracted varied in length. That is, in order to ensure that the final word of each utterance heard by participants was neither predictable nor marked by phrase final lengthening, all target and filler utterances consisted only of the beginning of longer sentences. Experimental stimuli were constructed by splicing out the desired utterances from the larger contexts in which they were embedded. For consistency across the 48 target phrases, each phrase was read in the plural and singular form, once with and once without liaison, using a single carrier phrase. The experiment objectives were explained to the native French speaker who was instructed to record the four versions of each target phrase in exactly the same manner, with the exception of the singular/plural and liaison/no-liaison distinctions. The speaker’s productions were verified by the author.

Some acoustic measurements of the target stimuli were carried out in order to evaluate any inconsistencies in liaison segment or final word durations across conditions which might impact the analysis or interpretation of reaction time results. As shown in Table 3.2, the mean duration of the liaison consonant /z/ was consistent across plural and singular noun+adjective conditions. However, the mean duration of the final word of target utterances was 32ms and 15ms shorter when liaison was produced than when
liaison was not produced, in the plural and singular noun+adjective sequences, respectively.

<table>
<thead>
<tr>
<th>Condition</th>
<th>/z/ Duration</th>
<th>Final Word Duration</th>
<th>Liaison-No Liaison Word Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plural Noun+Adjective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>55ms (10)</td>
<td>452ms (58)</td>
<td>32ms</td>
</tr>
<tr>
<td>No Liaison</td>
<td>NA</td>
<td>484ms (55)</td>
<td></td>
</tr>
<tr>
<td>Singular Noun+Adjective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>58ms (9)</td>
<td>455ms (63)</td>
<td>15ms</td>
</tr>
<tr>
<td>No Liaison</td>
<td>NA</td>
<td>470ms (54)</td>
<td></td>
</tr>
</tbody>
</table>

(Note: Standard Deviations are given in parentheses)

Table 3.2: Mean liaison segment and final word durations for Experiment 1a

All of the stimulus phrases were recorded onto DAT and transferred to .wav format. Target and filler phrases were extracted from their larger sentential context and then the acoustic durations of the adjectives and liaison segments in the target stimuli were measured from waveforms and spectrograms using Xwaves. Four experimental lists were created, each containing one of the four stimulus phrases for each of the 48 target items. Thus, the target phrases in each list were balanced across plural and singular conditions, and in terms of whether or not liaison was produced, such that each participant heard only one version of each test item. Experimental items were randomly ordered for each participant.
3.2.3 Procedure

Participants were tested individually in a sound attenuated booth, and were instructed to repeat the last word of each phrase as quickly and accurately as possible. The beginning of each trial was indicated by a black “+” which appeared in the middle of the screen for 600 msec. This fixation cross was followed by a blank screen for 500 msec, and then by the auditory presentation of a stimulus over headphones at a comfortable listening level. A head-mounted microphone detected the onset of the participants’ responses. At the end of each trial, a message indicating the participant’s reaction time appeared on the screen for 1200 msec, in order to encourage fast responses. If the participant’s response was not detected, the visual message would indicate this in order to encourage the participant to adjust the head-mounted microphone and/or speak more loudly. A 500 msec pause followed each trial. A practice session of 18 trials which were representative of the experimental set was followed by the experimental session, which included one break at the mid-point of the experiment. A separate stationary microphone in the room recorded each participant’s entire session, so that the accuracy of the participants’ responses could later be checked. The duration of the session was approximately 25 minutes. A post-experiment questionnaire was completed by each participant.
3.2.4 Results

Two response types were collected for each trial: accuracy of the repeated utterance, and reaction time from both the onset and the offset of the repeated target word. Onset reaction time measurements were calculated from the beginning of the vowel in the final word of the target phrase, to the beginning of the participant’s repetition of that same word. Any processing difference resulting from the presence or absence of the immediately preceding liaison consonant was therefore captured in the onset measurement. The offset reaction time measurements were calculated from the end of the final word in the target stimulus, to the beginning of the participant’s repetition of that same word. The offset measurement reflects the processing time to initiate word repetition from the moment at which the silence following the final word can be detected. The interpretation of onset vs. offset measurements will be further investigated in the General Discussion, within the context of the Experiment 1a and 1b results.

3.2.4.1 Error analysis

Accuracy of the repeated utterance was determined by comparing the last word of the target stimulus to the recorded utterance of the participant. Incorrect responses consisted of multiple words, the wrong word, or disfluencies, and accounted for 3.5% of the target responses. In order to minimize the influence of a small proportion of extreme responses which might otherwise skew the statistical analyses, each participant’s mean reaction time to target stimuli was calculated, and any responses above or below 2.5
standard deviations from that mean were considered outliers. These outliers resulted in the additional removal of 5.0% of the target responses measured from the onset of the last word, as well as the removal of an additional 5.0% of the target responses from the offset of the last word. All errors were removed from further analyses. Table 3.3 presents the total errors for reaction times measured by onset and offset of the last word, for each experimental condition.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Total Onset Error</th>
<th>Total Offset Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plural Noun+Adjective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>6.3%</td>
<td>6.3%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>12.0%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Singular Noun+Adjective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>7.3%</td>
<td>7.8%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>8.3%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Total Error</td>
<td>8.5%</td>
<td>8.5%</td>
</tr>
</tbody>
</table>

Table 3.3: Target errors in Experiment 1a

3.2.4.2 Reaction time analysis

All missing data resulting from errors was replaced by averaging the participant’s target mean and the item’s target mean (Winer, Brown, & Michel, 1991). Table 3.4 reports the resulting RT means and standard deviations calculated after data replacement, for both reaction times calculated from the onset and offset of the last word.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Onset Mean RT</th>
<th>Onset RT Diff</th>
<th>Offset Mean RT</th>
<th>Offset RT Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plural Noun+Adj</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>882ms (101)</td>
<td>43ms</td>
<td>429ms (93)</td>
<td>13ms</td>
</tr>
<tr>
<td>No Liaison</td>
<td>925ms (106)</td>
<td></td>
<td>442ms (104)</td>
<td></td>
</tr>
<tr>
<td>Singular Noun+Adj</td>
<td></td>
<td>12ms</td>
<td>446ms (114)</td>
<td>-5ms</td>
</tr>
<tr>
<td>Liaison</td>
<td>900ms (122)</td>
<td></td>
<td>441ms (105)</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td>912ms (114)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note: Standard Deviations are indicated in parentheses)

Table 3.4: Reaction time results of Experiment 1a

Results for both onset and offset reaction times were evaluated using a 2 Environment (Plural vs. Singular) X 2 Liaison (Liaison vs. No Liaison) Repeated Measures Analysis of Variance (ANOVA), with participants and items as random variables. There was a main effect of liaison in the onset analysis (F1(1,15)=31.082, p<.001; F2(1, 47)=9.744, p<.01), such that responses to vowel-initial words following liaison consonants were shorter than responses to vowel-initial words not preceded by liaison. The main effect of liaison was qualified by an interaction between Liaison and Environment (F1(1,15)=8.066, p<.05; F2(1, 47)=4.004, p<.06). Planned comparisons showed significantly shorter reaction times to liaison relative to no liaison in the plural noun+adjective condition (F1(1,15)=31.372, p<.001; F2(1, 47)=15.572, p<.001), but no effect of liaison in the singular noun+adjective condition (Fs<2.6, p>.1). Analyses of offset reaction times revealed no main effect of liaison (Fs<1.1, p>.3), and no significant interaction between Liaison and Environment (Fs<3.2, p>.09).
3.2.5 Discussion

Experiment 1a examined the effects of the liaison consonant on the perception of the following vowel-initial word in French in two different contexts. Liaison was predicted to delay repetition times of the following vowel-initial adjective in the environment where liaison is prohibited, and no effect was predicted in the environment where liaison is optional but infrequent. Neither prediction was born out by the experimental results.

Since liaison is prohibited in the singular noun+adjective context, it was anticipated that some participants might perceive these phrases as speech errors, which would then inhibit word recognition and translate into delayed repetition times. Somewhat surprisingly, the misuse of liaison in this prohibited context did not result in a delay in RT responses. The presentation of experimental stimuli that listeners may consider to include speech errors warrants further exploration, as the nature of those errors and the participants’ awareness and reactions to those sequences are integral to the interpretation of the results.

In order to divert attention that might otherwise be focused on unusual liaison sequences, grammatical errors of gender and number were intentionally included in some of the filler stimuli. Information gleaned from a questionnaire, as well as from informal discussions following the experiment, suggests that these error fillers did effectively mask the unusual use of liaison in the target condition. In response to whether they had heard “anything unusual” or any “strange pronunciations”, nearly all of the participants reported grammatical errors due to gender and/or number agreement, while very few
cited the misuse of liaison. When asked directly about the use of liaison in the singular noun+adjective target phrases, participants generally agreed that liaison isn’t produced in that environment, although their reactions varied. One of the few participants who did notice unusual use of liaison claimed that she thought the recordings were of a young speaker who, in an effort to sound very educated, over-generalized the application of liaison to an environment in which it shouldn’t prescriptively occur. Perhaps this participant, and any others who may have noticed unusual use of liaison, shifted their expectations of liaison production by the speaker who produced the experimental stimuli. That the use of liaison in the singular noun+adjective condition is tolerated by listeners, and not considered to be a glaring error like those resulting from gender or number agreement, may at least partially explain why the presence of the liaison segment did not slow participants’ reaction times in this task.

Liaison “errors” in the singular noun+adjective sequences may have been interpreted as mismatches between singular and plural forms, in which case some participants may have reported liaison errors as number errors. That is, while these target phrases began with a singular determiner *le* or *la*, the liaison consonant which was sometimes produced was the plural marker */z/*. The morphological contribution of the liaison consonant */z/* is usually redundant, since plurality is generally expressed elsewhere in context, such as by plural determiners (e.g. *les* ‘the’, or *des* ‘some). However, the liaison consonant */z/* was not a redundant plural marker in the singular noun+adjective stimuli, but rather conflicting information regarding the number of the noun phrase. If the mismatch in the experimental stimuli was sometimes resolved by
interpreting the phrases containing /z/ as plural phrases, then some of the singular noun+adjective sequences may actually have been processed in the same way as the plural noun+adjective sequences. While it is not clear whether participants interpreted the liaison consonant in the singular noun+adjective sequences as liaison errors or as number mismatches, neither error type nor combination of error types resulted in processing delays of vowel-initial words following the liaison consonant.

No liaison effect was expected in the plural noun+adjective condition, since listeners are familiar with both the presence and absence of liaison consonants in that environment. However, the analysis of repetition times measured by the onset of the repetition indicated that the presence of liaison in the plural noun+adjective condition resulted in significantly shorter reaction times relative to the absence of liaison. This result runs counter to the syllable-based segmentation strategies which predict that the resyllabification of a liaison consonant to the onset of a vowel-initial word causes misalignment of word and syllable onsets, resulting in delayed word recognition of the vowel-initial word following the liaison segment.

Responses in the plural noun+adjective condition suggest not only that liaison doesn’t hinder word recognition, but that it can actually facilitate word recognition of vowel-initial words following the liaison consonant. This is especially important given the assessment that optional liaison between plural nouns and adjectives occurs infrequently (Delattre, 1955, 1956; Ågren, 1973, Moisset, 2000). That is, despite the claims and observations that liaison does not occur very frequently in the plural noun+adjective environment, the optional liaison variant in this context is nevertheless a
useful perceptual cue to listeners. If some participants noticed an unusually high likelihood of liaison production by the speaker, as previously mentioned, it is possible that the observed facilitation of liaison consonants in the onset responses is due in part to an adjustment in the participants’ expectations of the speaker’s use of liaison. It is not yet clear why the results were significant when comparing repetition time measures to liaison and no liaison targets from the onset of the last word, but not when comparing repetition times from the offset of the last word, but further investigation of these two measures will be addressed in the general discussion.

Experiment 1a showed shorter processing times for the repetitions of vowel-initial words following a liaison consonant in an environment where liaison is considered optional but infrequent, and no effect of liaison in an environment where liaison is considered prohibited. These results are consistent with previous studies which have shown that the presence of liaison consonants do not delay the recognition of following vowel-initial words (Gaskell, Spinelli, & Meunier, 2002; Spinelli, McQueen, & Cutler, 2003). Gaskell et al. (2002) found that liaison produced in an obligatory liaison environment facilitated listeners’ perception of the following vowel-initial word relative to a control condition, but that responses in the liaison condition were not significantly different from those in enchaînement and syllable aligned conditions. However, since the targets in the liaison condition of Gaskell et al.’s study were all produced with the liaison consonant, we do not yet know whether the presence and absence of liaison in obligatory liaison environments are treated equally by the perception system. In Experiment 1b the
effect of the liaison consonant is tested in the obligatory context used by Gaskell et al. (2002), as well as in a new context where liaison is optional.

3.3 Experiment 1b

3.3.1 Liaison environments: obligatory; optional but rare

Experiment 1b used the same cued shadowing task which was used in Experiment 1a, but tested the effects of liaison on word recognition in two new environments, one in which liaison is considered obligatory and the other in which it is considered optional.

The stimuli which were used in the obligatory condition consisted of adjective+noun sequences, which is the same environment tested in previous liaison studies by Dejean de la Bâtie & Bradley (1995), Stridfeldt (2003), Gaskell et al. (2002), and Spinelli et al. (2003). Liaison between a prenominal adjective and modified noun is widely considered to be obligatory (e.g. Delattre, 1947), and corpus studies indicate very high rates of liaison in this environment. On his hierarchy scale of liaison usage of 1 to 10, where a 10 indicates the strongest degree of cohesion between words and therefore the greatest likelihood of liaison usage, Delattre (1955) ranked adjective+noun sequences as a 10. Tranel (1987) describes the use of liaison between an adjective and a noun as generally obligatory, and his practical advice to learners of French includes a simple rule that liaison occurs before the noun in a noun phrase. Malécot’s (1975) practical rules for liaison identify the use of liaison in the adjective+noun environment as universally required, and in his study based on 50 half hour conversations with middle-class
Parisians, Malécot reports liaison rates of 93.2% after adjectives and 98% before nouns. Based on 16,000 potential liaison sites in the Corpus d’Orléans, taken from 45 informal interviews recorded between 1969 and 1970, De Jong (1994) reports a liaison rate of 94.3% after prenominal adjectives. Although the use of liaison in the adjective+noun environment may not be categorical, liaison is considered to be obligatory in this environment for the purpose of this study.

The second environment tested in Experiment 1b consisted of plural noun+verb sequences, which Delattre (1956) described as optional but rare. While Delattre (1955) assigned a ranking of 5 to liaison in the plural noun+adjective environment (the optional but infrequent context in Experiment 1), his ranking for liaison usage in plural noun+verb sequences dropped to a 2 on his 10 point hierarchy scale. Tranel (1987) and Bybee (2001) also consider liaison between a plural noun and an adjective to be optional, but while Tranel considers liaison between a plural noun and a verb to be restricted to a very formal style of speech, Bybee considers liaison to be prohibited in this environment. Corpus studies do not specify the rate of liaison in plural noun+verb sequences, although related figures include liaison rates of 22.6% after nouns (De Jong, 1994), 16% after nouns (Moisset, 2000), and 2.8% after plural nouns (Malécot, 1975). For the purposes of this study, the realization of liaison in plural noun+verb sequences is considered to be optional but rare.

As with Experiment 1a, Experiment 1b tests the liaison effect on the processing of the vowel-initial word following the liaison environment in two different conditions. The anticipated result in the adjective+noun condition, where liaison is considered obligatory,
is that the presence of liaison will speed up participants’ response times relative to the absence of liaison, since speakers consistently produce liaison in that environment and therefore expect to hear it produced. The anticipated result in the plural noun+verb condition, where liaison is considered optional but rare, is that response times will not be affected by the presence or absence of liaison, since the likelihood of liaison in this environment is similar to that of the prohibited environment tested in Experiment 1a, for which there was no liaison effect reported.

3.3.2 Method

3.3.2.1 Participants.

Eighteen paid native French speakers took part in Experiment 1b, and none had participated in Experiment 1a. All of the participants were students from the Université de Nantes, France, and were studying abroad for one academic quarter at The Ohio State University in Columbus, Ohio. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

3.3.2.2 Materials and design.

In the adjective+noun condition, 24 prenominal adjectives were selected, and each adjective was paired with a vowel-initial noun containing three syllables. Due to the restricted number of adjectives which commonly occur prenominally, the number of
syllables in the adjectives varied (either 1 or 2 syllables), as did the liaison segment (/z/ in 12 target phrases, and /t/ in 12 target phrases). In the plural noun+verb condition, 24 nouns were selected from the 48 nouns used in the singular noun+adjective and plural noun+adjective conditions from Experiment 1a. This was done in order to control, as much as possible, the penultimate words in the target phrases across experiments. Each bisyllabic noun ending in a vowel was paired with a vowel-initial verb conjugated in the 3rd person plural and containing three syllables. See Table 3.5 for examples of Experiment 1b target stimuli, Appendix B for the complete list of target stimuli, and Appendix C for the complete list of filler stimuli.

<table>
<thead>
<tr>
<th><strong>Condition</strong></th>
<th><strong>Spoken Phrase</strong></th>
<th><strong>Gloss</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjective+Noun</td>
<td><em>un grand avantage</em></td>
<td>‘a big advantage’</td>
</tr>
<tr>
<td>Liaison</td>
<td>[ʁ.gʁ.ʁ.a.v.ʁ.aʒ]</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td><em>un grand avantage</em></td>
<td>‘a big advantage’</td>
</tr>
<tr>
<td></td>
<td>[ʁ.gʁ.a.v.ʁ.aʒ]</td>
<td></td>
</tr>
<tr>
<td>Noun+Verb</td>
<td><em>les bijoux appartiennent</em></td>
<td>the jewels belong’</td>
</tr>
<tr>
<td>Liaison</td>
<td>[le.bi.ʒə.z.a.p.ʁ.tjɛ̃]</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td><em>les bijoux appartiennent</em></td>
<td>the jewels belong’</td>
</tr>
<tr>
<td></td>
<td>[le.bi.ʒə.p.ʁ.tjɛ̃]</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5: Example stimuli for Experiment 1b

In addition to keeping the target phrase length (3 words) constant across experiments, as well as keeping constant the liaison consonants and word lengths when possible, the average frequencies of the target words and of the words preceding the target words in Experiment 1b were matched with the corresponding frequencies in Experiment 1a (see Table 3.6 below). The consistency in target word lengths and word
frequencies in the four liaison environments across the two experiments was sought in order to facilitate the comparison of results across experiments, since the overall objective of Experiment 1 was to evaluate the impact of liaison over four different environments which vary in terms of the likelihood of liaison production. Average frequencies were based on the frequencies provided by BRULEX, which give Log10 values of lexical frequencies out of 100 million words in a text corpus.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Penultimate Word</th>
<th>Ultimate Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sing/Pl Noun+Adj (Exp1)</td>
<td>358 (51)</td>
<td>332 (31)</td>
</tr>
<tr>
<td>Adjective+Noun (Exp2)</td>
<td>*361 (22)</td>
<td>331 (36)</td>
</tr>
<tr>
<td>Plural Noun+Verb (Exp2)</td>
<td>349 (44)</td>
<td>333 (36)</td>
</tr>
</tbody>
</table>

(Note: * BRULEX frequency values weren’t available for 10 of 24 words, mostly common adjectives such as petit ‘little’ and grand ‘big’.) Table 3.6: Experiments 1a and 1b stimuli frequencies

Of the 96 filler phrases which were used in Experiment 1a, all but 24 were used as fillers in Experiment 1b. The omitted fillers were those which contained errors in gender agreement or number agreement, and which were used in order to distract participants from the target phrases in which liaison was produced in the prohibited liaison environment. These fillers were replaced in Experiment 1b by 24 new filler phrases which began with sequences very similar to those in the adjective+noun and noun+verb target phrases (i.e. a determiner followed by a bisyllabic adjective or noun, followed by a 3-syllable vowel-initial noun or verb, with liaison occurring half of the time between the 2nd and 3rd word), but which contained either 5 or 7 words, instead of 3 words.
As was done in Experiment 1a, some segment and word durations were measured for Experiment 1b target stimuli in order to identify any inconsistencies across conditions which might impact the analysis or interpretation of reaction time results. As shown in Table 3.7, below, the mean duration of the liaison consonant /t/ is consistent across the adjective + noun and noun + verb conditions. Also, the final word durations were slightly shorter in the liaison conditions of both adjective+noun and noun+verb conditions. Both of these observations are consistent with the liaison consonant and final word durations reported in Experiment 1a.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Consonant /t/ Liaison</th>
<th>Duration /z/ Liaison</th>
<th>Final Word Duration</th>
<th>No Liaison - Liaison Word Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjective+Noun</td>
<td>67ms (13)</td>
<td>62ms (10)</td>
<td>490ms (44)</td>
<td>12ms</td>
</tr>
<tr>
<td>Liaison</td>
<td></td>
<td></td>
<td>502ms (43)</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noun+Verb</td>
<td>62ms (8)</td>
<td></td>
<td>518ms (52)</td>
<td>19ms</td>
</tr>
<tr>
<td>Liaison</td>
<td></td>
<td></td>
<td>537ms (56)</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Note: Standard Deviations are given in parentheses)
Table 3.7: Mean liaison segment and final word durations for Experiment 1b

Two experimental lists were created such that each list contained 24 target phrases from each of the two conditions (adjective+noun and noun+verb), where half of the phrases in each condition were produced with liaison and the other half were produced without liaison. Thus, each participant heard only one version of each test item. Experimental items were randomly ordered for each participant, and each list began with the same 18 practice trials used in Experiment 1a.
3.3.3 Procedure.

The procedure in Experiment 1b was identical to that in Experiment 1a.

3.3.4 Results

3.3.4.1 Error analysis

As in Experiment 1a, the responses that were collected for each trial were the accuracy of the repeated utterance, and the reaction times from the onset and the offsets of the repeated target word. Incorrect responses consisted of the wrong word, multiple words, repeated words, disfluencies, or poor microphone detection, and accounted for 11.1% of the target responses. Each participant’s mean reaction time to target stimuli was calculated, and any responses above or below 2.5 standard deviations from that mean were considered outliers. These errors resulted in the additional removal of 3.4% of the target responses measured from the onset of the last word, and 4.2% of the target responses measured from the offset of the last word. All errors were removed from further analyses. Errors by experimental condition are given in Table 3.8.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Total Onset Error</th>
<th>Total Offset Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjective+Noun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>12.5%</td>
<td>14.4%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>13.9%</td>
<td>13.9%</td>
</tr>
<tr>
<td>Noun+Verb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>16.2%</td>
<td>16.7%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>15.3%</td>
<td>16.2%</td>
</tr>
<tr>
<td>Total Error</td>
<td>14.5%</td>
<td>15.3%</td>
</tr>
</tbody>
</table>

Table 3.8: Target errors in Experiment 1b
3.3.4.2 Reaction time analysis

All missing data resulting from errors were replaced by averaging the participant’s target mean and the item’s target mean. Resulting repetition time means calculated after data replacement are given in Table 3.9, along with standard deviations.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Onset Mean RT</th>
<th>Onset RT Diff</th>
<th>Offset Mean RT</th>
<th>Offset RT Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjective+Noun</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>1048ms (200)</td>
<td>16ms</td>
<td>551ms (191)</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td>1064ms (196)</td>
<td></td>
<td>561ms (192)</td>
<td></td>
</tr>
<tr>
<td>Noun+Verb</td>
<td></td>
<td>34ms</td>
<td></td>
<td>19ms</td>
</tr>
<tr>
<td>Liaison</td>
<td>1027ms (185)</td>
<td></td>
<td>507ms (177)</td>
<td></td>
</tr>
<tr>
<td>No Liaison</td>
<td>1061ms (210)</td>
<td></td>
<td>526ms (205)</td>
<td></td>
</tr>
</tbody>
</table>

(Note: Standard Deviations are indicated in parentheses)
Table 3.9: Reaction time results of Experiment 1b

Results for both onset and offset reaction times were evaluated using a 2 Environment (Adjective+Noun vs. Noun+Verb) X 2 Liaison (Liaison vs. No Liaison) Repeated Measures Analysis of Variance (ANOVA), with participants and items as random variables.

There was a main effect of liaison in the onset analysis by participants ($F1(1,17)=4.609, p<.05; F2(1,23)=1.793, p<.2$), such that responses to vowel-initial words following liaison consonants were shorter than responses to vowel-initial words not preceded by liaison. There was no interaction between Liaison and Liaison Environment ($Fs<.8, p>.4$). Planned comparisons showed significantly shorter reaction times by item of liaison relative to no liaison in the noun+verb condition.
(F1(1,17)=3.223, p<.1; F2(1,23)=5.075, p<.05), but no effect of liaison in the adjective+noun condition (Fs<1.2, p>.4).

Analyses of offset reaction times revealed no main effect of liaison (Fs<2.1, p>.17), and no interaction between liaison and environment (Fs<.32, p>.5). There was, however, a main effect of environment, not observed in other analyses (F1(1,17)=14.691, p<.01; F2(1,23)=6.132, p<.05), such that reaction times to the noun+verb condition were shorter than those to the adjective+noun condition.

The absence of a liaison effect in the adjective+noun environment was unexpected and therefore followed up by a second series of analyses, in which the adjective+noun condition was split according to the identity of the liaison consonant /t/ or /z/. Since half of the liaison consonants in the adjective+noun condition were /t/ and the other half were /z/, while all of the liaison consonants in the noun+verb condition were /z/, this analysis was based on reaction time means across items, for each condition. Both onset and offset results in Table 3.10 indicate that mean reaction times did differ numerically according to liaison consonant, with longer liaison reaction times following /t/, and shorter liaison reaction times following /z/.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean Onset RT</th>
<th>Mean Offset RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>/t/ Adjective+Noun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>1060ms (158)</td>
<td>562ms (147)</td>
</tr>
<tr>
<td>No Liaison</td>
<td>1045ms (155)</td>
<td>535ms (154)</td>
</tr>
<tr>
<td>/z/ Adjective+Noun</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>1036ms (168)</td>
<td>540ms (173)</td>
</tr>
<tr>
<td>No Liaison</td>
<td>1083ms (163)</td>
<td>587ms (164)</td>
</tr>
<tr>
<td>Noun+Verb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaison</td>
<td>1027ms (185)</td>
<td>507ms (140)</td>
</tr>
<tr>
<td>No Liaison</td>
<td>1061ms (210)</td>
<td>526ms (164)</td>
</tr>
</tbody>
</table>

(Note: Standard Deviations are indicated in parentheses)

Table 3.10: Reaction time results of Experiment 1b
Results for both onset and offset reaction times were evaluated using a 3 Environment (/t/ Adjective+Noun vs. /z/ Adjective+Noun vs. Noun+Verb) X 2 Liaison (Liaison vs. No Liaison) Repeated Measures Analysis of Variance (ANOVA), with participants and items as random variables.

There was a main effect of liaison in the onset analysis ($F(1,17)=4.685$, $p<.05$; $F(2,11)=2.358$, $p<.16$), such that responses to vowel-initial words following liaison consonants were shorter than responses to vowel-initial words not preceded by liaison. This effect was qualified by a marginal interaction between liaison and environment in the onset measurements ($F(1,17)=3.06$, $p<.07$; $F(2,11)=1.302$, $p<.3$). Post-hoc comparisons showed significantly shorter reaction times to liaison relative to no liaison in the onset measurements of /z/ adjective+noun condition, ($F(1,17)=6.3$, $p<.05$; $F(2,11)=2.682$, $p<.12$), but no effect of liaison in either the /t/ adjective+noun condition ($Fs<.7$, $p>.6$), or the noun+verb condition ($Fs<3.4$, $p>.24$).

Analyses of offset reaction times revealed no main effect of liaison ($Fs<1.9$, $p>.18$), but there was an interaction between liaison and liaison environment in the offset measures ($F(1,17)=4.748$, $p<.05$; $F(2,11)=2.773$, $p<.09$). Post-hoc comparisons showed significantly shorter reaction times to liaison relative to no liaison in the /z/ adjective+noun condition ($F(1,17)=7.319$, $p<.05$; $F(2,11)=4.273$, $p<.06$), but no effect of liaison in either the /t/ adjective+noun condition ($Fs<2.6$, $p>.23$), or the noun+verb condition ($Fs<1.2$, $p>.39$). There was also a main effect of environment ($F(1,17)=10.233$, $p<.001$; $F(2,12)=6.815$, $p<.01$). Post-hoc comparisons showed significantly shorter reaction times in the noun+verb condition than in the /z/
adjective+noun condition \( (F_1(1,17)=15.018, p<.001; F_2(1,1)=8.769, p<.01) \), and between the /t/ adjective+noun condition and the noun+verb condition \( (F_1(1,1)=7.051, p<.05; F_2(1,1)=4.117, p<.06) \), but not between the /z/ adjective+noun condition and the /t/ adjective+noun condition \( (Fs<1.5, p>.36) \).

3.3.5 Discussion

As in Experiment 1a, Experiment 1b examined the effects of the liaison consonant on the perception of the following vowel-initial word in two different environments. It was anticipated that the results for the optional but rare condition (noun+verb) would pattern like the prohibited condition (singular noun+adjective) in Experiment 1a, where liaison had no effect. The presence of a liaison consonant was predicted to have a strong facilitatory effect in the obligatory condition (adjective+noun), given that a liaison effect was found in the optional but infrequent condition (plural noun+adjective) in Experiment 1a. Both predictions were ultimately confirmed, though the effect in the obligatory context was only found for the liaison consonant /z/ and not for /t/.

Although there was a numerical advantage of repetition times to vowel-initial words following the presence versus the absence of the liaison consonant in the noun+verb condition, this difference was not significant. Therefore, while liaison did not hinder word recognition in this context, it didn’t facilitate word recognition either. Offset reaction times to the noun+verb condition were significantly shorter than to the adjective + noun condition, whether liaison was produced or not. This is likely due to the differences in final word durations across the two conditions. That is, since the final word
in the noun + verb condition was on average longer than the final word in the adjective + noun condition, participants had more time to process the verbs than the nouns, thereby allowing them to respond more quickly. When liaison took place, the final word in the noun + verb condition was on average 28ms longer than in the adjective + noun condition (i.e. 518ms vs. 490ms), and the reaction times to noun + verb targets with liaison were 43ms longer than in the adjective + noun condition (i.e. 551ms vs. 507ms). When liaison did not take place, the final word in the noun+verb condition was 35ms longer than in the adjective + noun condition (i.e. 537ms vs. 502ms), and the reaction times to noun + verb targets with liaison was also 35ms longer than in the adjective + noun condition (i.e. 561ms vs. 526ms).

Surprisingly, liaison had no effect in the initial analysis of the obligatory adjective+noun condition, where shorter repetition times to vowel-initial words following liaison consonants were expected. However, further analysis revealed that /t/ and /z/ liaison consonants did not have the same effect on listener responses. While the presence or absence of the /t/ liaison consonant had no effect on response times, the presence of /z/ liaison resulted in significantly shorter response times than the absence of /z/ liaison. This difference may be explained, at least in part, by the fact that /t/ occurs very frequently as both a liaison consonant and as a word-initial consonant in the French language, while /z/ occurs very frequently as a liaison consonant but very rarely as a word-initial consonant. That is, /t/ in a liaison environment activates both /t/-initial and vowel-initial words, while /z/ in a liaison environment acts as a good predictor of a following vowel-initial
word. The differences between /t/ liaison and /z/ liaison will be explored further in the
general discussion.

The different patterns of liaison effects based on liaison environment support the
results in Experiment 1a, which also found that the more likely liaison is to occur in a
given environment, the more it is to facilitate word recognition of the following vowel-
initial word. The difference in liaison effect based on /t/ vs. /z/ liaison consonants,
however, suggests that the effect of liaison expectation is tempered by the frequency of
the competing lexical analysis.

3.4 General discussion

Experiments 1a and 1b investigated the effects of liaison in four different
environments, using a cued shadowing task in which participants repeated the last word
that they heard as quickly as possible. The four environments were carefully selected
according to predicted and observed rates of liaison, whereby liaison is considered
obligatory between a prenominal adjective and a noun, optional but infrequent between a
plural noun and an adjective, optional but rare between a noun and a verb, and prohibited
between a singular noun and an adjective. It was predicted that participants would not
only be sensitive to the presence or absence of liaison consonants, but also to the
likelihood of liaison across the spectrum of obligatory, optional, and prohibited contexts.
Repetition times were expected to pattern according to listeners’ expectations of liaison
such that liaison consonants would have greater facilitatory effects where they are most
expected (e.g. obligatory context), and would have inhibitory effects where they are least
expected (e.g. prohibited context). The predicted outcomes were overall confirmed in that the presence and absence of liaison consonants did result in significantly different repetition times in some contexts, and in that the liaison effect patterned according to the likelihood of liaison in the experimental conditions, in interaction with the likelihood of the competing lexical analysis for the particular liaison consonant.

The assumption when interpreting the results of the repetition task carried out in Experiments 1a and 1b is that any difference in the amount of time required to initiate the repetition of vowel-initial words following the liaison environment reflects the processing required for the listener to resolve the identity of the word-initial segment. The moment from which repetition times are measured is therefore critical. Onset and offset measurements were both used to test liaison effects, and while each measurement requires a different interpretation, the pattern of the liaison effect is consistent across measurements.

Repetition time measurements from the moment the final word begins in the acoustic signal includes the time required to perform the repetition task starting immediately after the liaison consonant environment. This onset measurement therefore captures any processing difference resulting from the presence or absence of liaison. However, the interpretation of onset reaction times is confounded by the shorter mean durations of vowel-initial words following a liaison consonant, since the onset reaction time measures include the word durations. That is, although onset measures resulted in significantly shorter reaction times after liaison in some contexts, this is in part because the words following the liaison consonants were shorter in duration. The detection of the
end of the final word could therefore take place sooner, resulting in shorter repetition times. It would therefore be problematic to rely solely on onset measurements for the purpose of interpreting the reaction times in this cued shadowing task, given the duration differences in the last words of target phrases.

Reaction time calculations from the offset of the final word in the acoustic signal indicate the processing time from the point at which all of the information required for target identification had been made available (i.e. the detection of silence following the final word). While offset measures do not include the durations of the final word, the known differences in final word duration may nevertheless be implicated in the offset calculations. That is, listeners have more time to identify the final word when the liaison consonant is not produced, and have less time to process any lingering effect of the presence of liaison consonants.

The average duration differences of the final words in each of the four experimental conditions are provided in Table 3.11 below, along with the average repetition time differences for both onset and offset measurements. The word duration following liaison consonants is consistently shorter across all experimental conditions, and the numerical difference between repetition times following liaison consonants generally increases relative to repetition times following the absence of liaison as the likelihood of liaison increases.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liaison with /z/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj /z/+Noun</td>
<td>5ms</td>
<td>47ms</td>
<td>47ms</td>
</tr>
<tr>
<td>PL Noun+Adj</td>
<td>32ms</td>
<td>43ms</td>
<td>13ms</td>
</tr>
<tr>
<td>Noun+Verb</td>
<td>19ms</td>
<td>34ms</td>
<td>19ms</td>
</tr>
<tr>
<td>SG Noun+Adj</td>
<td>15ms</td>
<td>12ms</td>
<td>-5ms</td>
</tr>
<tr>
<td>Liaison with /t/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj /t/+Noun</td>
<td>20ms</td>
<td>-15ms</td>
<td>-27ms</td>
</tr>
</tbody>
</table>

(Note: Duration differences of the Final Word (FW) and of onset and offset RTs were calculated by subtracting mean Liaison durations and RTs from mean Non Liaison durations and RTs.)

Table 3.11: Summary of Results from Experiment 1a and Experiment 1b

Results using onset and offset measurements supported the hypothesis that listeners are sensitive to the presence or absence of liaison consonants, and well as the hypothesis that the liaison effect varies according to the likelihood of liaison occurrence. In the obligatory adjective+noun context, where liaison consonants are most expected to be produced, the presence of /z/ liaison consonants resulted in significantly shorter repetition times to following vowel-initial words, whether using onset or offset measures. At the other extreme in the liaison production continuum, where the use of liaison is considered prohibited in the singular noun+adjective context, no liaison effect was found using the onset or offset measures. The liaison effects in the optional conditions were less consistent across onset and offset measures. The onset responses following liaison consonants in the optional but infrequent plural noun+adjective context were significantly shorter by participant and by item, and significantly shorter by item in the optional but rare plural noun+verb context, whereas these comparisons were not significant in the analyses of offset responses.
Taken together, the results of onset and offset measures in Experiment 1a and Experiment 1b indicate that the presence of liaison can facilitate word recognition of the following vowel-initial word, and that this effect is more likely to take place in contexts where liaison consonants are more likely to occur in production.

In addition to differing liaison effects based on liaison environment, the results from Experiment 1 suggest that word recognition of the following vowel-initial word is sensitive to the identity of the liaison consonant. While the targets in the optional but infrequent, optional but rare, and prohibited conditions all exclusively used the liaison consonant /z/, targets in the obligatory environment were evenly split between /z/ and /t/ liaison consonants due to the scarcity of adjectives which allow /z/ liaison in the adjective+noun condition.

As shown in Table 11, relative to trials in which /z/ liaison did not occur, repetition times to vowel-initial words following /z/ liaison in the obligatory condition were 47 ms shorter using both onset and offset measures. The significant effect of the liaison consonant /z/ in the obligatory condition and sometimes in the optional conditions suggests that potential /z/ liaison consonants serve as a reliable cue to a following vowel-initial word, especially in contexts where liaison is most often produced. This is likely the case because /z/ frequently operates as a plural marker, but only very rarely occurs in word-initial position. It is worth noting that the presence of /z/ liaison consonants never hindered word recognition of the following vowel-initial word, even in the singular noun+adjective context where liaison is considered prohibited.
Repetition times of vowel-initial words following /t/ liaison in the obligatory condition were 15 ms and 27 ms *longer* than repetitions to trials in which /t/ liaison did not occur, using onset and offset measures. The absence of a liaison effect with the consonant /t/ in this obligatory context complements Dejean de la Bâtie and Bradley’s (1995) results, in which phoneme monitoring responses to /t/-initial words were longer for potential /t/ liaison sequences (e.g., *excellent tableau* ‘excellent painting’) than for non-liaison sequences (e.g. *vrai tableau* ‘real painting’). These results, as well as those from the obligatory context in Experiment 1b, suggest that potential /t/ liaison consonants tend to provoke the activation of both /t/-initial words and vowel-initial words. That is, /t/ occurs frequently in “underlyingly” word-initial position, as well as occurring frequently in the competing analysis as a liaison consonant.

In order to better understand the potential competition in lexical access between words ending in liaison consonants /t/ or /z/, and consonant-initial words beginning with /t/ or /z/, the distributions and frequencies of potential /t/- and /z/-liaison words and of /t/- and /z/-initial words were investigated using the Lexique 2 corpus (New, Pallier, Ferrand, & Matos, 2001). Potential /t/-liaison words were defined as words ending in the letters ‘t’ or ‘d’, but not pronounced in canonical form with a final /t/. Similarly, potential /z/-liaison words were defined as words ending in the letters ‘s’, ‘x’, or ‘z’, but not pronounced in canonical form with a final /z/. That is, the final consonants in these words are latent and generally could be pronounced when followed by a vowel-initial word. These definitions are admittedly simplistic and do not, for example, take into account the range of linguistic factors which influence the likelihood that liaison will actually take
place when a latent liaison consonant is present (see Chapter 1 for details on these factors). Nevertheless, these definitions are sufficient for the purpose of approximating, at least at a very high level, the distributions and frequencies of words in the French language that have the potential for being produced with a liaison consonant. Consonant-initial words beginning with /t/ or /z/ were simply defined as words which phonemically begin with one consonant or the other.

As shown in Table 3.12 below, one fifth (20%) of the word types in French end with potential /t/-liaison, and 4.7% of word types are /t/-initial. The mean and median word frequencies for /t/-initial words are slightly greater than those for potential /t/-liaison words. In the case of /z/, however, over a third (35.2%) of the word types end with potential /z/-liaison, while a mere 0.2% are /z/-initial. Mean and median frequencies of /z/-initial words are lower than those for potential /z/-liaison words. Overall, the distributions and frequencies of these word types suggest that there is likely to be more competition for activation of /t/-initial words when /t/-liaison is produced, than activation of /z/-initial words when /z/-liaison is produced.
### Table 3.12: Distributions and frequencies of potential /t/- and /z/-liaison words and of /t/- and /z/- initial words

<table>
<thead>
<tr>
<th>Word Type</th>
<th>/t/</th>
<th>/z/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential liaison</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word type %</td>
<td>20.0%</td>
<td>35.2%</td>
</tr>
<tr>
<td>Mean freq</td>
<td>21.2 / 136.5</td>
<td>20.1 / 157.2</td>
</tr>
<tr>
<td>Median freq</td>
<td>6.4 / 121.1</td>
<td>6.4 / 147.5</td>
</tr>
<tr>
<td>Consonant-initial word</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word type %</td>
<td>4.7%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Mean freq</td>
<td>23.4 / 157.2</td>
<td>14.0 / 125.6</td>
</tr>
<tr>
<td>Median freq</td>
<td>7.6 / 147.4</td>
<td>5.3 / 121.6</td>
</tr>
</tbody>
</table>

The two frequency measures that were used for Table 3.12 (the text-based *Frantext*, and the web-based *FastSearch*) were also used to plot the distribution of potential /t/-liaison, /t/-initial words, potential /z/-liaison, and /z/-initial words in the graphs below. It is clear from Figure 3.1 that a) the French language is rich in potential /t/-liaison words, b) potential /t/-liaison words vary greatly in their frequencies, c) most potential /t/-liaison words are very infrequent (since Table 3.12 reports a median log frequency of 6.4 per million in *Frantext* and of 121.1 per million using *FastSearch*), and d) the two frequency measures are highly correlated.

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17 Note that both the text-based *Frantext* and the web-hit based *FastSearch* frequencies were used and reported in Table 3.12. The mean or median log of word occurrence per million in *Frantext* is presented first, followed by the log of web pages per million containing the word using *FastSearch* (e.g. 6.4 and 121.1 using *Frantext* and *FastSearch*, respectively, in the case of median potential liaison).
By comparing the frequency distributions of potential /t/-liaison word types in Figure 3.1 to /t/-initial word types in Figure 3.2, it is clear that both word types are well represented and that they overlap greatly in their frequency ranges, despite the overall greater likelihood and higher mean/median frequencies for potential /t/-liaison words. It appears plausible that when /t/ liaison does take place, that some potential /t/-liaison and /t/-initial words could be activated and compete during the process of word recognition.
The same observations which were made about potential /t/-liaison in Figure 3.1 can be made about potential /z/-liaison in Figure 3.3, below.
Whereas the comparison of Figures 3.1 and 3.2 indicate that potential /t/-liaison words and /t/-initial words overlap greatly in their frequency distributions, the same cannot be said about potential /z/-liaison words and /z/-initial words in Figures 3.3 and 3.4. On the contrary, the sparseness of /z/-initial words in Figure 3.4 serves to illustrate the minimal impact which we can expect these words to have on the activation of lexical candidates when /z/ liaison does take place. This is especially clear when contrasted with the density and range of potential /z/-liaison words represented in Figure 3.3, which account for over a third of the word types in the French language.
Given the small number of liaison consonants, and the unique distributional pattern that each of these consonants has with the liaison process and with the French language, it is not surprising that each liaison consonant should have different effects on speech processing. Whereas the target stimuli in some perceptual studies have been restricted to a single liaison consonant (e.g. /t/ in the case of Dejean de la Bâtie & Bradley, 1995), other studies have used experimental stimuli that included multiple liaison consonants without distinguishing consonant identity (e.g. Stridfeldt, 2003; Gaskell et al., 2002; Spinelli et al., 2003). Additional studies which focus on the effects of individual liaison consonants, as well as those which carefully weigh the contributions of each liaison consonant, are no doubt necessary in order to further our understanding of how the liaison process as a whole impacts speech processing.
The resyllabification resulting from liaison creates competition between the activation of vowel-initial words and consonant-initial words, and the listener resolves this competition by making use of a variety of linguistic and extralinguistic cues. Experiments 1a and 1b have shown that French listeners are sensitive to the presence or absence of liaison consonants, to the likelihood of liaison in a given environment, and to the identity of the liaison consonant itself. However, there are many additional sources of information that apply probabilistically which the listener has access to during word recognition, such as acoustic, lexical, and contextual cues. In order to account for the effects of liaison on speech perception, an effective model of word recognition must not only incorporate the various sources of information which the listener has access to, but must also address the way in which the appropriate word is recognized through the integration of these different cues.
4. Experiment 2 – Photograph and Phrase Norming

4.1 Introduction

While the primary input digested by the speech perception system is undoubtedly acoustic and structural in nature, other important speech perception cues are not directly encoded in the acoustic signal itself. That is, speech perception is conditioned by the history of listeners’ linguistic experiences, including their exposure to linguistic information such as sound systems of languages, pronunciation variants, language-specific rhythmic units, and lexical frequencies, but also to the social contexts in which speech is experienced. Listeners internalize the linguistic tendencies of individual speakers and of speaker groups, create associations between speech patterns and speakers, and continually strengthen or weaken these associations in response to additional speaker input. Ultimately, listeners develop linguistic expectations for individual speakers as well as for groups of speakers, and these sociolinguistic stereotypes play an important role in speech perception.

As reviewed in Chapter 1, the realization of liaison consonants in French is influenced by a wide range of linguistic factors (e.g. liaison consonant, lexical frequency, syntactic context), as well as by a variety of sociolinguistic factors (e.g. speech register, age, social class). Speech perception and word recognition studies discussed in Chapter 2, as well as the results from Experiment 1 in Chapter 3, indicate that many linguistic
factors that are associated with the likelihood of liaison production are also implicated in
the perception of phrases in which liaison can occur. For instance, the presence of liaison
consonants in syntactic contexts in which liaison is most likely to be produced can
facilitate the recognition of the following vowel-initial word, relative to contexts in which
liaison is not likely to be produced. In other words, listeners internalize the probabilistic
nature of the production of speech variants, and make use of this knowledge in speech
perception by anticipating the speech patterns modeled after what they’ve heard. The role
of sociolinguistic factors on the perception of liaison, which has received limited
attention in the literature thus far, is the focus of the three remaining experiments
presented in this thesis.

4.1.1 The influence of age and social class on liaison perception

The social markers most strongly associated with French liaison are register, age,
social class, and to a lesser degree, gender. The choice to employ liaison or to avoid it is
associated with prestige, formality, and proper education, and is more likely to occur in
more formal registers (Blount, 1989; Delattre, 1947; Bannert, 1998; Moisset, 2000). In
their review of liaison in five corpora, Booij and De Jong (1987) found that older
speakers produce more liaison than younger speakers. This pattern was also reported in
studies by Malécot (1975), De Jong (1988), and Moisset (2000). It is not clear whether
people start using more liaison as they grow older, or whether this pattern is an indication
of a diachronic shift in liaison usage, as indicated by a gradual loss in the use of liaison
over time. De Jong’s findings suggest that the use of liaison may be decreasing in the
language overall, as some of the contexts which were once considered obligatory are now considered variable. On the other hand, the use of liaison has been linked with the speaker’s level of education, and is associated with “proper” French, both of which suggest that at least some speakers may produce more liaison as they grow older, become more educated, and are surrounded by other members of higher classes in society. Studies by Booij and De Jong (1987), De Jong (1988), and Moisset (2000) all report gradual increases in the use of liaison from lower to upper socio-economic classes.

Age and Social Class were selected as the two social factors to be manipulated in the designs of Experiments 2-4. Due to its linear nature, age is a fairly simple variable to manipulate. A given speaker has an absolute age (e.g. 33 years old) which falls within an age range (e.g. 30-35 years), and that speaker’s age can be easily compared to that of another speaker (e.g. 33 yrs old vs. 55 yrs old). Social class, on the other hand, is a less objective measure than age, and one for which participants may attribute a wider range of interpretation. Social class is an abstract social construct which is derived from subjective perceptions of an individual’s identity, including for example the individual’s wealth, level of education, occupation, and status in society. This combination of social attributes does not lend itself to an easily quantifiable indicator of social class by which an individual can be measured or compared. Nevertheless, as with speaker age, an attempt was made in Experiments 2-4 to either capture participants’ perceptions of speakers’ social class levels, or to present that information to participants. The focus in the current study was to gather perceptual judgments from participants in Experiments 2 and 3, and to collect reaction time measurements from participants in Experiment 4.
4.1.2 Outline of Experiments 2-4

Experiments 2-4 test the hypothesis that listeners internalize the use of liaison according to the perceived age and social class of the speaker, and that they make use of this information during speech perception. This is a methodologically challenging objective, since participants will naturally differ in their perceptions of age and social class. The objective of Experiment 2 was to norm visual and auditory stimuli which would later be used in Experiments 3 and 4, by 1) gathering participant judgments of the estimated age and social class levels of individuals in a series of photographs, and 2) collecting intelligibility ratings of liaison phrases excised from conversational speech. Experiment 3 consisted of a series of offline tasks which were designed to tap into French listeners’ stored associations between liaison and speaker age and/or social class. Participants listened to the phrases that were normed in Experiment 2, and first 1) estimated the speakers’ ages and social class levels, and then 2) selected the speaker from a set of photographs which was carefully selected based on the age and social class normalizations in Experiment 2. While the Experiment 3 tasks explicitly and implicitly solicited speaker age and social class estimates following auditory stimuli containing liaison phrases, Experiment 4 addressed the online effects of the associations between liaison and social factors during word recognition. In Experiment 4, participants’ expectations of the social identities of speakers was manipulated in a speaker familiarity task which consisted of introducing each speaker using a combination of a photograph and some information about the speaker’s age and/or social class. Participants then engaged in a cross-modal priming task in which they listened to phrases allegedly
produced by the speaker to which they had just been introduced. By comparing reaction
time results to the identical auditory stimuli and visual primes when, for example, some
participants thought they were listening to younger speakers and other participants
thought they were listening to older speakers, the objective of Experiment 4 was to
address whether and how listeners’ expectations of the social identities of speakers
affects word recognition.

4.1.3 Experiment 2 tasks

Experiment 2 was designed to gather participant judgments of the ages and social
class levels of individuals presented visually in a series of photographs, and also to assess
the intelligibility of a set of short spontaneous utterances from a corpus of radio speech.
To this end, participants in Experiment 2 completed three short tasks.

In the Absolute Norming task, participants were presented with photographs of
individuals and then estimated their ages and social class levels along continuums of age
and social class ranges. The objective of this task was to evaluate whether the
photographs would adequately evoke different age and social class levels from
participants. Since Experiments 3 and 4 would require the selection of photographs which
varied in age but not class, in class but not age, and in both age and social class, it was
crucial for the the photograph estimates in Experiment 2 to display a range in the
combination of age and social class estimates.

In the Relative Norming task, participants were presented with two group
photographs at a time, and in a force-choice paradigm were asked to indicate which
photographs represented the older group of individuals, and which photograph represented the group belonging to the higher social class. The objective of this task was to gather judgments of the social identities of groups in order to justify the relative classification of each group photograph into younger/older age groups and into lower/higher social class groups, once again to facilitate the experimental design for Experiment 4.

In the Phrase Norming task, participants listened to short utterances of spontaneous speech produced by a variety of speakers and typed out the words that they heard. The objective of this task was to quantify the intelligibility of each utterance by calculating the percentage of accurate transcriptions. Only the highly intelligible utterances would be considered for speech stimuli in Experiments 3 and 4, while unintelligible utterances would be discarded.

4.2 Radio France corpus of liaison phrases

The purpose of developing a corpus of spontaneous speech utterances was to create a large bank of recordings from which auditory stimuli could be selected for use in Experiments 2-4. Recordings of different speakers would eventually be associated with unrelated portraits of individuals in Experiment 4, and participants would be led to believe that they were listening to recordings of the actual individuals in those photographs. In order to present participants with credible pairings of auditory and visual stimuli, and to successfully manipulate the association of utterances from a given speaker
with photographs of different individuals, it was crucial for the speech utterances to sound as natural and as authentic as possible.

The standard approach to creating auditory stimuli for speech experiments is to recruit a native speaker of the appropriate language, to provide them with a script consisting of carefully crafted phrases, and then to coach the speaker to produce those phrases with the desired pronunciations and intonations in a sound-proof booth. The advantage to this methodology is that the experimenter is empowered with the ability to control and manipulate any and every aspect of the speech stimuli, including syllable length, word frequency, speech rate, clarity of pronunciation, phrasal intonation, and so on. This approach has clear benefits with respect to keeping a host of factors constant while alternating only the desired variables in question. However, there is nevertheless a cost associated with the resulting stimuli. That is, although stimuli recorded by trained voice actors can provide skilled simulations of the variables that are targeted, we cannot know exactly how the simulations are related to the actual variations encountered in everyday listening tasks. For example, despite a well-intended experimenter’s attempts to coach a native speaker to produce a given phrase identically two times, once with the liaison consonant and once without, by drawing necessary attention to liaison the experimenter might lead the speaker to read the phrases in a way that isn’t completely faithful to the way they might have otherwise spontaneously uttered the same sequences of words. For example, one or both pronunciations might be produced in a manner that is exaggerated, or otherwise less ‘natural’, for the sake of creating contrast. Although the auditory stimuli used in Experiment 1 were generated using this standard practice, by
enlisting a native speaker to record a carefully prepared list of stimuli, a very different
approach was undertaken to generate speech stimuli for Experiments 2-4.

The need to present participants with auditory stimuli that they could accept as
originating from the individuals presented in photographs, as well as the desire to create
an experience that was one step closer to a series of genuine interactions between a
listener and a speaker, led to the development of a large corpus of spontaneous and
unscripted speech from which a carefully selected set of utterances could be used as
experimental stimuli. The most significant advantage to using spontaneous speech in an
experimental design is the guarantee that participants will be presented with speech
stimuli that are as natural and as faithful to the speech input which they are exposed to in
their everyday lives. This approach naturally comes with its own cost, which is that the
experimenter must relinquish the ability to control every aspect of the speech input, from
the speakers’ word selections to their pronunciations and delivery.

The source of speech selected as the basis for auditory stimuli used in
Experiments 2-4 consists of radio interviews from Radio France, France’s national public
service radio broadcaster. The spontaneous, conversational, and unscripted discourse
which is characteristic of radio interviews lends itself well to ‘natural’ speech; a great
contrast to lists of stimuli read by a carefully coached native speaker. The selection of
Radio France as the source for auditory material is also ideal because of the wide variety
of easily accessible programs that are available in high audio quality from the internet.

The Radio France programs that were considered for inclusion in the development
of this corpus all consisted of an interview format with a single host and at least one
guest. Programs that were long in duration and had only one guest were particularly desirable as they generally included more speech input from the guest, while programs that aired more frequently made it possible to aggregate speech samples from the program host across multiple interviews.

Programs were selected from two of seven Radio France networks, France Inter and France Culture, and each program consisted of a single interview which aired for at least 30 minutes. Recordings were made from 10 different programs on the France Inter network, a generalist station which includes entertaining and informative talk, as well as a variety of music programs and news. An additional 4 programs were recorded from the France Culture network, which focuses on cultural programs that span the arts, history, science, and philosophy. A total of 149 interviews were recorded from these 14 programs, between September 2005 and February 2006. Liaison phrases were identified from 81 different speakers (sometimes only from the host, not the guest), which included 38 women and 43 men. Of the 14 program hosts, 7 were women and 7 were men. See Figure 4.1, below, for the number of interviews, speakers, and liaison phrases from each of the 14 programs.
Table 4.1: Radio France programs

<table>
<thead>
<tr>
<th>Network</th>
<th>Program</th>
<th>#Interviews</th>
<th>#Speakers</th>
<th>#Liaison Phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Au Fil De L’Histoire</td>
<td>2</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Inter</td>
<td>Café Bazar</td>
<td>10</td>
<td>5</td>
<td>373</td>
</tr>
<tr>
<td></td>
<td>Éclectik</td>
<td>25</td>
<td>8</td>
<td>605</td>
</tr>
<tr>
<td></td>
<td>Le Pont Des Artistes</td>
<td>4</td>
<td>1</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Le Téléphone Sonne</td>
<td>12</td>
<td>1</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>Les Petits Bateaux</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>L’Humeur Vagabonde</td>
<td>24</td>
<td>10</td>
<td>610</td>
</tr>
<tr>
<td></td>
<td>Nocturne</td>
<td>7</td>
<td>2</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>Philophil</td>
<td>6</td>
<td>2</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Quand J’Serai Grand</td>
<td>17</td>
<td>18</td>
<td>941</td>
</tr>
<tr>
<td>France</td>
<td>Affinités Électives</td>
<td>15</td>
<td>5</td>
<td>464</td>
</tr>
<tr>
<td>Culture</td>
<td>Continent Sciences</td>
<td>12</td>
<td>12</td>
<td>974</td>
</tr>
<tr>
<td></td>
<td>En Étrange Pays</td>
<td>12</td>
<td>13</td>
<td>1007</td>
</tr>
<tr>
<td></td>
<td>Tout Arrive</td>
<td>2</td>
<td>2</td>
<td>77</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>149</td>
<td>81</td>
<td>5568</td>
</tr>
</tbody>
</table>

To the extent that all programs were based on an interview format, speech register was kept constant. However, each program had a specific theme, each interview had a unique topic, each host had their own interview style, and each guest contributed a different energy to the interview. The topics of discussion ranged widely across the set of interviews, including for example: taxonomy, particle physics, living in the Antarctic, lodging in Paris, sexuality, urban riots, African relations in France, comedy routines, evolution, classic novels, the history of fashion, comic strips, and the lives and careers of many guests artists. The diversity of speakers and range of interview topics offered a rich and varied source of phrases from which to select experimental stimuli.

Since the purpose of creating a corpus was to generate a dataset of potential experimental stimuli with which to test hypotheses about the effect of liaison on speech perception, each interview was mined for phrases containing liaison environments in which the liaison consonant was either produced or not. As no transcripts were available
for the interviews, the process of creating the dataset consisted of carefully listening to each interview, identifying liaison phrases, and transcribing those phrases in a consistent manner which would make it easy to locate that utterance in the original soundfile if it were to be later selected for use as stimuli in an experiment. Liaison phrases consisted of three words with the liaison environment occurring at the boundary between the second and third word. The last word of the liaison phrase could not be aligned with a pause or with the end of an intonational phrase characterized by phrase-final lengthening. All liaison environments were included in the transcription process, with the exception of liaison after determiners (e.g. des /z/ amis, ‘some friends’), since liaison is essentially categorical in this context and the transcription of these frequently occurring sequences would have unnecessarily slowed down the corpus development. Most liaison environments in the transcribed phrases consisted of combinations of adjectives, adverbs, nouns, and verbs. Phrases with liaison environments were not transcribed if the speech overlapped with any background noise, music, or speech from another individual in the interview. Liaison phrases that included speech errors or disfluencies in the three-word sequence were also not included in the dataset.

Some of the Radio France programs proved to be better sources of liaison phrases than others. Programs which contributed more towards the dataset tended to air more frequently, to consist of longer programs, and to have only a single guest in a given interview. The identification and transcription of liaison phrases from 149 interviews resulted in a corpus of 5568 liaison phrases which were then coded according to a series of parameters that would facilitate the process of stimuli selection. Each phrase was
associated with a filename, the name of the program, program host or guest status, a speaker id, speaker gender, and time at which the phrase occurred in the file. Details about the liaison phrase itself were also coded, such as the actual words preceding and following the liaison environment, the parts of speech of those two words, the liaison consonant, and whether liaison occurred or not.

The process of generating a corpus of liaison phrases from a large set of radio interviews required far more effort than would have been necessary had the utterances been read by one or more native speakers. However, since the success of these later experiments depended on convincing participants that they were listening to speech produced by individuals presented in photographs, it was critical that the utterances be as natural and as authentic as possible. While radio speech is not consistently unscripted and spontaneous at every moment, since the individuals on the radio are aware that they are being recorded, the radio speech that was used for these experiments was nonetheless characterized by a high degree of conversational fluidity. This quality in speech is not only a significant departure from the style that would otherwise be employed by a trained reader who is producing experimental stimuli, but the radio speech also exhibits a candor that listeners in Experiments 3 and 4 could accept as authentic. Ultimately, the creation of a repository of Radio France recordings for the purpose of generating auditory stimuli in Experiments 2-4 ensured that participants would be presented with a generous variety of speech utterances from a diverse set of speakers.
4.3 Method

4.3.1 Participants

Fourteen native French speakers participated in Experiment 2 and were each paid 10 Euros. Participants were recruited at l’Université Paris 1 Panthéon – Sorbonne, l’Université Paris 2, l’École des Hautes Études en Sciences Sociale, and l’École Supérieur de Commerce de Paris (ESCP-EAP), all in Paris, France. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

4.3.2 Materials and design

4.3.2.1 Visual stimuli

A series of 20 group photographs, each containing a set of individuals, was used in the Absolute Norming and Relative Norming tasks. Candidate group photographs were identified on French websites, and their selection was subject to the following criteria. All of the individuals in the group had to be facing forward, looking in the direction of the camera, and people’s faces had to be unobstructed and of approximately the same size. All - or nearly all - of the individuals in each group photograph had to be positioned in such a way that they could be circled or cut out from the group photograph and presented visually as photographs of individuals. These conditions were generally met by groups consisting of a similar number of individuals who were intentionally having their
photograph taken, who were posing, and who were kneeling, sitting, and/or standing in rows. Given that the objective of the first two tasks was to generate absolute and relative age and social class estimations, each group photograph had to consist of individuals who were homogeneous in age and social class. However, the overall set of group photographs had to range in age and social class. In addition, since the photographs of individuals would be paired with recorded utterances from a variety of male and female speakers in Experiments 3 and 4, the presence of both men and women in each group photograph was required. The set of 20 group photographs which were selected consisted of 7 to 21 individuals in each photograph, and averaged 13.9 individuals per photograph. At least one man and one woman were in each photograph, and overall the 20 group photographs averaged 54% men and 46% women. See Appendix D for the 20 group photographs, labeled alphabetically from A to T.

Since participants in the Absolute Norming task would provide age and social class judgments for an individual, not a group, a series of individual photographs was derived from each of the 20 group photographs. Each individual photograph consisted of a group photograph with the addition of a single bright red circle around one individual in the group (See Appendix E for an example of an individual circled within a group context). A total of 177 individual photographs were generated, where as few as 6 and as many as 12 individual photographs were created from each of the 20 group photographs. Two lists of individual photographs were created for the Absolute Norming task, such

\footnote{One photograph was of a large group of individuals, of which some were cut off. Only those individuals who were not cut off were counted when calculating the number of individuals per photograph. Also, a different photograph contained both a baby and a dog, neither of which were counted towards the individual total.}
that half of the individual photographs generated from each group photograph were included in each list.

There were a few reasons for presenting individuals within their group contexts during the Absolute Norming task, in which participants estimated the age and social class of an individual. First, the group photographs effectively framed the individuals within a social context that provided valuable information about the individuals’ social identities. For example, the location in which a photograph was taken and the perceived ages and social classes of the other individuals in that same photograph were expected to help participants make informed assessments regarding the social identity of the individuals within that group. Second, since participants would be presented with the same group photographs during the subsequent Relative Norming task, the prior presentation of individuals within their group context would allow participants to consciously explore the social identities of individuals within the groups before later providing relative judgments across groups. Finally, and most importantly, since speakers in Experiments 3 and 4 would be identified by the same group photographs with circled individuals, it was critical for the age and social class judgments about those individuals to be performed within the context of very same photographs.

In each trial of the Relative Norming task, participants were presented with two different group photographs side by side. While these photographs were identical to those presented in the Absolute Norming task, minus the red circles identifying an individual in each photograph, the group photographs in the Relative Norming task appeared smaller on the screen since two appeared at a time. Given the 20 group photographs, there were
180 possible photograph pairs (e.g. photographs A and B, photographs A and C, etc.). Two lists of photograph pairs were created for this task, each containing half (95) of the possible combinations of the twenty group photographs.

4.3.2.2 Auditory stimuli

The auditory stimuli used in Experiment 2 consisted of a total of 200 phrases, including 94 targets selected from the Radio France corpus of liaison phrases, and 106 fillers derived from the same set of interviews. Each of 48 different speakers contributed a total of 1 to 7 recordings. The speakers participated in 11 different radio programs, and 11 of the speakers were program hosts while the remaining 37 speakers were program guests. Each speaker contributed between 0 and 5 target stimuli. See Appendix F for the list of speakers that contributed to the auditory stimuli.

All target stimuli consisted of 3 or 4 words and contained a liaison environment between the last two words of the phrase. The 94 targets consisted of 47 target pairs, each made up of a liaison target (in which the liaison consonant was produced) and a non-liaison target\(^\text{19}\) (in which the liaison consonant was not produced). Whereas an experiment in which the stimuli was prepared by the experimenter and recorded by a native speaker would likely have used target stimuli in which the only difference between the liaison and non-liaison pairs would have been the presence or absence of the liaison

\(^{19}\)Some of the liaison phrases that were transcribed in the Radio France corpus of liaison phrases included terminology or jargon that, while appropriate in the context of the interview, would have likely revealed to participants in Experiment 2 that the speaker was very knowledgeable in a certain area of specialization. Such phrases were not selected as stimuli as it was anticipated that they might skew participants’ age and especially social class level estimations.
consonant (e.g. Experiment 1), this close pairing was not possible with the spontaneous speech stimuli used in this experiment. The liaison and non-liaison pairs were therefore selected with the objective of making the pairs as similar as possible, with the exception of the realization of the liaison consonant. Of the 47 target pairs, 11 pairs were lexically identical and differed only in the presence or absence of liaison (see example a in Figure 4.2, below), 5 pairs were identical in the words preceding and following the liaison environment (see example b), 21 pairs were identical in the word preceding the liaison environment (see example c), 7 pairs were identical in the word following the liaison environment (see example d), and 3 pairs were similar but not identical in either the words preceding or following the liaison environment (see example e). See Appendix G for the full list of Target phrases.

<table>
<thead>
<tr>
<th>Liaison</th>
<th>Liaison Target</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Liaison</td>
<td>faut jamais /z/ oublier</td>
</tr>
<tr>
<td>No Liaison</td>
<td></td>
<td>faut jamais (z) oublier</td>
</tr>
<tr>
<td>b.</td>
<td>Liaison</td>
<td>Il devait /t/ être</td>
</tr>
<tr>
<td>No Liaison</td>
<td></td>
<td>ça devait (t) être</td>
</tr>
<tr>
<td>c.</td>
<td>Liaison</td>
<td>c’est trop /p/ injuste</td>
</tr>
<tr>
<td>No Liaison</td>
<td></td>
<td>c’est trop (p) enfantin</td>
</tr>
<tr>
<td>d.</td>
<td>Liaison</td>
<td>des terres /z/ étrangères</td>
</tr>
<tr>
<td>No Liaison</td>
<td></td>
<td>des langues (z) étrangères</td>
</tr>
<tr>
<td>e.</td>
<td>Liaison</td>
<td>des poèmes /z/ homériques</td>
</tr>
<tr>
<td>No Liaison</td>
<td></td>
<td>les parcours (z) historiques</td>
</tr>
</tbody>
</table>

Table 4.2: Example target stimuli for Experiment 2

Three different liaison consonants were used across seven different syntactic contexts, as illustrated in Table 4.3, below. The liaison consonant and syntactic context were consistent across each of the 47 target stimuli pairs.
### Table 4.3: Experiment 2 target stimuli details

<table>
<thead>
<tr>
<th>Syntactic Context</th>
<th># Target Stimuli</th>
<th>Liaison Consonant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun_Adjective</td>
<td>30</td>
<td>30 /z/</td>
</tr>
<tr>
<td>Verb_Verb</td>
<td>28</td>
<td>20 /t/, 8 /z/</td>
</tr>
<tr>
<td>Adverb_Adjective</td>
<td>18</td>
<td>12 /t/, 4 /z/, 2 /p/</td>
</tr>
<tr>
<td>Adverb_Verb</td>
<td>6</td>
<td>4 /z/, 2 /p/</td>
</tr>
<tr>
<td>Adjective_Noun</td>
<td>6</td>
<td>6 /z/</td>
</tr>
<tr>
<td>Verb_Adjective</td>
<td>4</td>
<td>2 /t/, 2 /z/</td>
</tr>
<tr>
<td>Verb_Noun</td>
<td>2</td>
<td>2 /t/</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>94</strong></td>
<td><strong>54 /z/, 36 /t/, 4 /p/</strong></td>
</tr>
</tbody>
</table>

The filler stimuli consisted of short phrases produced by the same speakers who produced the target stimuli. Filler phrases ranged from 3 to 6 words and were excised from larger sentential contexts in spontaneous speech.

There were no pauses within any of the target or filler phrases, nor were any of the phrases aligned to the beginning or to the end of an intonational phrase. These constraints helped eliminate one large obvious source of inconsistency by avoiding the effects associated with phrasal edges, such as word lengthening at the ends of phrases.

To the extent possible, given the highly variable nature of the audio source, the stimuli were balanced by speaker gender. Of the 48 speakers 21 were women, and of the 11 program hosts 6 were women. Women speakers accounted for 44% of the stimuli (47% of liaison targets, 51% of non-liaison targets, and 39% of fillers).

Two stimuli lists were created, each containing half of the target stimuli and half of the filler stimuli. Target pairs, one where a liaison consonant was produced and one where none was present, were split and balanced across lists.
4.4 Procedure

Participants in Experiment 2 completed three separate tasks: the Absolute norming task, the Relative norming task, and the Phrase norming task. The experiment lasted approximately 1 hour.

4.4.1 Absolute norming task

In each trial, the participant was presented with a photograph containing a group of people in which a single individual within the group was identified with a bright red circle. The participant was asked to press a number between 1 and 8 in order to indicate the age range which they felt best corresponded to the circled individual. The available age ranges spanned from 21 to 60 in 5-year increments (i.e. 1 for ages 21-25, 2 for 26-30, 3 for 31-35, 4 for 36-40, 5 for 41-45, 6 for 46-50, 7 for 51-55, or 8 for 56-60). After selecting an age range, the participant was then instructed to rank the social class of the same individual identified by the red circle. The social classes were labeled 1 through 4, where 1 corresponded to low, 2 to medium-low, 3 to medium-high, and 4 to high. Each participant was presented with one of the two lists of individual photographs, and the photographs in each list were presented in randomized order.
4.4.2 Relative norming task

In each trial, the participant was presented with two photographs at a time, appearing side by side on the screen. While these were the same photographs that the participant had seen in the Absolute Norming task, these group photographs did not contain any red circles to single out an individual. Instead, the participant engaged in a forced-choice paradigm in which they were asked to first compare the two group photographs and to determine which photograph represented the older group, and then which one represented the higher social class group. In each case the participant indicated their response by pressing either ‘A’ or ‘B’, which were the labels under the photograph to the left and right, respectively. Each participant was presented with one of two lists of visual stimuli, which consisted of half of the possible pairs between 20 group photographs. The side of the screen (left or right) on which a given group photograph was presented was balanced across each list, and the presentation of photograph pairs within a list was randomized.

4.4.3 Phrase norming task

After completing four practice trials, each participant listened to a series of 100 short phrases in French and typed the words that they heard onto the screen. Each phrase was only heard one time, and participants were instructed to enter their best guess if they were unsure about what they heard. As these participants were accustomed to AZERTY keyboards, but in this case typing on QWERTY keyboards, they were told not to be
overly concerned with occasional typographical errors or missing accents. There were two lists of 100 stimuli, and half of the participants were presented with each list. Stimuli were presented in random order for each participant.

4.5 Results

4.5.1 Absolute norming results

The distribution of age judgments for the 177 individual photographs, shown in Figure 4.1 below, indicates that the photographs presented to participants represented the full spectrum of age ranges. The youngest age ranges were more often selected than the oldest age ranges.

Figure 4.1: Distribution of age ranges selected in the absolute norming task
As illustrated in Figure 4.2 below, 79% of the individual photographs presented to participants were associated with either the Medium-Low or Medium-High social class levels. That the High and Low social class levels accounted for only 21% of social class estimates suggests that only a few of the photographs presented to participants did not fall into one of the mid-range social classes.

![Figure 4.2: Distribution of social class ranges selected in the absolute norming task](image)

The purpose of this portion of the experiment was to gather age and social class judgments for individuals within group photographs, so that believable descriptions could be created for each of those individuals. In order to translate participants’ selections of age ranges into absolute ages, each selection of an age range was replaced with the middle age in that range. That is, all selections of the age range 21-25 were assigned the age 23, all selections of the age range 26-40 were assigned the age 28, and so on. The
average age and average social class scores were calculated for each of the 20 group photographs, by taking the mean of the average age and of the average social class scores across the individual photographs derived from each group photograph. The average age and average social class scores for each group photograph A-T are plotted in Figure 4.3, below, to illustrate the range in estimated age and social class combinations across photographs.

4.5.2 Relative norming results

Each of the 20 group photographs was paired with the other 19 group photographs, resulting in 180 possible combinations of 2 different group photographs. For each pair of photographs, participants selected the one which they thought
represented the older group and then selected the one which they thought represented the higher social class. In Figure 4.4, the percentage of times that each photograph was selected as the older photograph is plotted against the percentage of times it was selected as the higher social class photograph.

![Graph showing the selection of photographs as older vs. higher social class](image)

Figure 4.4: Group photographs selected as the older vs. higher class photograph

4.5.3 Phrase norming results

Each of the transcribed target utterances was compared to the original wording, and the percent correct was calculated based on participants’ accuracy in identifying the last two words of the utterances. Each transcription received a maximum of two points; the first for accurately identifying the word preceding the liaison environment and the second for accurately identifying the word following the liaison environment. The
percent accuracy was derived for each target utterance, as well as for all liaison targets and all non-liaison targets.

Spelling mistakes were not uncommon in participant transcriptions, and such errors did not count against transcription accuracy so long as the intended words were still clear. Also, participants’ transcriptions were considered accurate when the inflections which departed from the original wording were homophonous (e.g. *il devait être* ‘he must have been’, versus *ils devaient être* ‘they must have been’). The accuracy of each utterance thus ranged from 0 to 100 percent, where 100 percent indicated that all transcribers of that utterance accurately transcribed both the word preceding and following the liaison environment.

With the exception of a couple utterances that were poorly recognized and removed from the analyzed dataset (45% correct for one Liaison target and 31.3% correct for one Non-Liaison target), targets were generally very well understood (i.e. the remaining targets were 75% correct and above). Table 4.4 below indicates that the average intelligibility was comparably high in both Liaison and Non-Liaison targets, and that the last two words of target utterances were frequently recognized accurately by all participants.

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20Note that there may have been a higher than normal incidence of spelling mistakes since the French participants, who are most familiar with AZERTY keyboards used in France, were typing on QWERTY keyboards during this Phrase Norming task.
While the last two words of target utterances were most often both accurately transcribed, sometimes only the first, the second, or neither of the last two words was accurately transcribed. Table 4.5, below, indicates how often each of the possible four combinations of two words were accurately transcribed.

<table>
<thead>
<tr>
<th>Accurately Transcribe Final Words</th>
<th>Liaison Targets</th>
<th>Non-Liaison Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both</td>
<td>94.0%</td>
<td>90.8%</td>
</tr>
<tr>
<td>Only First</td>
<td>1.4%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Only Second</td>
<td>1.7%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Neither</td>
<td>2.9%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

Table 4.5: Transcription accuracy of final two words in target stimuli

In five of the liaison targets the /t/ liaison consonant could have been interpreted by participants as either a liaison consonant or as a direct object pronoun. For example, when the /t/ liaison is produced in the phrase on pourrait appeler ‘we could call’, it is homophonous with the phrase on pourrait t’appeler ‘we could call you’. Participants always interpreted these consonants as liaison consonants.

Whereas some transcription errors were due to the omission of the word preceding and/or following the liaison environment, it was more common for one or both

21 The other four ambiguous phrases were on peut imaginer ‘we can imagine’, il faut écrire ‘it’s necessary to write’, qui voudrait utiliser ‘who would like to use’, il faudrait ajouter ‘it would be necessary to add’.
words to be transcribed incorrectly. Transcription errors resulting from liaison target phrases generally followed one of two patterns. When the word preceding the liaison environment was incorrectly interpreted, it was often because it was substituted by another plausible word ending in the same liaison consonant (see a-d in Table 9, below). On the other hand, when the word following the liaison environment was incorrectly transcribed, it was often because it had been interpreted as a consonant-initial word (see e-g in Table 4.6, below).

<table>
<thead>
<tr>
<th>Original phrase</th>
<th>Transcribed phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. des terres étrangères</td>
<td>des affaires étrangères</td>
</tr>
<tr>
<td>‘foreign lands’</td>
<td>‘foreign affairs’</td>
</tr>
<tr>
<td>b. des noyaux exotiques</td>
<td>des moyens exotiques</td>
</tr>
<tr>
<td>‘some exotic pits’</td>
<td>‘some exotic means’</td>
</tr>
<tr>
<td>c. les médias américains</td>
<td>des émissaires américains</td>
</tr>
<tr>
<td>‘the American media’</td>
<td>‘some American emissaries’</td>
</tr>
<tr>
<td>d. qu’il aurait aidé</td>
<td>devrait aider</td>
</tr>
<tr>
<td>‘that he would have helped’</td>
<td>‘(he/she/it) should help’</td>
</tr>
<tr>
<td>e. complètement agnostique</td>
<td>complètement diagnostique</td>
</tr>
<tr>
<td>‘completely agnostic’</td>
<td>‘completely diagnostic’</td>
</tr>
<tr>
<td>f. des poèmes homériques</td>
<td>des poèmes d’amérique</td>
</tr>
<tr>
<td>‘some homeric poems’</td>
<td>‘some American poems’</td>
</tr>
<tr>
<td>g. de ne pas avoir</td>
<td>de ne pas savoir</td>
</tr>
<tr>
<td>‘to not have’</td>
<td>‘to not know’</td>
</tr>
</tbody>
</table>

Table 4.6: Example of liaison errors

Transcription errors resulting from non-liaison target phrases sometimes resulted from incorrect inflection of the penultimate word in the phrase (see a in Table 4.7, below), or from an incorrect word ending in the correct vowel (see b). When the transcription of the final word was incorrect, it was most often because the initial vowel of the final word was misinterpreted (see c). In one case, the vowels immediately
preceding and following the liaison environment were identical and the initial vowel of the final word was deleted, resulting in a plausible but incorrect interpretation (see d).

<table>
<thead>
<tr>
<th>Original phrase</th>
<th>Transcribed phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. <em>il pourrait emmener</em></td>
<td><em>il pourra emmener</em></td>
</tr>
<tr>
<td>‘he could take along’</td>
<td>‘he’ll be able to take along’</td>
</tr>
<tr>
<td>b. <em>faut jamais oublier</em></td>
<td><em>vous avez oubliés</em></td>
</tr>
<tr>
<td>‘must never forget’</td>
<td>‘you have forgotten’</td>
</tr>
<tr>
<td>c. <em>vous avez assisté</em></td>
<td><em>vous avez insisté</em></td>
</tr>
<tr>
<td>‘you have assisted’</td>
<td>‘you have insisted’</td>
</tr>
<tr>
<td>d. <em>ne va pas avoir</em></td>
<td><em>pas voir</em></td>
</tr>
<tr>
<td>‘will not have’</td>
<td>‘not see’</td>
</tr>
</tbody>
</table>

Table 4.7: Example non-liaison errors

4.6 Discussion

Since the results from the Absolute Norming and Relative Norming tasks each provide age and social class estimations for the same 20 group photographs, the combination of results across tasks provides a more robust indication of the age and social class judgments than the results from a single task. Figure 4.5, illustrates that the average ages per group photograph estimated in the Absolute Norming task complement nicely the results of the forced-choice judgments of ages in the Relative Norming task. That is, the older the individuals in a group are estimated to be, the more likely that group is judged to be the older out of two group photographs. The two methods which were used to estimate the ages of the individuals in a series of photographs were highly correlated, as indicated by the $R^2$ value of 0.9093 and the best-fitting straight line (the linear regression) in Figure 4.5, below.
As shown in Figure 4.6 below, the results of the Absolute Norming and Relative Norming tasks were also complementary with respect to social class estimation. That is, the more likely the individuals in a group are estimated to belong to a higher class, the more likely that group is judged to be the higher class photograph out of two group photographs. Note that the results from both tasks suggest that one of the group photographs, M, clearly stood out as representing a lower class group of individuals with respect to the other photographs. The $R^2$ value of 0.8634 indicates that the methods for estimating social class are highly correlated, though not as strongly as they were for estimating age.
The two methods of gathering participant judgments of age and social class for individuals and groups portrayed in a series of group photographs resulted in a distribution of highly correlated age and social class estimates that will facilitate effective designs for subsequent experiments which involve the simultaneous presentation of visual and auditory stimuli. In addition, the overall high degree of intelligibility demonstrated by participants who transcribed short spontaneous phrases from the Radio France corpus will enable the selection of future target stimuli whose perceptual clarity is both measurable and consistent across experimental manipulations. Table 4.8, below, provides a summary of age and social class results per group picture.
<table>
<thead>
<tr>
<th>Group Picture</th>
<th>Age Average</th>
<th>% Selected As Older</th>
<th>Social Class Average</th>
<th>% Selected As Higher Social Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>23.8</td>
<td>4.7</td>
<td>2.2</td>
<td>37.6</td>
</tr>
<tr>
<td>B</td>
<td>23.6</td>
<td>6.0</td>
<td>2.7</td>
<td>48.0</td>
</tr>
<tr>
<td>C</td>
<td>52.7</td>
<td>92.5</td>
<td>2.6</td>
<td>43.5</td>
</tr>
<tr>
<td>D</td>
<td>24.3</td>
<td>13.5</td>
<td>2.3</td>
<td>55.4</td>
</tr>
<tr>
<td>E</td>
<td>38.0</td>
<td>46.3</td>
<td>2.4</td>
<td>45.6</td>
</tr>
<tr>
<td>F</td>
<td>28.4</td>
<td>26.7</td>
<td>2.4</td>
<td>37.3</td>
</tr>
<tr>
<td>G</td>
<td>40.5</td>
<td>56.5</td>
<td>2.5</td>
<td>61.2</td>
</tr>
<tr>
<td>H</td>
<td>49.4</td>
<td>93.2</td>
<td>3.5</td>
<td>89.8</td>
</tr>
<tr>
<td>I</td>
<td>33.5</td>
<td>38.3</td>
<td>2.4</td>
<td>49.7</td>
</tr>
<tr>
<td>J</td>
<td>39.7</td>
<td>57.3</td>
<td>2.2</td>
<td>29.3</td>
</tr>
<tr>
<td>K</td>
<td>43.4</td>
<td>65.3</td>
<td>2.5</td>
<td>49.0</td>
</tr>
<tr>
<td>L</td>
<td>40.6</td>
<td>63.3</td>
<td>2.7</td>
<td>56.8</td>
</tr>
<tr>
<td>M</td>
<td>35.9</td>
<td>54.4</td>
<td>1.6</td>
<td>2.7</td>
</tr>
<tr>
<td>N</td>
<td>28.0</td>
<td>31.3</td>
<td>3.4</td>
<td>90.7</td>
</tr>
<tr>
<td>O</td>
<td>48.1</td>
<td>72.8</td>
<td>2.3</td>
<td>29.9</td>
</tr>
<tr>
<td>P</td>
<td>42.2</td>
<td>75.6</td>
<td>3.1</td>
<td>75.3</td>
</tr>
<tr>
<td>Q</td>
<td>44.5</td>
<td>51.2</td>
<td>3.5</td>
<td>86.0</td>
</tr>
<tr>
<td>R</td>
<td>34.5</td>
<td>31.4</td>
<td>2.4</td>
<td>24.4</td>
</tr>
<tr>
<td>S</td>
<td>44.9</td>
<td>66.7</td>
<td>2.3</td>
<td>20.2</td>
</tr>
<tr>
<td>T</td>
<td>42.6</td>
<td>76.7</td>
<td>3.6</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Table 4.8: Age and social class ratings per group picture
5. Experiment 3 – The Effects of Liaison on Age and Social Class Estimation

5.1 Introduction: Forming social expectations based on speech patterns

Speech performs the dual function of communicating the speaker’s intent to the listener, as well as providing the listener with cues as to the speaker’s social identity. The speaker’s unconscious and/or deliberate use of language, dialect, accent, intonation, and pronunciation variants are just some of the ways in which social information is encoded in speech and transmitted to the listener. The mapping of linguistic and social information is accomplished when the listener compares the social characteristics embedded in the speech signal with previously encoded associations of speakers’ social identities and speech characteristics. Naturally, the social mapping that is facilitated by speech is dependent on the probabilistic distribution of linguistic features within and across social groups, the listener’s familiarity with the speech patterns of these social groups, the degree to which the listener has previously associated specific speech patterns with specific social groups, and the strength with which the new speech input activates previously associated linguistic and social information.

The listener’s ability to store information about a speaker’s speech patterns and to access this information at a later time is exemplified by a study conducted by Johnson, Flemming, & Wright (1993), in which listeners were presented with synthesized vowels that spanned a range of F1-F2 combinations, and who were then asked to select the “best”
exemplar of different English vowel categories, as well as the vowel “as you would say it”. Relative to the vowel qualities in natural speech, the vowels which were selected by the participants represented an expanded acoustic vowel space. This effect was reproduced in the consonant context “hud” with three different groups of listeners who differed in their degree of familiarity with the speaker (Johnson, 2000). The listeners who were colleagues of the speaker were instructed to select productions of words which they thought best matched the speaker’s productions. Familiarity with the speaker reduced the “hyperspace” effect for certain vowels, which suggests that the listeners who were most familiar with the speaker were able to access stored representations of the speaker’s prior pronunciations. Listeners’ abilities to encode speaker-specific information have also been shown to facilitate speech processing (e.g. Goldinger, 1996; Goldinger, Kleider, & Shelly, 1999). Furthermore, listeners are also capable of generalizing speech patterns across larger categories of speakers. For instance, listener estimation of speaker age is sensitive to spectral information, pitch, and speech rate (Schötz, 2003; Stölten & Engstrand, 2003).

Stereotyping is the process by which previously held beliefs about social categories are used to classify a new individual as a member of an established category. Sociolinguistic stereotyping relies on the association between social groups (e.g. nationality, age, gender, etc.) and speech properties (e.g. language, dialect, accent, pronunciation, etc.) in order to establish categories. By encoding our linguistic experiences with social information, we continually create, reinforce, and/or weaken our sociolinguistic stereotypes. This chapter explores the relationship between language and
social identity by addressing some the ways in which pronunciation patterns activate social stereotypes which inform listeners’ judgments of speakers’ social identities. In particular, this chapter will report on Experiment 3, in which participants made judgments about speakers’ ages and social class levels based on their use of liaison in short phrases.

5.1.1 Age and social class perception, and liaison

As reviewed in Chapter 1, the realization of liaison consonants in spoken French is conditioned by a variety of linguistic and sociolinguistic factors. Native French speakers are generally aware of the use of liaison, in terms of when they’re supposed to produce it, and also in terms of which people are actually most likely to produce it. As anecdotal evidence of this awareness, Delattre (1955) quoted someone’s reaction to the use of -s (/z/) liaison in the following exclamation: *Cet affreux s vous vieillirait de dix ans!*, ‘That awful –s will age you by ten years!’. From personal communication, French participants who had completed Experiment 2 and who were asked to give examples of people who produce a relatively high proportion of liaison often mentioned older family members or people with esteemed occupations, such as lawyers, professors, or the president. The correlation between social identity and liaison use is not only statistically significant in the listener’s experience, but it is also manifested in the listener’s expectations of the speech patterns of individuals based on their social identity.

In a study on the perception of French liaison, Bergen (2005) tested whether listeners make use of speakers’ socially-marked production of liaison consonants when
making social judgments based on auditory stimuli. Bergen first analyzed the use of liaison in read speech by 173 native speakers of French from the IDIAP French Polyphone corpus of French-speaking inhabitants of Switzerland (Chollet et al., 1996). Using logistic regression in VARBRUL, the presence or absence of liaison was correctly predicted for 88.3% of the coded 2559 tokens. Of the 19 linguistic and social factors originally included in the model (e.g. liaison consonant identity, grammatical class of liaison, word frequency, speaker age, etc.), 12 were selected on the basis of providing statistically significant improvements on the model’s predictive power. The only social factor which was selected was age, although speaker gender and level of highest education displayed slight trends. An interaction between age and liaison word grammatical class was identified such that older and middle-aged speakers produced roughly the same percentage of liaison in verbs and adverbs, whereas young speakers omitted more liaison consonants when the liaison word was a verb than when it was an adverb (Bergen, 2001:149):

<table>
<thead>
<tr>
<th>Age</th>
<th>Adverb</th>
<th>Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>43%</td>
<td>37%</td>
</tr>
<tr>
<td>Middle</td>
<td>38%</td>
<td>39%</td>
</tr>
<tr>
<td>Old</td>
<td>52%</td>
<td>51%</td>
</tr>
</tbody>
</table>

Table 5.1 : Liaison valence as a product of grammatical class and speaker age

Bergen (2001) tested whether listeners’ social judgments about speakers are influenced by the interactions between the production of the liaison consonant and the grammatical class of the liaison word. Experimental stimuli consisted of 36 word pairs
(liaison word and following word) and varied according to the age of the speaker (Old, Middle, Young), the grammatical class of the liaison word (Adverb, Verb), and whether or not the liaison consonant was produced. Participants performed a forced-choice age-judgment task in which they heard a spoken stimulus and immediately made a decision as to whether the speaker who produced the stimulus was “young”, “middle”, or “old”.

As shown in Table 5.2 below, the predicted interaction of results was found (Bergen, 2001:153), suggesting that listeners are aware of the correlations between the syntactic and social factors which influence liaison, and that this knowledge influences language processing. The proportion of “young” judgments to “old” judgments was much greater when adverbs were pronounced with liaison (45% to 12%) than when verbs were pronounced with liaison (37% to 25%). Also, the proportion of “young” responses to adverbs with liaison (45%) was greater than the proportion of “young” responses to adverbs without liaison (36%). Statistical significance tests on these data revealed a significant interaction between liaison valence and liaison word grammatical class.

<table>
<thead>
<tr>
<th></th>
<th>Liaison Adverb</th>
<th>No Liaison Adverb</th>
<th>Liaison Verb</th>
<th>No Liaison Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>45%</td>
<td>37%</td>
<td>36%</td>
<td>26%</td>
</tr>
<tr>
<td>Middle</td>
<td>43%</td>
<td>38%</td>
<td>53%</td>
<td>61%</td>
</tr>
<tr>
<td>Old</td>
<td>12%</td>
<td>25%</td>
<td>11%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Table 5.2: Age judgments for middle-aged speakers as a function of liaison valence and grammatical class

Bergen suggests that listeners’ knowledge of the conditional probabilities of the social factors that characterize a linguistic process may benefit language processing: “If
older speakers are more likely to produce liaison in particular contexts, then having access to this knowledge makes predicting and identifying properties of the linguistic signal just a little bit easier” (Bergen, 2005). Socially marked liaison consonants might therefore play a dual role: listeners form an impression of speakers’ identities according to their use of liaison, and conversely listeners anticipate certain liaison realizations based on their knowledge of speakers’ social identities.

Experiment 3 explored the first half of the liaison-social identity duality, by testing whether listeners associate the higher rate of liaison use with speaker groups which are known to produce liaison at higher rates (i.e. older speakers and speakers of higher social classes). Experiment 4 investigated the second half of the duality equation by testing whether participants’ expectations of the social identities of speakers has an effect on word recognition of liaison phrases.

5.1.2 Experiment 3 tasks

Experiment 3 was designed to test whether native French listeners internalize the variation in liaison production across multiple social strata, age and social class, and make use of this knowledge when forming social expectations about speakers. The participants, who are all native speakers of French, have experienced the correlation between liaison production and speaker social identity. Therefore, when participants hear phrases containing liaison consonants, it is anticipated that they will be more likely to estimate speakers of older age and higher social classes, relative to when they hear equivalent phrases in which liaison is not produced.
Three versions of Experiment 3 were tested in order to investigate the interactions between liaison and age estimation, between liaison and social class estimation, and between liaison and both age and social class estimation. Each experiment consisted of two tasks. In the first task, participants listened to a series of short spontaneous utterances and then made a social judgment of the speaker based on each recording. In particular, participants in Experiment 3a estimated the speaker’s age, participants in Experiment 3b estimated the speaker’s social class level, and participants in Experiment 3c first estimated the speaker’s age and then the speaker’s social class level. The age and social class judgments collected in this task were elicited in a very direct manner which required participants to consciously reflect on the mapping of a speech utterance to a speaker’s age and/or social class. This explicit age estimation task required participants to focus on the acoustic information in the speech signal which acts as cues to speaker age.

The second task in each experiment required participants to once again listen to short spontaneous phrases, but this time to identify the speaker from a set of portraits of individuals presented on the screen. The portraits in each trial were either balanced by age (Experiment 3a), social class level (Experiment 3b), or both (Experiment 3c). This second task therefore collected age and social class judgments in a far more implicit manner than the first task, since participants were not explicitly made aware of either the liaison phrases or of the carefully balanced photographs. An effect using this task would suggest a deeper level of integration between the representation of phonological patterns and social information.
If listeners can make use of their social experience with liaison to make generalizations about the social status of speakers they have not encountered before, results in Experiment 3 should show that participants will make older and higher social class estimates for speakers when they hear phrases with liaison consonants, as opposed to when they hear equivalent phrases in which liaison is not produced. Similarly, participants should select photographs of older and higher class individuals when they hear liaison consonants as opposed to when they do not.

5.2 Experiment 3a

5.2.1 Liaison and age

Liaison corpus studies indicate that older speakers are more likely to produce liaison than younger speakers (Booij and De Jong, 1987; Malécot, 1975; De Jong, 1988; and Moisset, 2000). If listeners internalize the interaction of liaison production and speaker age, then the perceived age of a speaker might increase or decrease in accordance with their use of liaison.

The participants in Experiment 3a listened to short spontaneous phrases containing liaison environments in varied syntactic contexts and estimated speaker age in two different ways. Participants estimated speaker age in the first task by selecting one of multiple age ranges, while in the second task they estimated speaker age indirectly by identifying the speaker from a set of portraits which were carefully selected based on age estimations established in Experiment 2. Liaison production is expected to influence the
estimated age of the speaker such that participants pick older age ranges in the first task and photographs of older individuals in the second task after hearing liaison phrases as opposed to non-liaison phrases.

5.2.2 Method

5.2.2.1 Participants

Fourteen native French speakers participated in Experiment 3a and were each paid 10 Euros. Participants were recruited at l’Université Paris 1 Panthéon – Sorbonne, l’Université Paris 2, l’École des Hautes Études en Sciences Sociale, and l’École Supérieur de Commerce de Paris (ESCP-EAP), all in Paris, France. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

5.2.2.2 Materials and design

5.2.2.2.1 Auditory stimuli

The auditory stimuli for Experiment 3 (i.e. 3a, 3b, and 3c) consisted of a subset of the short spontaneous phrases that were used in Experiment 2, once again with the intent to present participants with recordings of natural, spontaneous, and unscripted speech. However, whereas Experiment 2 was designed to derive intelligibility accuracy for the utterances, Experiment 3 used the intelligibility accuracy to ensure that participants were presented with a set of equally understandable liaison and non-liaison targets.
Since the purpose of the Experiment 3 tasks was to elicit age and social class judgments for each speaker, it was important for each speaker to be equally represented across the entire set of speech utterances. The auditory stimuli consisted of a total of 246 phrases (86 targets and 160 fillers) comprised of 6 recordings from each of 41 different speakers. The speakers participated in 11 different radio programs\textsuperscript{22}, and 11 of the speakers were program hosts while the remaining 30 speakers were program guests. Each speaker contributed at least 1 and no more than 4 target stimuli.

To the extent possible, the stimuli were balanced by speaker gender. Of the 41 speakers 19 were women, and of the 11 program hosts 6 were women. Women speakers accounted for 46% of the stimuli (44% of liaison targets, 51% of non-liaison targets, and 46% of fillers).

Target stimuli in Experiment 3 consisted of 3 or 4 words and contained a liaison environment between the last two words of the phrase. Each liaison target was paired with a non-liaison target, though the two phrases in a given pair were not necessarily produced by the same speaker. For example, the utterance *faut jamais [/z/] oublier* ‘must never forget’ was produced with liaison, and was paired with the utterance *faut jamais (z)* oublier ‘must never forget’ in which liaison was not produced. The target stimuli consisted of the same targets that were used in Experiment 2, with the exception of 4 pairs of target stimuli. Each of the 4 pairs was removed because the intelligibility accuracies for one or both of the liaison and non-liaison phrases were low, relative to the other targets. The final list of target stimuli consisted of 43 pairs for which the average

\textsuperscript{22} The 11 programs were Affinités Électives, Café Bazar, Continent Sciences, Éclectik, En Étrange Pays, L’Humeur Vagabonde, Nocturne, Les P’tits Bateaux, Philophil, Quand J’Serai Grand, Le Téléphone Sonne

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intelligibility accuracy was 96.6% in the case of liaison targets and 95.3% for non-liaison targets. The lowest intelligibility was 80% and 75% accuracy for liaison and non-liaison targets, respectively, and the median and mode accuracies were both 100% for liaison and non-liaison targets.

As was discussed in Chapter 1, the likelihood that a liaison consonant is produced is greatly influenced by linguistic factors such as syntactic context, word frequency, and bigram frequency (the probability of a word given the previous word). In order to test whether the presence or absence of liaison consonants have an effect on listeners’ perceptions of speaker age and/or social class, it was therefore important for the target phrases containing liaison environments to be as balanced as possible with respect to the linguistic factors which influence the likelihood of liaison. If the source of auditory stimuli had been phrases read and recorded by one or more native speakers, the content of the phrases could have been carefully controlled. However, since the source of the auditory stimuli in Experiment 3 was spontaneous and unscripted, a concerted effort was required in order to identify pairs of liaison and non-liaison phrases which were as similar as possible in their lexical composition. When available, both target utterances in a given pair originated from the same speaker. In most cases, however, the liaison and non-liaison targets in a given pair were combined from different speakers.

Of the 43 target pairs, 10 pairs were lexically identical and differed only in the presence or absence of liaison (see example a in Table 5.3, below), 5 pairs were identical in the words preceding and following the liaison environment (see example b), 18 pairs were identical in the word preceding the liaison environment (see example c), 7 pairs
were identical in the word following the liaison environment (see example d), and 3 pairs were similar but not identical in either the words preceding or following the liaison environment (see example e). See Appendix G for the full list of Target phrases.

<table>
<thead>
<tr>
<th>Liaison</th>
<th>Liaison Target</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Liaison</td>
<td>faut jamais /z/ oublier</td>
<td>‘must never forget’</td>
</tr>
<tr>
<td>No Liaison</td>
<td>faut jamais (z) oublier</td>
<td>‘must never forget’</td>
</tr>
<tr>
<td>b) Liaison</td>
<td>Il devait /t/ être</td>
<td>‘he must have been’</td>
</tr>
<tr>
<td>No Liaison</td>
<td>ça devait (t) être</td>
<td>‘it must have been’</td>
</tr>
<tr>
<td>c) Liaison</td>
<td>c’est trop /p/ injuste</td>
<td>‘it’s too unfair’</td>
</tr>
<tr>
<td>No Liaison</td>
<td>c’est trop (p) enfantin</td>
<td>‘it’s too childish’</td>
</tr>
<tr>
<td>d) Liaison</td>
<td>des terres /z/ étrangères</td>
<td>‘foreign lands’</td>
</tr>
<tr>
<td>No Liaison</td>
<td>des langues (z) étrangères</td>
<td>‘foreign languages’</td>
</tr>
<tr>
<td>e) Liaison</td>
<td>des poèmes /z/ homériques</td>
<td>‘the Homeric poems’</td>
</tr>
<tr>
<td>No Liaison</td>
<td>les parcours (z) historiques</td>
<td>‘the historical journeys’</td>
</tr>
</tbody>
</table>

Table 5.3: Example target stimuli for Experiment 3

The average frequencies and standard deviations of the target words and of the words preceding the target words in Experiment 3 are provided in Table 5.4, below. These are based on the two types of frequencies provided by Lexique 2 (New, Pallier, Ferrand, & Matos, 2001): FreqFrant, based on a corpus of literary texts, and FreqWeb, based on a corpus of 15 million online web pages. The average frequencies and standard deviations per corpus and liaison condition are calculated based off of the Log10 values of the lexical frequencies. The relative consistency in word frequencies and standard deviations suggest that the auditory stimuli in Experiment 3 were well balanced with respect to lexical frequency.
Three different liaison consonants were used across six different syntactic contexts, as illustrated in Table 5.5, below. The liaison consonant and syntactic context were consistent across each of the 43 target stimuli pairs.

<table>
<thead>
<tr>
<th>POS Context</th>
<th># Target Stimuli</th>
<th>Liaison Consonant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun_Adjective</td>
<td>30</td>
<td>30 /z/</td>
</tr>
<tr>
<td>Verb_Verb</td>
<td>26</td>
<td>18 /t/, 8 /z/</td>
</tr>
<tr>
<td>Adverb_Adjective</td>
<td>18</td>
<td>12 /t/, 4 /z/, 2 /p/</td>
</tr>
<tr>
<td>Adverb_Verb</td>
<td>6</td>
<td>4 /z/, 2 /p/</td>
</tr>
<tr>
<td>Verb_Adjective</td>
<td>4</td>
<td>2 /t/, 2 /z/</td>
</tr>
<tr>
<td>Verb_Noun</td>
<td>2</td>
<td>2 /t/</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>48 /z/, 34 /t/, 4 /p/</td>
</tr>
</tbody>
</table>

Table 5.5: Experiment 3 target stimuli details

The 160 filler stimuli consisted of the filler stimuli that were used in Experiment 2, as well as an additional set of short phrases of 3 to 6 words, produced by the same speakers who produced the target stimuli. These additional phrases were selected using the same criteria which were used for all other auditory stimuli in Experiments 2 and 3 (see section 4.3.2.2 for more details).

Two lists of auditory stimuli were created such that participants could be presented with half of the auditory stimuli (123 phrases) during the first experimental
task, and the other half during the second task. Since the task objectives were to have the participants associate speakers with an age range in the first task and with a portrait in the second task, it was important for the auditory stimuli from each speaker to be equally represented in each task. As such, 3 phrases from each of the 41 speakers were included in each stimulus list. Stimulus type was evenly balanced across the two lists, such that each list contained the same ratio of Liaison targets, Non-Liaison targets, and filler utterances. The Liaison and Non-Liaison target stimuli for each target pair were split across lists.

5.2.2.2.2 Visual stimuli

The objective of the second task in Experiment 3 was to have participants listen to short utterances and then to identify the speaker who had recorded that utterance from a set of individual portraits which included both younger and older individuals. The age and social class judgments from the Absolute Norming and Relative Norming tasks in Experiment 2 were used to select four group photographs to be used in Experiment 3a, such that the photographs varied in estimated age, but not in estimated social class. Two of the selected group photographs consisted of younger individuals (E, F), while the other two group photographs consisted of older individuals (C, S). For each of these four group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest) of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 5.6, below. Also included is the likelihood that each group photograph was selected as the oldest group or
as the highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 4 group photographs (E, F, C, and S) that were used to create the portraits for Experiment 3a.

<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Higher SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>38</td>
<td>46.3</td>
<td>2.4</td>
<td>45.6</td>
</tr>
<tr>
<td>F</td>
<td>28</td>
<td>26.7</td>
<td>2.4</td>
<td>37.3</td>
</tr>
<tr>
<td>Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>53</td>
<td>92.5</td>
<td>2.6</td>
<td>43.5</td>
</tr>
<tr>
<td>S</td>
<td>45</td>
<td>66.7</td>
<td>2.3</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Table 5.6: Experiment 2 results for group photographs used to create Experiment 3a visual stimuli, based on all Experiment 2 stimuli for those group photographs

As shown in Table 5.6, both the age estimates and likelihood of being selected as the older photograph were lower for the two younger group photographs E and F than for the two older group photographs C and S. The average social class estimates, and the likelihood of being selected as the higher social class photograph, on the other hand, was roughly consistent across all four group photographs.

Since participants in Experiment 3a would be presented with portraits of individuals, and not with group photographs, all of the individuals from each of the 4 group photographs E, F, C, and S were considered as portrait candidates. Each portrait was created cutting out an individual from the one of the four group photographs, resulting in 24 portraits of younger individuals and 24 portraits of older individuals, such that each age group was balanced by gender. Age and social class estimates were
provided for 36 of these 48 individuals during the Absolute Norming task\textsuperscript{23} in Experiment 2, and the averages for these individuals are provided in Table 5.7, below. Note that the average age rating of the younger portraits is lower than the average age rating of the older portraits, while the social class rating remains constant.

<table>
<thead>
<tr>
<th>Age Average</th>
<th>Social Class Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>2.4</td>
</tr>
<tr>
<td>49</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Table 5.7: Experiment 2 results for group photographs used to create Experiment 3a visual stimuli.

Whereas the individual photographs created for the Absolute Norming task in Experiment 2 consisted of a group photograph with a bright red circle surrounding an individual, the portraits for Experiment 3 did not include the entire group photograph. Instead, portraits were cut out of the group photographs such that they only included the headshot for a single individual. The primary reason for this approach was that four separate portraits were presented simultaneously on the screen during each experimental trial, thereby requiring the subject of each portrait to be relatively small and yet clearly identifiable. The portrait strategy also made it possible to present participants with any combination of individuals from the group photographs, including multiple individuals.

\textsuperscript{23} At the time the Absolute Norming task was carried out it was thought sufficient to collect age and social class judgments for 6 to 12 individuals per photograph, and not for each individual in every photograph. When it later came to selecting photographs for Experiment 3, however, there were few combinations of the 20 photographs which allowed for varying one social factor (e.g. age) while keeping the other constant (e.g. social class). The need therefore arose to approximate ages and social classes for individuals not presented during Experiment 2; this was done based on the ages and social class levels of the other individuals in the same group picture.
from the same group. In order to make the portraits appear the same size on the screen, each portrait was adjusted to be roughly 2 inches tall and 1.5 inches wide. See Appendix H for example portraits of younger and older individuals created from group photographs E, F, C, and S.

5.2.3 Procedure

Participants in Experiment 3a completed two tasks, each consisting of 123 trials. The experiment took roughly one hour to complete.

In the first task, participants were told that they would hear short phrases in French recorded by different people, and that they’d only hear each phrase once. Participants were instructed to focus on the speaker’s age, as they would be asked to estimate it following each recording. Each trial began with a fixation cross in the middle of the screen for 1000 msec, followed by a blank screen for 500 msec. An auditory stimulus was then presented over headphones at a comfortable level, after which participants were instructed to press a number between 1 and 8 in order to indicate the age range which they thought best corresponded to the speaker. Age ranges spanned from 21 to 60 in 5-year increments (i.e. 1 for ages 21-25, 2 for 26-30, 3 for 31-35, 4 for 36-40, 5 for 41-45, 6 for 46-50, 7 for 51-55, or 8 for 56-60).

In the second task, participants were told that they would again hear short phrases in French, but that this time they should focus on imagining the physical characteristics of the speaker, as after each recording they would identify the portrait of the individual which they thought produced the speech recording. Each trial began with a fixation cross
in the middle of the screen for 1000 msec, followed by a blank screen for 500 msec. An auditory stimulus was then presented over headphones at a comfortable level, after which four portraits were displayed on the screen. The portraits were labeled 1 through 4, clockwise, starting with the portrait in the top left corner. Participants identified the portrait of the individual that they thought produced the speech utterance by typing the portrait’s corresponding label 1, 2, 3, or 4. Each trial consisted of four different portraits of which half were younger individuals and half were older individuals. Each portrait was presented the same number of times throughout the overall task, and the presentation of each portrait was evenly distributed in each corner. Utterances produced by male voices were always associated with four portraits of men, and utterances produced by female voices were always associated with four portraits of women.

Half of the participants were presented with the first list of auditory stimuli in the first task and the second list of auditory stimuli in the second task, and the other half of the participants were presented with the auditory stimuli lists in reverse order. Trials in each task were randomly ordered for each participant.

5.2.4 Results

In the first task, participants listened to an auditory stimulus and estimated the age range of the speaker on a scale of 1 to 8, where 8 corresponded to the oldest age group.

24 Although there were 24 portraits of women and 24 portraits of men, there were only 19 female and 22 male speakers. This mismatch was not problematic because participants were not expected to learn to associate a specific voice with a specific portrait, or to count the number of speakers and the number of different portraits in order to notice the discrepancy.
The mean response to liaison targets was 5.12 (median and mode were both 5), and the mean response to non-liaison targets was 5.0 (median and mode were both 5), both of which indicate that age estimates tended to fall on the older end of the provided age rating scale. Figure 5.1, below, illustrates the percentage of 1-8 responses to liaison targets, and to non-liaison targets. For example, the most common response to liaison and non-liaison targets was age range 5, which corresponds to the age range 41-45. Figure 5.1 indicates that 22.3% of age estimates following liaison targets were a 5, and that 19.6% of age estimates following a non-liaison targets were a 5. This distribution of responses across age ranges indicates that the presence or absence of liaison had little effect on age estimations. Despite a numerical difference such that liaison targets were slightly older, a 2-tailed Student’s t-test showed no difference in age rating between liaison and no liaison t(599)=0.85.

Figure 5.1: Distribution of age estimates for liaison and non-liaison targets (Exp 3a)
In the second task, participants matched an auditory stimulus to one of four portraits, two of which were of younger individuals and two of which were of older individuals. Participants therefore associated each auditory stimulus to either a younger age group or to an older age group. As shown in Figure 5.2, participants were more likely to select a portrait of an older individual than of a younger individual, regardless of liaison production. Though there was a slight tendency to associate liaison targets with portraits of younger individuals, and non-liaison targets with portraits of older individuals, there was overall very little difference in age estimation by portraits. A 2-tailed Student’s t-test showed no difference in portrait age rating between liaison and no liaison t(600)=0.57.

Figure 5.2: Age estimates by portrait for liaison and non-liaison targets (Exp 3a)
Since the predicted liaison effect (older age estimates following liaison targets, and younger age estimates following no liaison targets) was not found in either the age ranking task, nor in the portrait selection task, the results from both tasks were collapsed in a single analysis which compared younger vs. older estimates based on the presentation of liaison and no liaison auditory stimuli. The overall impact of liaison on age perception across tasks was possible since each participant was involved in both the age ranking task and the portrait selection task, and since the liaison target pairs were counterbalanced across participants and tasks. Ratings of 1-4 in the first task were reassigned to a younger score, while ratings of 5-8 were reassigned to an older score. Figure 5.3, below, represents the combined scores of both tasks in Experiment 3a, which shows that participants were more likely to rate the speaker as an older speaker, regardless of the presence or absence of liaison. A one-way repeated measures ANOVA, with both participants and items as random variables, indicated no effect of liaison (both $F_s<1$).
While the combined results from the two tasks in Experiment 3a did not yield a liaison effect, the participant response bias towards older speakers, regardless of liaison, is apparent in Figure 5.3. The bias was confirmed by comparing younger responses to older responses using a Pearson’s Chi-squared test with Yates’ continuity correction ($X^2 = 26.04$, df = 1, $p < 0.001$).

5.2.5 Discussion

Participants in Experiment 3a estimated speaker age in two different tasks, the first of which explicitly required the selection of an age range following the presentation of an auditory stimulus. The second task, in which participants selected one of four portraits following an auditory stimulus, was a far more indirect method of capturing age estimation. While the portraits were carefully selected based on age estimations in
Experiment 2, the presentation of 2 younger and 2 older portraits was not made explicit to participants. Neither task, nor the combined results from the two tasks, revealed the predicted interaction between age and liaison.

The relative youth of the participants may in part explain the absence of age and liaison interaction in the Experiment 3a results. Younger individuals in their early 20s are probably not as accurate as older individuals (e.g. in their 40s) when it comes to distinguishing between individuals in older age groups (e.g. 40 vs. 45 vs. 50 yrs old). It may be that the participants in Experiment 3a, who were all in their early 20s, had a tendency to categorize speakers in the rating task as either belonging to their own age group, or to a general category of older speakers. Revisiting Figure 5.1, above, we notice that participants were more likely to rate speakers as belonging to their same age range (i.e. 21-25 or 26-30) when following target phrases including non-liaison consonants, as opposed to liaison consonants. However, once speakers were considered older than the participant (i.e. 31 and above), the age ratings were smoothly distributed along a bell curve from rating 31-35 to 56-60, with very little distinction between liaison and no liaison targets. A comparison of participant ratings for the first two age groups (i.e. 21-25 and 26-30) vs. the remaining six age groups indicates that the distribution of younger and older estimates by liaison and no-liaison is indeed a significant departure from what we might expect from chance, using Pearson’s Chi-squared test with Yates’ continuity correction (X-squared = 4.38, df = 1, p<0.04). When comparing the number of estimates to one of the two youngest age ranges following a liaison target (n=20) or no-liaison target (n=36), Pearson’s Chi-squared test with Yates’ continuity correction indicates that
participants’ association between no-liaison targets and younger speaker age is significantly different from chance ($X^2 = 4.57, \text{df} = 1, p<0.04$).

While the only evidence suggesting an interaction between liaison and estimated speaker age was found when investigating the estimates for the two youngest age ranges in the age ranking task, the combined results from the two tasks in Experiment 3 revealed a clear participant response bias towards older speakers. It is interesting to note, however, that this bias was inconsistent across experimental tasks. That is, the Pearson’s Chi-squared test with Yates’ continuity correction indicated that the bias towards selecting older speakers was present in the age ranking task ($X^2 = 41.01, \text{df} = 1, p<0.001$), but not in the age portrait task ($X^2 = 0.56, \text{df} = 1, p>0.4$). This distinction is clear when comparing Figure 5.1, in which the liaison and no liaison age rating curves are both skewed towards older speakers, with Figure 5.2, in which there is only a slight preference for selecting older portraits.

The presence of the age bias in the age rating task, but not the portrait task, is most likely a reflection of the explicit focus placed on age estimation in the first task, as opposed to the implicit age estimation in the second task. That is, during the age ranking task participants were most likely focused on the acoustic correlates of age, since the task objective was to estimate speaker age. Participant responses suggest that the average speaker age is slightly skewed towards the older age ranges provided by the age rating scale. In the portrait task, on the other hand, participants were likely attending to a wider variety of visual and facial cues which they could use to match each auditory stimulus to
a portrait. The shift in attention to visual cues, and away from age estimation, resulted in a greatly reduced age bias relative to the results from the age rating task.

Although the ages of the actual speakers are not known, the age bias in the participants’ age judgments was not only present in response to the target liaison phrases, but also in response to the filler trials. The mean response to Experiment 3a fillers in the age rating task was 5.09 (median and mode were both 5). Based on the 64% of fillers that were associated with older age ratings (i.e. ratings of 5-8 were considered older, on the scale of 1-8), the Pearson’s Chi-squared test with Yates’ continuity correction confirmed the bias towards selecting older speakers (X-squared = 82.51, df = 1, p<0.001). In the portrait rating task, 59% of the portraits selected after hearing a filler stimulus corresponded to an older portrait. The Pearson’s Chi-squared test with Yates’ continuity correction confirmed the bias towards selecting older speakers in the portrait task fillers (X-squared = 35.71, df = 1, p<0.001). The age bias was therefore present in response to target and filler stimuli, in the age rating task and to a lesser degree in the portrait task.

Further investigation of the speakers who were rated as younger or older revealed that the judgment of younger vs. older female speakers was roughly even, while male speakers were judged to be overall older. In Figure 5.4, the age judgments to filler trials were collapsed over the age rating and portrait rating tasks, and split according to female speakers vs. male speakers.
A one-way repeated measures ANOVA, with both participants and items as random variables, indicated an effect of gender by participants and by items (F1(1,13)=35.679, p<0.001; F2(1,158)=13.767, p<0.001), such that responses to male targets elicited higher social class ratings than responses to female targets.

Given the inconsistency in overall age rating by speaker gender, the results of liaison targets in the combined age rating and portrait tasks were revisited, this time taking speaker gender into account. This was possible thanks to the adequate balance of liaison and no liaison targets contributed by female and male speakers. Female speakers contributed 19 of the 43 liaison targets and 22 of the 43 no liaison targets. The combined results from the age rating and portrait tasks, by speaker gender, are presented below in Figure 5.5.

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Figure 5.4: Combined Exp 3a age results, filler stimuli

![Bar chart showing percentage of responses by gender and age](image.png)

**Age Estimates For Filler Stimuli:**
**Combined Results: 1-8 ranking and portrait Tasks**

Female Speakers:
- Older: 52%
- Younger: 48%

Male Speakers:
- Older: 69%
- Younger: 31%
Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Speaker Gender (Female vs. Male) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was no main effect of liaison (F<1), but there was a main effect of speaker gender (F(1,13)=47.231, p<0.001) such that targets by male speakers elicited higher social class ratings than targets by female speakers, regardless of liaison. There was also an interaction between liaison and speaker gender (F(1,13)=13.257, p<0.003).

The interaction between liaison and speaker gender was explored with a 2-tailed Student’s t-test for age ratings in response to female speakers, and for age ratings in response to male speakers. The difference in age ratings between liaison and no liaison for female speakers was marginally significant t(572)=1.83, p<0.07, such that liaison targets were more likely to result in younger estimates than no-liaison targets. Results for
male speakers, on the other hand, showed no difference in age rating between liaison and no liaison \( t(628)=1.225 \).

The investigation of age ratings by speaker gender, using both filler and target stimuli, indicate that the observed age bias is accounted for by participants’ judgments of the male speakers as older. While there was no age bias in response to female speakers, there was an unexpected interaction between their target stimuli and participants’ age estimations, such that liaison targets were associated with younger female speakers. This association is consistent with Booij & De Jong’s (1987) finding of a higher rate of liaison in the speech of women, but inconsistent with other studies which reported the opposite trend (Bannert, 1998; Léon & Tennant, 1990) or no difference in liaison use by gender (Moissset, 2000).

Since the liaison consonants /t/ and /z/ resulted in different reaction time patterns in Experiment 1, analyses of liaison consonant identity were pursued in Experiment 3. The combined results from the age ranking and age portraits tasks were split according to the 17 /t/ liaison target pairs and 24 /z/ liaison target pairs, and are shown in Figure 5.6, below. The 2 /p/ liaison target pairs were not included in this analysis.
Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Liaison Consonant (/t/ vs. /z/) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was no main effect of liaison (F<1.4, p>0.2), but there was a main effect of liaison consonant (F(1,13)=40.759, p<0.001) such that /t/ targets elicited higher social class ratings regardless of liaison. There was also an interaction between liaison and liaison consonant (F(1,13)=6.069, p<0.3).

The interaction between liaison and liaison consonant was explored with a 2-tailed Student’s t-test for age ratings in response to /t/ liaison, and for age ratings in response to /z/ liaison. Results for /t/ liaison showed no difference in age rating between liaison and no liaison t(474)=0.97. Results for /z/ liaison, on the other hand, showed a significant difference in age rating between liaison and no liaison t(670)=2.31, p<0.03,
such that liaison targets were more likely to result in younger estimates than no-liaison targets.

There is a striking similarity in patterns between the speaker gender analysis and the liaison consonant analysis. That is, there was a strong age bias with male speakers and with /t/ liaison, and the same interaction between liaison and age (i.e. liaison targets associated with younger speakers, and no liaison targets associated with older speakers) with female speakers and with /z/ liaison. The distribution of target stimuli by gender and liaison consonant is therefore provided in Table 5.8, below.

<table>
<thead>
<tr>
<th></th>
<th>/t/ consonant</th>
<th>/z/ consonant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>NL</td>
</tr>
<tr>
<td>Female Speakers</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Male Speakers</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 5.8: Experiment 3 target stimuli, by speaker gender and liaison consonant.

Although the distribution of /t/ liaison targets by female and male speakers was fairly close, male speakers did contribute 4 more /t/ consonant targets (i.e. 56% of /t/ targets) than female speakers. The age bias for male speakers was consistent across filler and target stimuli, and the greater proportion of male /t/ targets likely resulted in the age bias reported for /t/ liaison.

The interaction observed between liaison and age estimation for /z/ targets does not appear to be confounded by age bias. In fact, since male speakers contributed slightly more /z/ targets with liaison than did female speakers (i.e. 13 male vs. 11 female), the age
estimation for /z/ targets in which the liaison consonant was produced might have been even younger had there not been an age bias associated with male speakers.

It is not clear whether the interaction observed between liaison and age estimation for female speakers is confounded by the interaction between /z/ targets and age estimation. That is, while there was overall no age bias observed for female speakers, for filler or target stimuli, female speakers contributed more /z/ target stimuli than /t/ target stimuli (i.e. 24 /z/ vs. 15 /t/). It is possible that the apparent association between younger female speakers and the elevated use of liaison is actually accounted for by the interaction between /z/ liaison and age estimation.

Participants in Experiment 3a were expected to provide older age estimations when they heard target phrases in which liaison was produced, and younger age estimations when liaison was not produced. This effect was not found, however, and instead the results indicated an age bias towards older male speakers regardless of liaison, as well as evidence of interactions between liaison and age estimation for /z/ liaison and for female speakers. While the reported interactions warrant follow-up studies, Experiment 3b instead explores listeners’ associations between liaison use and the speaker’s social class.
5.3 Experiment 3b

5.3.1 Liaison and social class

Variation in liaison production today results from a process of consonant deletion which has been driven by both a regular and phonetically driven sound change, as well as by socially-motivated factors. The ‘proper’ application of liaison consonants is associated with knowledge of the French spelling system, which in turn is linked to level of education, speech register, and ultimately, to the social class of the speaker. Higher rates of liaison production in upper socio-economic classes are described by grammarians (e.g. Fouché, 1961; Walter, 1988) and are attested in liaison corpus studies (e.g. Booij and De Jong, 1987; De Jong, 1988; Moisset, 2000).

Participants in Experiment 3b performed the same two tasks as those in Experiment 3a, with the exception that participants focused on speaker social class level rather than on speaker age. Participants listened to the same short spontaneous phrases containing liaison environments that were used in Experiment 3a, and estimated speaker social class by selecting one of multiple social class ranges in the first task, and by identifying the speaker from a set of portraits in the second task. The individuals selected for the portraits were carefully selected based on social class estimations established in Experiment 2. Liaison production is expected to influence the estimated social class level of the speaker such that participants pick higher social class ranges in the first task and photographs of higher social class individuals in the second task after hearing liaison phrases as opposed to non-liaison phrases.
5.3.2 Method

5.3.2.1 Participants

Eighteen native French speakers participated in Experiment 3b and were each paid 10 Euros. Participants were recruited from the same Parisian universities as those who took part in Experiment 3a. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

5.3.2.2 Materials and design

5.3.2.2.1 Auditory stimuli

The auditory stimuli which were used for Experiment 3b were identical to those which were used for Experiment 3a. The same two experimental lists were also used, such that the use of each list was balanced across the two tasks.

5.3.2.2.2 Visual stimuli

Portraits of individuals were created for Experiment 3b in the same manner as they were for Experiment 3a, with the exception that the portraits this time varied according to their social class ratings but were constant in their age ratings. Once again, the age and social class ratings were based on participant estimations established in the Absolute Norming and Relative Norming tasks carried out in Experiment 2.
Four group photographs were selected as consisting of lower social class individuals (G, J, M, O), and four group photographs were selected as consisting of higher social class individuals (N, P, Q, T). For each of these eight group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest) of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 5.9, below. Also included is the likelihood that each group photograph was selected as the oldest or highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 8 group photographs (G, J, M, O, N, P, Q, and T) used to create the portraits for Experiment 3b.

<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Higher SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>40</td>
<td>56.5</td>
<td>2.5</td>
<td>61.2</td>
</tr>
<tr>
<td>J</td>
<td>40</td>
<td>57.3</td>
<td>2.2</td>
<td>29.3</td>
</tr>
<tr>
<td>M</td>
<td>36</td>
<td>54.4</td>
<td>1.6</td>
<td>2.7</td>
</tr>
<tr>
<td>O</td>
<td>48</td>
<td>72.8</td>
<td>2.3</td>
<td>29.9</td>
</tr>
<tr>
<td>Higher SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>28</td>
<td>31.3</td>
<td>3.4</td>
<td>90.7</td>
</tr>
<tr>
<td>P</td>
<td>42</td>
<td>75.6</td>
<td>3.1</td>
<td>75.3</td>
</tr>
<tr>
<td>Q</td>
<td>45</td>
<td>51.2</td>
<td>3.5</td>
<td>86.0</td>
</tr>
<tr>
<td>T</td>
<td>43</td>
<td>76.7</td>
<td>3.6</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Table 5.9: Experiment 2 results for group photographs used to create Experiment 3b visual stimuli.

As shown in Table 5.9, both the social class level estimates and likelihood of being selected as the higher social class photograph were lower for the four lower social class group photographs G, J, M, and O, than for the four higher social class group photographs N, P, Q, and T. However, the average age and the likelihood of being
selected as the older group photograph were fairly constant across lower and higher
social class group photographs.

Individuals from each group photograph were considered as portrait candidates,
and specific individuals were selected according to their age and social class estimates. A
series of portraits was created from each of eight group photographs, resulting in 24
portraits of higher social class individuals and 22 portraits of lower social class
individuals. Had there been two more women among the lower social class group
photographs then there would have been the same number of lower and higher social
class portraits, each balanced by gender. Age and social class estimates were collected for
44 of the 46 individuals during the Absolute Norming task in Experiment 2, and their
averages are provided in Table 5.10, below. Note that the average social class level was
judged as lower for those photographs in the lower social class category, relative to the
photographs in the higher social class category, while there was little difference in judged
age across the same categories.

<table>
<thead>
<tr>
<th></th>
<th>Age Average</th>
<th>Social Class Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Social Class</td>
<td>43</td>
<td>2.1</td>
</tr>
<tr>
<td>Higher Social Class</td>
<td>40</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 5.10: Experiment 2 results for group photographs used to create Experiment 3b
visual stimuli.

As with Experiment 3a, portraits for Experiment 3b were cut out of the group
photographs such that they only included the headshot for a single individual. The size of
each portrait was adjusted to appear as roughly 2 inches tall and 1.5 inches wide.
5.3.3 Procedure

Participants in Experiment 3b completed two tasks, each consisting of 123 trials. The experiment took roughly one hour to complete.

The first task in Experiment 3b was identical to that in Experiment 3a, with the exception that after hearing an auditory stimulus, participants ranked the speaker according to social class level rather than according to age. The social classes were labeled 1 through 8, along a continuum which was labeled as low, medium-low, medium-high, and high, where 1 corresponded to the low end of the spectrum and 8 corresponded to the high end. Note that the social class ranking scale was 1-4 in Experiment 2, but was broadened to 1-8 in Experiment 3 in order to encourage a wider range of participant scoring, and to be consistent with the age scale in the first task.

The second task in Experiment 3b was also identical to that in Experiment 3a, with the exception that the portraits which were presented to participants consisted of individuals who belonged to lower and higher social groups, rather than to younger and older age groups. Each trial consisted of four different portraits of which half were individuals of lower social class and half were individuals of higher social class. Each portrait was presented the same number of times throughout the overall task, and the presentation of each portrait was evenly distributed in each corner.

Half of the participants were presented with the first list of auditory stimuli in the first task and the second list of auditory stimuli in the second task, and the other half of the participants were presented with the auditory stimuli lists in reverse order. Trials in each task were randomly ordered for each participant.
5.3.4 Results

In the first task, participants listened to an auditory stimulus and estimated the social class level of the speaker on a scale of 1 to 8, where 8 corresponded to the highest social class group. The mean response to liaison targets was 5.45 (median and mode were both 6), and the mean response to non-liaison targets was 4.58 (median was 5 and mode was 3). The distribution of responses across age ranges for each target type, as shown in Figure 5.7, illustrates that the presence of liaison consonants resulted in the selection of higher social class ranges relative to non-liaison targets. For instance, liaison targets were about twice as likely to lead to the selection of the social class ranges 5 or 6 (17.3% and 22.2% of liaison responses, respectively), than to the selection of ranges 3 or 4 (10.9% and 9.6% of liaison responses, respectively). Non-liaison targets, on the other hand, showed little variation throughout the 3 to 6 range (17.8% and 16.8% of non-liaison responses, respectively). A 2-tailed Student’s t-test showed a significant difference in age rating between liaison and no liaison t(772)=6.42, p<0.001, such that liaison targets were more likely to result in higher social class estimates than no-liaison targets.
In the second task, participants matched an auditory stimulus to one of four portraits, two of which were of lower social class individuals and two of which were of higher social class individuals. Figure 5.8 shows that participants were more likely to select a higher social class portrait following a liaison stimulus, and a little more likely to select a lower social class portrait following a non-liaison stimulus. A 2-tailed Student’s t-test showed a significant difference in age rating between liaison and no liaison t(772)=4.83, p<0.001, such that liaison targets were more likely to result in higher social class estimates than no-liaison targets.

Figure 5.7: Distribution of social class estimates for liaison and non-liaison targets (Exp 3b)
As was done in the analysis of Experiment 3a results, the responses to the two tasks in Experiment 3b were combined in order to evaluate the overall impact of social class on liaison perception across tasks. Ratings of 1-4 in the first task were reassigned to a lower social class score, while ratings of 5-8 were reassigned to a higher social class score. The combined scores of the Experiment 3b tasks are represented below in Figure 5.9, which clearly show that participants were more likely to associate liaison phrases with speakers of higher social status than of lower social class. A one-way repeated measures ANOVA, with both participants and items as random variables, indicated an effect of liaison by participants and by items (F1(1,17)=42.999, p<0.001; F2(1,42)=28.128, p<0.001), such that responses to liaison targets elicited higher social class ratings than responses to no-liaison targets.

Figure 5.8: Social class estimates by portrait for liaison and non-liaison targets (Exp 3b)
5.3.5 Discussion

Participants in Experiment 3b estimated the social class level of speakers in two different tasks, the first of which explicitly required the selection of a social class level range following the presentation of an auditory stimulus. In the second task, participants selected one of four portraits following an auditory stimulus, where half of the portraits represented lower social class individuals while the other half represented higher social class individuals. Results from both Experiment 3b tasks confirmed the anticipated results that participants are more likely to associate liaison targets with speakers who belong to higher social groups.

The combined results of the two tasks, in Figure 5.7, clearly illustrate that the liaison effect was driven by participants’ responses to targets with liaison consonants, and
not by targets in which liaison was absent. That is, social class estimates after liaison
targets were more than twice as likely to result in a higher social class ranking (68%) than
a lower social class ranking (32%), whereas social class estimates after no liaison targets
were more evenly distributed across higher and lower social classes (49% and 51%,
respectively). Since all of the liaison environments used Experiment 3 were environments
in which liaison is considered optional (e.g. noun+adjective, verb+verb, and
adverb+adjective), it may be that no liaison is the variant that listeners generally expect,
whereas liaison is the marked variant with respect to social class.

Whereas the age bias observed in Experiment 3a was present in the age rating
task, but not in the age portrait task, the liaison effect on social class estimation in
Experiment 3b was observed in both tasks. This reflects the strength of liaison production
as a marker of higher social class, since the effect was found using both an explicit task
(social class rating along a scale) and an implicit task (selecting one of multiple portraits
balanced by estimated social class levels).

Since a difference in age estimation was observed based on speaker gender, the
combined results from the social class ranking and social class portraits tasks were also
split according to speaker gender, as shown below in Figure 5.10.
Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Speaker Gender (Female vs. Male) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was a main effect of liaison (F(1,17)=40.77, p<0.001), such that responses to liaison targets elicited higher social class ratings than responses to no-liaison targets. There was no main effect of speaker gender (F<1, p>0.5), and no interaction between liaison and speaker gender (F<1.1, p>0.3). As opposed to Experiment 3a, in which liaison phrases (with or without liaison) produced by male speakers led to older speaker estimations, and liaison phrases produced by female speakers led to an interaction between liaison and age estimation, there was no effect of speaker gender on responses in Experiment 3b. That is, participant responses to liaison targets resulted in higher social class ratings than responses to no-liaison targets, for both female and male speakers.
The combined results from the social class ranking and social class portraits tasks were split according to the 24 /z/ liaison target pairs and 17 /t/ liaison target pairs, and are shown in Figure 5.11, below. The 2 /p/ liaison target pairs were not included in this analysis.

![Figure 5.11: Combined Exp 3b social class ratings, /t/ vs. /z/](image)

Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Liaison Consonant (/t/ vs. /z/) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was a main effect of liaison (F(1,17)=45.059, p<0.001), such that responses to liaison targets elicited higher social class ratings than responses to no-liaison targets. There was no main effect of liaison consonant (F<1, p>0.8), and no interaction between liaison and liaison consonant (F<1.3, p>0.2). As opposed to Experiment 3a, in which /t/ liaison phrases (with or without liaison) led to
older speaker estimations while /z/ liaison phrases did not, the /t/ and /z/ liaison targets in Experiment 3b were consistent in that liaison production with either consonant resulted in higher social class judgments.

5.4 Experiment 3c

5.4.1 Age and social class

Since the use of liaison is associated with both the age and social class of the speaker, the objective of Experiment 3c was to test whether the combination of these two factors has an additive effect on participants’ judgments of speakers’ social identities. The first two tasks in Experiment 3c replicated the first tasks of Experiments 3a and 3b, in which participants listened to auditory stimuli and then selected an age range or social class range which best corresponded to the speaker who produced the stimulus. The third task in Experiment 3c followed the same methodology as the second tasks in Experiments 3a and 3b, with the exception that participants selected portraits that either corresponded to younger and lower social class individuals, or to older and higher social class individuals. Participants were expected to be more likely to select portraits of older and higher social class individuals after hearing liaison targets.
5.4.2 Method

5.4.2.1 Participants

Twenty-five native French speakers participated in Experiment 3c and were each paid 10 Euros. Participants were recruited from the same Parisian universities as those who took part in Experiments 3a and 3b. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

5.4.2.2 Materials and design

5.4.2.2.1 Auditory stimuli

The auditory stimuli that were used for Experiment 3c were identical to those which were used for Experiments 3a and 3b. However, since there were three tasks in Experiment 3c, the auditory stimuli were separated into three separate lists such that each participant was presented with a third of the stimuli (82 trials) during each task. Each of the 41 speakers contributed 2 utterances to each of the 3 stimulus lists. While this distribution ensured equal presentation of speaker per task, the varied contributions of phrase types by speaker did not make it possible to perfectly balance liaison, non-liaison, and filler phrases across tasks. The ratio of liaison to non-liaison targets was especially challenging to balance (14L/14NL in list 1, 10L/20NL in list 2, and 19L/9NL in list 3), given the uneven distribution of liaison production among speakers, and the reduced list size. The overall target to filler ratio was, on the other hand, much more balanced (66%
fillers in lists 1 and 3, and 63% fillers in list 2). Liaison and Non-Liaison target stimuli for each target pair were split across the three lists such that the two utterances from a given pair were never in the same list.

5.4.2.2.2 Visual stimuli

The same selection process which was used for Experiments 3a and 3b was used for identifying the group photographs to be used in Experiment 3c. Whereas the group photographs in Experiment 3a were selected in order to present participants with a contrast in age, and the photographs in Experiment 3b contrasted social class, the photographs in Experiment 3c did both. Only two of the possible four combinations of age and social class were included, however, in order to present participants with a series of individuals whose age and social characteristics were both associated with either the presence or the absence of liaison. That is, since the incidence of liaison production is associated with older speakers and with speakers of higher social class, the group photographs selected for Experiment 3c consisted of either younger and lower class individuals, or older and higher class individuals. As was the case with the group photographs in Experiments 3a and 3b, an important criteria in the selection of group photographs for Experiment 3c was that age and social class both be as consistent as possible across the individuals within a given group photograph.

Three group photographs were selected as consisting of younger and lower social class individuals (E, F, I), two of which had been used as the group photographs of younger individuals in Experiment 3a. Three group photographs were selected as
consisting of older and higher social class individuals (H, Q, T), two of which had been used as group photographs in Experiment 3b. For each of these six group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest) of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 5.11, below. Also included is the likelihood that each group photograph was selected as the oldest or highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 6 group photographs (E, F, I, H, Q, and T) used to create the portraits for Experiment 3c.

<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Higher SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E &amp; F</td>
<td>38</td>
<td>46.3</td>
<td>2.4</td>
<td>45.6</td>
</tr>
<tr>
<td>Lower SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>33</td>
<td>38.3</td>
<td>2.4</td>
<td>49.7</td>
</tr>
<tr>
<td>Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H &amp; Q</td>
<td>49</td>
<td>93.2</td>
<td>3.5</td>
<td>89.8</td>
</tr>
<tr>
<td>Higher SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>43</td>
<td>76.7</td>
<td>3.6</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Table 5.11: Experiment 2 results for group photographs used to create Experiment 3b visual stimuli, based on all Experiment 2 stimuli for those group photographs

As shown in Table 5.12, both the average age and likelihood of being selected as the older group photograph were lower for the three younger and lower social class group photographs, than for the older and higher social class group photographs. Also, the average social class level and likelihood of being selected as the higher social class photograph were lower for the three younger and lower social class group photographs, than for the older and higher social class group photographs.
Individuals from each group photograph were considered as portrait candidates, and specific individuals were selected according to their age and social class estimates. A series of portraits was created from each of six group photographs, resulting in 24 portraits of younger and lower social class individuals and 24 portraits of older and higher social class individuals, such that each group was balanced by gender. Age and social class estimates were provided for 40 of the 48 individuals during the Absolute Norming task in Experiment 2, and their averages are provided in Table 5.12, below.

<table>
<thead>
<tr>
<th></th>
<th>Age Average</th>
<th>Social Class Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger and Lower Social Class</td>
<td>30</td>
<td>2.4</td>
</tr>
<tr>
<td>Older and Higher Social Class</td>
<td>46</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Table 5.12: Experiment 2 results for group photographs used to create Experiment 3c visual stimuli, based on individual photographs selected for Experiment 3c portraits

As with Experiments 3a and 3b, portraits for Experiment 3b were cut out of the group photographs such that they only included the headshot for a single individual. The size of each portrait was adjusted to appear as roughly 2 inches tall and 1.5 inches wide.

Note that the set of portraits which were created from the group photographs that were also used by Experiment 3a or 3b were not identical to those created for Experiment 3c.
5.4.3 Procedure

Participants in Experiment 3c completed three tasks, each consisting of 82 trials, for a combined total of 246 trials. Experimental items within each list were randomly ordered for each participant. The experiment took roughly one hour to complete.

The first two tasks in Experiment 3c were identical to the first tasks in Experiment 3a and 3b, respectively, with the exception that there were fewer trials (82 instead of 123). The third task in Experiment 3c was identical to the second tasks in Experiment 3a and 3b, with the exception that the portraits which were presented to participants were different than those presented in the first two experiments. Whereas Experiment 3a presented portraits of younger and older individuals, and Experiment 3b presented portraits of lower and higher class individuals, the portraits in Experiment 3c consisted of individuals who were either younger and of lower social class groups, or who were older and of higher social groups. The presentation of the two types of portraits was equally distributed in corners 1, 2, 3, and 4. As with the first two tasks, there were fewer trials in the third task of Experiment 3c, relative to the equivalent tasks in Experiments 3a and 3b (82 instead of 123).

Participants in Experiment 3c were split into three groups such that each group was presented with a different list of auditory stimuli for each of the three tasks. Trials in each task were randomly ordered for each participant.
5.4.4 Results

In the first task, participants listened to an auditory stimulus and estimated the age range of the speaker on a scale of 1 to 8, where 8 corresponded to the oldest age group. The mean response to liaison targets was 4.86 (median and mode were both 5), and the mean response to non-liaison targets was 4.55 (median and mode were both 5). The distribution of responses across age ranges for each target type, as shown in Figure 5.12, suggests a weak tendency to select higher age ranges following liaison consonants. A 2-tailed Student’s t-test showed a significant difference in age rating between liaison and no liaison $t(716)=2.12$, $p<0.03$, such that liaison targets were more likely to result in older age estimates than no-liaison targets.

![Figure 5.12: Distribution of age estimates for liaison and non-liaison targets (Exp 3c)](image-url)
In the second task, participants listened to an auditory stimulus and estimated the social class level of the speaker on a scale of 1 to 8, where 8 corresponded to the highest social class group. The mean response to liaison targets was 5.69 (median and mode were both 6), and the mean response to non-liaison targets was 4.87 (median and mode were both 5). The distribution of responses across social class ranges for each target type, as shown in Figure 5.13, illustrates an overlapping distribution of social class estimates such that the curve corresponding to liaison targets is displaced and associated with higher social class estimates. A 2-tailed Student’s t-test showed a significant difference in social class rating between liaison and no liaison $t(714)=6.51$, $p<0.001$, such that liaison targets were more likely to result in higher social class estimates than non-liaison targets.

![Figure 5.13: Distribution of social class estimates for liaison and non-liaison targets (Exp 3c)](image)
In the third task, participants matched an auditory stimulus to one of four photographs, two of which were younger and lower social class individuals and two of which were older and higher social class individuals. Figure 5.14 indicates that participants had a strong preference for selecting photographs of older and higher social class individuals regardless of whether the liaison consonant was produced or not. A 2-tailed Student’s t-test showed no difference in portrait age / social class rating between liaison and no liaison t(713)=0.57, p>0.5.

Figure 5.14: Portrait age and social class estimates, by liaison and no liaison. Exp3c

5.4.5 Discussion

The first task in Experiment 3c was a replication of the first task in Experiment 3a, in which participants estimated speakers’ ages along a scale of younger to older age.
ranges. There was no liaison effect in Experiment 3a results, despite a numerical
difference such that liaison targets led to a higher age estimate, but this same pattern was
significant in the Experiment 3c results. It is interesting to note, furthermore, that the
observation made in Experiment 3a regarding participant ratings for the first two age
groups (i.e. 21-25 and 26-30) vs. the remaining six age groups held true for the results in
Experiment 3c. That is, in both cases when participants rated speakers as belonging to
their same (young) age range, they were more likely to do so following non-liaison target
phrases. The participant ratings for the first two age groups vs. the remaining six age
groups in Experiment 3c were marginally a significant departure from what we might
expect from chance, using Pearson’s Chi-squared test with Yates’ continuity correction
(X-squared = 3.65, df = 1, p<0.06). The Chi-Square value when comparing the number of
estimates to one of the two youngest age ranges following a liaison target (n=40) or no-
liaison target (n=58) suggests that participants’ association between no-liaison targets and
younger speaker age is also marginally different from chance, using Pearson’s Chi-
squared test with Yates’ continuity correction (X-squared = 3.31, df = 1, p<0.07). Taken
together, the results of the first tasks of Experiments 3a and 3c suggest a weak tendency
for listeners to associate liaison with older speakers, and perhaps also an increased
sensitivity towards the use of liaison by the speakers of the same age group as the
listener.

The second task in Experiment 3c replicated the first task in Experiment 3b, in
which participants ranked speakers on their social class level along a scale of 1 to 8.
Results were consistent across experiments, with a strong effect of liaison such that
liaison targets were more likely to result in higher social class estimates than non-liaison targets.

In the third task of Experiment 3c, participants were more likely to select portraits of older and higher social class individuals than younger and lower social class individuals, regardless of liaison. These results clearly did not pattern like the Experiment 3b results, where liaison targets resulted in higher social class judgments, relative to no-liaison targets. On the other hand, they did pattern very similarly to the combined results of Experiment 3a, in which participants exhibited a bias towards ranking speakers as older, regardless of liaison.

Results from the third task in Experiment 3c were split according to target stimuli produced by female vs. male speakers, and are shown in Figure 5.15, below.

![Figure 5.15: Portrait age and social class estimates, by liaison and speaker gender. Exp3c.](image-url)
Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Liaison Consonant (/t/ vs. /z/) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was no main effect of liaison (F<0.2, p>0.7), no effect of speaker gender (F(1,24)=1.2, p>0.2), and a marginal interaction between liaison and speaker gender (F(1,24)>3.9, p<0.06). Whereas an age bias was observed with male speakers but not female speakers in Experiment 3a, both male and female speakers were associated with older and higher social class ratings in the third task of Experiment 3c. As was the case in Experiment 3b, speaker gender had no effect on results in the third task of Experiment 3c. Participant estimates of female and male targets were biased towards older and higher social class ratings regardless of whether or not liaison was produced.

Results from the age / social class portraits tasks were also split according to the 24 /z/ liaison target pairs and 17 /t/ liaison target pairs, and are shown in Figure 5.16, below. The 2 /p/ liaison target pairs were not included in this analysis.
Results were evaluated using a 2 Liaison (Liaison vs. No Liaison) X 2 Liaison Consonant (/t/ vs. /z/) Repeated Measures Analysis of Variance (ANOVA), with participants as a random variable. There was no main effect of liaison (F<1.1, p>0.7), but there was a main effect of liaison consonant (F(1,23)=12.676, p<0.002) such that /t/ targets elicited higher social class ratings regardless of liaison. There was no interaction between liaison and liaison consonant (F<1, p>0.5). These results are consistent with the liaison consonant analysis carried out in Experiment 3a, in which /t/ liaison targets were rated as older, whether or not liaison was produced.

While the results from the third task in Experiment 3c do not exactly match those from the combined results of the first two tasks in Experiment 3a, when the results are split by gender or by liaison consonant, the results of the Experiment 3c portrait task are nevertheless very similar to the Experiment 3a results overall. It is also clear that the...
strong effect of social class reported in Experiment 3b was not reproduced in the Experiment 3c portrait task, which suggests that even a strong association between liaison use and a social factor can be tempered by additional social input to the listener.

5.5 General discussion

Experiment 3 provides compelling results that French listeners have strong associations between liaison use and the social identity of the speaker. In particular, participants in Experiment 3b rated liaison phrases, as opposed to no-liaison phrases, as coming from speakers of higher social classes. This result was found using an explicit age rating task and using an implicit portrait task, and it was consistent across speaker gender and liaison consonant.

Although the association between liaison and speaker age was not as clear from Experiment 3a results, the ensuing analyses revealed a complex set of interactions between linguistic and sociolinguistic factors. The predicted pattern, such that participants would rate speakers as older following liaison targets and as younger following no-liaison targets was true for the age rating task in Experiment 3c. However, Experiment 3a results indicated that younger female speakers were associated with liaison use, whereas older female speakers were associated with the absence of liaison. Similarly, /z/ liaison was associated with younger speakers, whereas the absence of /z/ liaison was associated with older speakers.

The relative youth of the participants, with respect to the age ranges available for selection in the age rating task, is important to consider when interpreting the age-related
tasks in Experiment 3. The predicted pattern of estimating younger speakers after hearing no liaison, and older speakers after hearing liaison, did hold in the first tasks of Experiments 3a and 3c, when the grouping of age ranges was adjusted such that the older category consisted of all age ranges older than the participants’ own ages. The relative age of participants in age-estimation tasks is an area which will require further investigation.

Chapter 6 will continue the investigation of social effects on liaison, and of age and social class in particular. However, whereas Experiment 3 tested participants’ estimates of speaker age and social class based on the presence or absence of liaison in short phrases, Experiment 4 in Chapter 6 will first provide information to the participant about the speaker’s social identity. Once the participant’s expectations of the social identity of the speaker has been established, the participant will then engage in an online cross-modal priming task which will test whether their expectations impact their processing of phrases containing liaison. For example, if the participant is expecting speech input from a higher social class individual (for which Experiment 3 has established that listeners associate an elevated use of liaison), their reaction time responses to the presence or absence of liaison consonants in target phrases will address the impact of their expectations on word recognition.
6. Experiment 4 – Social Expectations, Liaison and Word Recognition

6.1 Introduction

Without any prior knowledge of the speaker, a listener will instinctively and immediately form an impression of the speaker’s identity upon hearing their voice. From identifying the language to potentially recognizing the actual individual who is speaking, the listener will be sensitive to qualities in the speech input which reveal information about the speaker, such as their age, gender, and linguistic background. For example, results from Experiment 3, in which participants listened to short phrases in French and then estimated the speaker’s age or social class, indicated that listeners tend to associate the production of liaison consonants with individuals who are of higher social class. The simplest explanation for this pattern is that listeners associate the realization of liaison consonants with higher social class levels, and therefore that listeners are more likely to form an impression of a higher social class individual when they hear liaison consonants.

The objective in Experiment 4 is to approach the same association between liaison production and social identity that was explored in Experiment 3, but from the context in which the listener already has some degree of familiarity with the speaker’s social identity. The hypothesis is that a listener will use their knowledge of the speaker’s social identity in order to adjust their speech perception to anticipate the speech patterns which the listener associates with the speaker or with the social groups to which the speaker
appears to belong. Conversely, if the speech patterns produced by the speaker depart sufficiently from the patterns anticipated by the listener, speech perception may be adversely affected.

6.1.1 Evidence that social expectations can affect speech processing

Listener sensitivity to speech patterns of individuals and larger groups suggests that the perception system makes use of previously encoded associations of talkers’ social identities and speech characteristics. One way to encode such information is through stereotype formation. Stereotyping is the process whereby previously held beliefs about social categories are used in identifying a new individual as a member of an established category. In this case, a sociolinguistic stereotype is the association between a certain speech property (e.g. language, dialect, accent, pronunciation, etc.) and a certain social group (e.g. nationality, age, sex, etc.). Although stereotypes can be useful resource-saving devices based on well-learned sets of associations (Macrae, Stangor, & Milne, 1994), their activation can also lead to biased information processing. For example, Rubin (1992) conducted a study in which undergraduate students listened to a four-minute lecture recorded by a native speaker of English raised in central Ohio. As they listened to the lecture, half of the students were presented with a photograph of an Asian instructor, while the other half were presented with a photograph of a Caucasian instructor. Immediately following the lecture, the students completed a listening comprehension test. Those who had been presented with the photograph of the Asian instructor not only reported hearing a stronger accent, but their comprehension accuracy was also lower than
that of the participants who had been presented with the photograph of the Caucasian instructor. In other words, the mere presentation of the photograph of a foreign-looking person was sufficient to bias listeners’ expectations of the intelligibility of the speaker, resulting in the disruption of language comprehension.

Using semantic priming experiments, Dijksterhuis and van Knippenberg (1996) demonstrated that stereotype activation can have facilitatory effects as well as inhibitory effects. In Experiment 1, participants in the priming condition were asked to imagine a typical soccer hooligan (negative stereotype), while those in the priming condition for Experiment 2 were asked to imagine a typical professor (positive stereotype). Participants in Experiment 1 then performed a lexical decision task while participants in Experiment 2 performed a word puzzle task. Relative to the control participants who had not been primed by stereotype activation, the primed participants responded faster to words which were semantically consistent with the stereotype traits. That is, stereotype activation fostered selective perception by the participants.

Johnson, Strand, and D’Imperio (1999) explored the role of listeners’ gender expectations in speech perception by manipulating similar visual and acoustic cues. Johnson et al. (1999, see also Strand, 1998) found that the gender of a visually presented face affects the location of phoneme boundaries in words such as “hood” to “hud”, and concluded that “when listeners identify a talker as either female or male, they access gender expectations for what the talker should sound like, and employ these expectations in speech perception”. Listener sensitivity to speech patterns of individuals and larger
groups suggests that the perception system makes use of previously encoded associations of talkers’ social identities and speech characteristics.

Johnson, Flemming, & Wright (1993) presented listeners with synthesized vowels that spanned a range of F1-F2 combinations, and for different English vowel categories they asked listeners to select the “best” exemplar, or the vowel “as you would say it”. Relative to the vowel qualities in natural speech, the vowels which were selected by the participants represented an expanded acoustic vowel space. This effect was reproduced in the consonant context “hud” with three different groups of listeners who differed in their degree of familiarity with the speaker (Johnson, 2000). The listeners who were colleagues of the speaker were instructed to select productions of words which they thought best matched the speaker’s productions. Talker familiarity reduced the “hyperspace” effect for certain vowels, which suggests that the listeners who were most familiar with the speaker were able to access stored representations of the talker’s prior pronunciations.

These studies all point to the fact that listeners encode and store talker-specific information which can later influence speech processing (see also Goldinger, 1996; Goldinger, Kleider, & Shelly, 1999). Listeners are also capable of generalizing speech patterns across larger categories of talkers, such that the activation of those categories affects behavior in language tasks and speech perception. Though these studies vary in their methodologies, they are all similar in that they addressed the effects of activated stereotypes in offline tasks which permitted participants time to process stimuli before providing responses.
The objective in Experiment 4 is to tap directly into the process of online word recognition to test whether explicit stereotype priming results in facilitatory and inhibitory effects of speech variants which are consistent and inconsistent with the speech patterns of the stereotyped group. The two social stereotypes that will be used in Experiment 4 are age and social class, both of which will be conveyed by means of the visual and auditory stimuli which were normed in Experiment 2 and used as stimuli in Experiment 3.

6.1.3 Experiment 4 outline

Participants in Experiment 4 were introduced to groups of speakers by means of a speaker familiarity task that was designed to set participants’ expectations for the social identities of the speakers whose voices they would then hear. There were three versions of Experiment 4, such that speaker groups either consisted of younger vs. older groups (Experiment 4a), lower vs. higher social class groups (Experiment 4b), or younger and lower social class vs. older and higher social class groups (Experiment 4c).

After each speaker group was introduced, participants then performed a cross-modal priming task in which they listened to short utterances allegedly recorded by the speakers in the group. Immediately following each utterance, a visual target consisting of a sequence of letters would appear on the screen and participants would make a lexical decision as quickly as possible by pressing one of two buttons indicating whether the visual target corresponded to a word or to a non-word. Target phrases contained a liaison environment in which the liaison consonant either was or not produced.
The hypothesis is that participants will expect to hear the speech patterns which are consistent with the linguistic stereotypes established in the speaker-familiarity task. That is, when participants have been biased to expect speakers who are older and/or of higher social classes, they will anticipate speech variants which they associate with members of those social groups, including an elevated rate of liaison. On the other hand, when participants have been biased to expect speakers who are younger and/or of lower social classes, they will anticipate a relatively low rate of liaison. The anticipated results are that the lexical decision reaction times will be shorter when participants’ expectations of the presence or absence of liaison consonants are met, and reaction times will be longer otherwise.

Since the same set of recordings were used for each of the three versions of this experiment, each voice that contributed a set of recordings was associated with a younger speaker, an older speaker, a lower class speak, a higher class speaker, a younger and lower class speaker, and an older and higher class speaker. In other words, all participants listened to the identical set of speech recordings, regardless of the age and/or social class status of the speakers they were led to believe had recorded the utterances. Experiment 4 success therefore hinged on the effectiveness of the speaker familiarity task, for if participants’ expectations of the speakers’ social identities were not properly established then the associations between liaison production and controlled social factors would not be primed as intended. The auditory and visual stimuli that were used in Experiments 2 and 3, as well as the age and social class judgments which were collected in those
experiments, were leveraged in Experiment 4 in order to create plausible speaker social identities that participants wouldn’t question.

6.2 Experiment 4a

6.2.1 Method

Participants in Experiment 4 were presented with group photographs like the ones used in Experiments 2 and 3, and were introduced to the individuals in those photographs one by one in a speaker familiarity task. The objective of this task was to create for the participant an expectation of the social identities of the speakers whose speech utterances the participant would then listen to. In particular, participants were introduced to group pictures which contrasted younger vs. older individuals (Experiment 4a), lower vs. higher social class individuals (Experiment 4b), and younger and lower social class individuals, and older and higher social class individuals (Experiment 4c). Following the speaker familiarity task, participants then engaged in a cross-modal priming task which combined visual and auditory input. Each trial started with the presentation of one of the individuals that the participant had just been introduced to, and was followed by an utterance allegedly produced by that individual. The participant then saw a sequence of letters appear on the screen and pressed one of two buttons as quickly as possible to indicate whether or not the letters formed a word in French. Utterances which contained liaison phrases were always followed by the visual presentation of the last word in the phrase, and reaction time measurements were captured in order to analyze the amount of time
taken to identify the word. The anticipated results were that participants’ reaction times would be influenced by the presence or absence of liaison consonants, and by the participants’ expectations of the social identities of the talkers. In particular, if the participant was expecting a speaker whose social identity was associated with the production of liaison (e.g. a higher social class speaker), their reaction times would be shorter relative to cases where there was a mismatch in expectations and speech input (e.g. a lower social class speaker + liaison).

6.2.1.1 Participants

Thirty-one native French speakers participated in Experiment 4a and were each paid 10 Euros. Participants were recruited at l’Université Paris 1 Panthéon – Sorbonne, l’Université Paris 2, l’École des Hautes Études en Sciences Sociale, and l’École Supérieur de Commerce de Paris (ESCP-EAP), all in Paris, France. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

6.2.1.2 Materials and design

6.2.1.2.1 Auditory stimuli

The auditory stimuli for Experiment 4 (i.e. 4a, 4b, and 4c) consisted of the same types of short spontaneous phrases that were used in Experiments 2 and 3, once again with the intent to present participants with recordings of natural, spontaneous, and
unscripted speech. As was the case in Experiment 3, the intelligibility of the auditory stimuli established in Experiment 2 was used to ensure that participants were presented with a set of equally understandable liaison and non-liaison targets.

Target stimuli consisted of 3 or 4 words and contained a liaison environment between the last two words of the phrase. A set of 36 pairs of target stimuli were selected\textsuperscript{26} such that each pair included one liaison target and one non-liaison target. The average intelligibility accuracy was 97.0\% for liaison targets and 95.6\% for non-liaison targets. The lowest intelligibility accuracy was 81.25\% and 75\% for liaison and non-liaison targets, respectively, and the median and mode accuracies were both 100\% for liaison and non-liaison targets.

Of the 36 target pairs, 7 pairs were lexically identical and differed only in the presence or absence of liaison (see example a in Table 6.1, below), 3 pairs were identical in the words preceding and following the liaison environment (see example b), 18 pairs were identical in the word preceding the liaison environment (see example c), 5 pairs were identical in the word following the liaison environment (see example d), and 3 pairs were similar but not identical in either the words preceding or following the liaison environment (see example e). See Appendix G for the full list of Target phrases.

\textsuperscript{26}Relative to the list of target pairs used in Experiment 3, three pairs were removed due to various constraints related to the assembly of the experimental lists, and one new pair was added.
Liaison | Liaison Target | Gloss
--- | --- | ---
a. Liaison | faut jamais /z/ oublier | ‘must never forget’
No Liaison | faut jamais (z) oublier | ‘must never forget’
b. Liaison | Il devait /t/ être | ‘he must have been’
No Liaison | ça devait (t) être | ‘it must have been’
c. Liaison | c’est trop /p/ injuste | ‘it’s too unfair’
No Liaison | c’est trop (p) enfantin | ‘it’s too childish’
d. Liaison | des terres /z/ étrangères | ‘foreign lands’
No Liaison | des langues (z) étrangères | ‘foreign languages’
e. Liaison | des poèmes /z/ homériques | ‘the Homeric poems’
No Liaison | les parcours (z) historiques | ‘the historical journeys’

Table 6.1: Example target stimuli for Experiment 4

The average frequencies and standard deviations of the target words and of the words preceding the target words in Experiment 4 are provided in Table 6.2, below. These were calculated in the same was as was done for the stimuli in Experiment 3, and differ only slightly due to the removal of three target pairs that were used in the previous experiment. Once again, the relative consistency in word frequencies and standard deviations suggest that the auditory stimuli in Experiment 4 were well balanced with respect to lexical frequency.

<table>
<thead>
<tr>
<th>Source</th>
<th>Condition</th>
<th>Penultimate Word</th>
<th>Ultimate Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>FreqFrant</td>
<td>Liaison</td>
<td>217 (81)</td>
<td>126 (76)</td>
</tr>
<tr>
<td>No Liaison</td>
<td>217 (81)</td>
<td>138 (66)</td>
<td></td>
</tr>
<tr>
<td>FreqWeb</td>
<td>Liaison</td>
<td>443 (66)</td>
<td>359 (86)</td>
</tr>
<tr>
<td>No Liaison</td>
<td>449 (61)</td>
<td>377 (65)</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.2: Experiment 4 stimuli frequencies
Three different liaison consonants were used across five different syntactic contexts, as illustrated in Table 6.3, below. The liaison consonant and syntactic context were consistent across each of the 36 target stimuli pairs.

<table>
<thead>
<tr>
<th>POS Context</th>
<th># Target Stimuli</th>
<th>Liaison Consonant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun_Adjective</td>
<td>22</td>
<td>22 /z/</td>
</tr>
<tr>
<td>Verb_Verb</td>
<td>26</td>
<td>18 /t/, 8 /z/</td>
</tr>
<tr>
<td>Adverb_Adjective</td>
<td>16</td>
<td>12 /t/, 2 /z/, 2 /p/</td>
</tr>
<tr>
<td>Adverb_Verb</td>
<td>6</td>
<td>4 /z/, 2 /p/</td>
</tr>
<tr>
<td>Verb_Adjective</td>
<td>2</td>
<td>2 /t/</td>
</tr>
<tr>
<td></td>
<td>72</td>
<td>36 /z/, 32 /t/, 4 /p/</td>
</tr>
</tbody>
</table>

Table 6.3: Experiment 4 target stimuli details

Since the two target phrases in a given pair often ended in the same word, it was necessary to split the 36 pairs of target stimuli into two lists, such that a given participant would only be presented with the stimuli from one of the lists. Each list therefore contained either the liaison or the non-liaison target for a given pair. This ensured that participants would never hear – and then see – the same final word in two different target trials. The penultimate word in each target phrase (i.e. the one ending in the liaison consonant) was also unique within the target phrases for each list. The speakers who produced the target phrases were also split according to the two lists, such that a given speaker only contributed phrases to one or the other. This split was necessary in order to ensure that a given speaker’s speech utterances were always associated with the same individual in a photograph.
The 36 targets in List 1 consisted of 17 liaison targets and 19 non-liaison targets. These were produced by 19 different speakers, each of whom contributed 1 to 4 different target stimuli. The speakers participated in 9 different radio programs, 5 as radio show hosts (3 women, 2 men), and 14 as guests (6 women, 8 men). The women accounted for 53% of the target stimuli, including 7 liaison targets and 10 non-liaison targets.

The 36 targets in List 2 consisted of 19 liaison targets and 17 non-liaison targets. These were produced by 18 different speakers (none of which contributed stimuli to List 1), and each speaker contributed 1 to 3 different target utterances. The speakers participated in 8 different radio programs, 6 as radio show hosts (3 women, 3 men), and 12 as guests (5 women, 7 men). The women accounted for 44% of the target stimuli, including 6 liaison targets and 10 non-liaison targets.

In addition to the 36 target stimuli, List 1 also included 158 control and filler stimuli. Each of the List 1 speakers contributed 8 to 12 stimuli, 48% of which were produced by women. List 2 included 142 control and filler stimuli, with each of its speakers contributing 7 to 12 stimuli. The women contributed 43% of the List 2 stimuli. Control and filler phrases ranged from 3 to 6 words in length for both lists, and were excised from larger sentential contexts in spontaneous speech. There were no pauses in

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27 It was not possible to perfectly balance liaison and non-liaison targets across lists, given the constraint that a given speaker could only be in one list, and that speakers did not all contribute the same number of target stimuli.

28 The 9 programs were Affinités Électives, Café Bazar, Continent Sciences, Éclectik, En Étrange Pays, L’Humeur Vagabonde, Nocturne, Philophil, Quand J’Serai Grand.

29 The 8 programs were Affinités Électives, Continent Sciences, Éclectik, En Étrange Pays, L’Humeur Vagabonde, Les P’tits Bateaux, Quand J’Serai Grand, Le Téléphone Sonne
these phrases, and as was also the case for target stimuli, the control and filler stimuli were neither aligned to the beginning nor to the end of intonational phrases.

The auditory stimuli for the control phrases were essentially equivalent to the target phrases in that they also included a liaison environment between the last two words. The important distinction between the auditory target and control trials were the visual targets which immediately followed. That is, while target phrases were followed by visual targets which consisted of the last word in the target phrase, control phrases were followed by visual targets that consisted of unrelated words.

Filler stimuli were selected in order to ensure that the phonological environment at the word boundary between the last two words of stimuli phrases was unpredictable across the experiment. The visual non-word targets which followed most of the filler stimuli also served to render the lexical status of the visual targets unpredictable. Some filler stimuli included a liaison environment between the last two words, but contrary to auditory target stimuli the visual targets following these fillers consisted of non-words. The remaining fillers consisted of phrase-final words that began with a consonant and were preceded by penultimate words that ended in either a vowel or a consonant. In some cases, the vowel-consonant sequence formed a potential liaison environment at the word boundary, such that a liaison environment would have been created had the following word been vowel-initial and not consonant-initial. See Table 6.4 for examples of control and filler stimuli, and see Appendix I for the full list of filler stimuli.
### Table 6.4: Examples of control and filler stimuli phrases

<table>
<thead>
<tr>
<th>Phrase Type</th>
<th>Boundary</th>
<th>Example</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>L</td>
<td>sur pattes /z/ arrières</td>
<td>‘on hind legs’</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>nous allons (z) entendre</td>
<td>‘we will hear’</td>
</tr>
<tr>
<td>Filler approaches’</td>
<td>L</td>
<td>les différentes /z/ approches</td>
<td>‘the different</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>les enfants (z) adorent</td>
<td>‘the children adore’</td>
</tr>
<tr>
<td></td>
<td>V_C</td>
<td>c’est un vrai mistère</td>
<td>‘it’s a real mystery’</td>
</tr>
<tr>
<td></td>
<td>V_C (pot L)</td>
<td>qui devient rare</td>
<td>‘that becomes rare’</td>
</tr>
<tr>
<td></td>
<td>C_C</td>
<td>cet espace précieux</td>
<td>‘that precious space’</td>
</tr>
</tbody>
</table>

In order to eliminate any potential priming effects from one trial to another, neither the final word nor the penultimate word of any target phrase appeared as the final or penultimate word in any control or filler phrase of the same list. See Table 6.5 for the distribution of each stimulus type across Lists 1 and 2, as well as for an indication of which trials were followed by a visual word target (W) or a visual non-word target (NW).

<table>
<thead>
<tr>
<th>Phrase Type</th>
<th>Boundary</th>
<th>List 1</th>
<th>List 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>W</td>
<td>NW</td>
</tr>
<tr>
<td>Target</td>
<td>L</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>L</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Filler</td>
<td>L</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>NL</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>V_C</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>V_C (pot L)</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>C_C</td>
<td>22</td>
<td>23</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>97</td>
<td>97</td>
</tr>
</tbody>
</table>

Table 6.5: Examples of control and filler stimuli phrases

The use of spontaneous speech as the basis for creating auditory stimuli presented a clear obstacle to achieving a perfect balance of phrase type and boundary type across
each list. Nevertheless, each phrase type was adequately represented for each list, with an approximate distribution of 20% target stimuli, 10% control stimuli, and 70% filler stimuli.

6.2.1.2.2 Visual stimuli

Each auditory stimulus was paired with a visual target which was displayed in the middle of the screen as soon as the auditory stimulus had been played. The visual target consisted of a series of letters, and since half of these letter sequences formed a word in French (e.g. écrire, ‘to write’) while the other half did not (e.g. anecdamel, not a word in French), the lexical status of the string was overall unpredictable. If the auditory stimulus was a target then the ensuing visual target was always the last word of the auditory stimulus. However, when control or filler stimuli were followed by visual targets which formed words, these words were unrelated to any of those in the preceding phrase. The visual targets which formed non-words consisted of phonotactically legal sequences in French of approximately the same length as those visual targets which formed words. In order to minimize strategic processing in this task, a fourth of the non-words were superficially similar to the final word of the prime phrase (e.g. des cadeaux emballés - EMBASO). The similarity between the final word in these phrases and the following sequence of letters ensured that a form link between prime and target was not predictive of a word target. See Appendix I for the visual target words and non-words that were paired with each auditory stimulus.
Participants in Experiment 4a were introduced to a series of individuals in a set of four group photographs, two of which represented a set of younger individuals, and two of which represented a set of older individuals. The same four photographs which were selected for Experiment 3a were once again chosen for Experiment 4a. Their selection was based on the age and social class rankings from the Absolute Norming and Relative Norming tasks in Experiment 2, which indicated that these photographs varied in estimated age but not in estimated social class.

For each of the four group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest) of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 6.6, below. Also included is the likelihood that each group photograph was selected as the oldest group or as the highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 4 group photographs (E, F, C, and S) used to create the portraits for Experiment 4a.

<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Upper SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>4.0</td>
<td>46.3</td>
<td>2.4</td>
<td>45.6</td>
</tr>
<tr>
<td>F</td>
<td>2.1</td>
<td>26.7</td>
<td>2.4</td>
<td>37.3</td>
</tr>
<tr>
<td>Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>6.9</td>
<td>92.5</td>
<td>2.6</td>
<td>43.5</td>
</tr>
<tr>
<td>S</td>
<td>5.4</td>
<td>66.7</td>
<td>2.3</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Table 6.6: Experiment 4a visual stimuli based on Experiment 2 group photograph results

As shown in Table 6.6, both the age estimates and likelihood of being selected as the older photograph were lower for the two younger group photographs E and F than for...
the two older group photographs C and S. On the other hand, the average social class
ranking and the likelihood of being selected as the higher social class photograph were
relatively consistent across all four group photographs.

A short description for each group photograph was crafted in order to provide
participants with a context that would help them identify with the individuals in the group
photographs. Photograph E was introduced in the talker familiarity task by the
description *Ce groupe, qui partage ensemble les joies de la randonnée dans la nature, se
réunit pour une photo-souvenir.*, ‘This group, which shares an enjoyment for nature
walks, is gathered for a group photo’. Photograph F was introduced by the description *Ce
groupe d’étudiants se réunit pour une photo qui sera pour tous un souvenir de leur année
d’études ensemble.*, ‘This group of students is gathered for a photograph which
commemorates their year of study together’. Photograph C was introduced by the
description *Ce groupe d’amis se retrouve pour fêter l’anniversaire de l’un d’entre eux.*, ‘This group is gathered to celebrate one of their birthdays’. Photograph S was introduced
by the description *Ce groupe d’amis vient de fêter leurs retrouvailles au restaurant. Cette
photo est prise en souvenir de l’excellent repas qu’ils viennent de prendre ensemble.*, ‘This group of friends has just celebrated their reunion at a restaurant. This photograph is
taken as a souvenir of the excellent meal that they shared together’.

Each of the 37 speakers who contributed auditory stimuli to the experimental lists
in Experiment 4 was associated with one individual from a younger group photograph (E
or F), and also with one individual from an older group photograph (C or S). The
objective of pairing each speaker with two separate individuals was to create the basis for
two distinct social identities, differing only in age, but associated with identical speech characteristics. Each identity was assigned a specific age and then personified by a name. Given that these social identities would be presented to participants as actual individuals in the real world, it was important for each combination of speaker, photograph, and age to be as authentic as possible.

Results from the Absolute Norming Task in Experiment 2, in which participants were presented with photographs of individuals and then estimated their ages, were leveraged in order to ensure that the ages assigned to the social identities in Experiment 4a were within the range of age judgments for those individuals. Results from the first task in Experiment 3a, in which participants listened to auditory stimuli and then estimated the age of the speaker, were leveraged in order to assign a plausible younger age and a plausible older age to a given speaker. Results from the second task in Experiment 3a, in which participants listened to auditory stimuli and then identified the speaker from a selection of portraits, were leveraged in order to assign each speaker to a younger individual and to an older individual which would be the best fits given the group photographs.

Since two sets of speakers formed the basis of two lists of auditory stimuli, and two distinct social identities were created for each speaker, a total of four experimental lists were assembled. The auditory stimuli from the 19 speakers in List 1 were used in both Lists 1a and 1b, but speakers whose social identities were younger in List 1a were older in List 1b, and vice versa. The same applied to the 18 speakers who provided the
auditory stimuli for Lists 2a and 2b. As shown in Table 6.7 below, each of the four lists was balanced by speaker gender and speaker age.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Gender</th>
<th>List 1a</th>
<th>List 1b</th>
<th>List 2a</th>
<th>List 2b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 44, 36, 24, 11</td>
<td>W</td>
<td>Older</td>
<td>Younger</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>22, 8, 47, 6, 9</td>
<td>M</td>
<td>Older</td>
<td>Younger</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>35, 32, 33, 16</td>
<td>W</td>
<td>Younger</td>
<td>Older</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>18, 19, 14, 21, 5</td>
<td>M</td>
<td>Younger</td>
<td>Older</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>40, 7, 17, 46</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>Older</td>
<td>Younger</td>
</tr>
<tr>
<td>39, 41, 45, 30, 27</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>Older</td>
<td>Younger</td>
</tr>
<tr>
<td>26, 12, 4, 34</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>Younger</td>
<td>Older</td>
</tr>
<tr>
<td>3, 42, 13, 48, 15</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>Younger</td>
<td>Older</td>
</tr>
</tbody>
</table>

Table 6.7: Experiment 4a lists

In order to establish a clear separation between the younger and older social identities, the ages which were assigned to each speaker were carefully constrained. Each speaker was assigned two ages, one for their younger identity and one for their older identity, and each pair of ages was separated by 20 years. Younger social identities fell within a 15-year range, from age 23 to 38. The older social identities also spanned 15 years, from age 43 to 58. The average younger age was 30 years old, and the average older age was 50 years old. The age ranges and average ages per list were consistent across younger and older lists, as shown in Table 6.8, below. For the complete list of speaker descriptions used in Experiment 4a, see Appendix J.
<table>
<thead>
<tr>
<th></th>
<th>List</th>
<th>Minimum Age</th>
<th>Maximum Age</th>
<th>Average Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td>1a</td>
<td>25</td>
<td>35</td>
<td>30.8</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>23</td>
<td>36</td>
<td>29.5</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>23</td>
<td>36</td>
<td>29.2</td>
</tr>
<tr>
<td></td>
<td>2b</td>
<td>26</td>
<td>38</td>
<td>30.2</td>
</tr>
<tr>
<td>Older</td>
<td>1a</td>
<td>43</td>
<td>56</td>
<td>49.5</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>45</td>
<td>55</td>
<td>50.8</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>46</td>
<td>58</td>
<td>50.2</td>
</tr>
<tr>
<td></td>
<td>2b</td>
<td>43</td>
<td>56</td>
<td>49.2</td>
</tr>
</tbody>
</table>

Table 6.8: Experiment 4a speaker ages by list

To complement the speaker descriptions, and to complete the visual presentation of speaker social identities, a series of individual photographs was derived from each of the 4 group photographs. Each individual photograph consisted of the group photograph along with the addition of a single bright red circle around the individual. See Appendix E for an example of an individual circled within a group context.

Though the quality of the photographs was generally fairly good, the resolution did worsen slightly once the photographs were enlarged onto the screen during the experiment. This was not necessarily a problem, however, as the slight degradation in precision may in fact have allowed for increased variation in the interpretation of the individuals’ social identities, and in particular their age. The social identity descriptions which accompanied the photographs may therefore have been more plausible, indeed clarifying, if the ages which were provided as part of the descriptions served to resolve any shortcomings in the visual clarity of the photographs.
6.2.2 Procedure

Experiment 4a consisted of four blocks, each of which began with a speaker familiarity task and was followed by a cross-modal priming task in which participants heard a short phrase in French and then pressed a button to indicate whether the sequence of letters which appeared on the screen formed a word or not. Participants were evenly distributed across Lists 1a, 1b, 2a, and 2b. The experiment took roughly one hour to complete.

The speaker familiarity task was designed to reinforce the participant’s knowledge of and familiarity with the speaker’s social identity, in particular with respect to their age. In the speaker familiarity task, participants were presented with a group photograph which included multiple individuals. Participants were told in the written instructions that the people in each group had been interviewed in a laboratory by a professional interviewer, and that the interviews varied greatly in their contents, since the interviewees chose to discuss various topics including their jobs, families, interests, hobbies, and their youth. One at a time, individuals in the group photograph were presented to the participants via a copy of the group photograph in which the individual was identified by a red circle. Below each such photograph was a brief caption indicating the individual’s name and age (e.g. “Matthieu, 27 ans”). Participants stepped through the series of introductions at their own pace, and they were encouraged to take their time during this exercise because this information would help them with the next part of the experiment.
The cross-modal priming task immediately followed each speaker familiarity task. Participants were instructed that they would hear short phrases from the interviews with the individuals that they had just been introduced to. Each trial began with the presentation of the individual’s name and age, in the middle of the screen for 1500ms, so that participants would focus on this information prior to the next step in which the group photograph with the circled individual was presented for an additional 1500ms. After having identified the circled individual in the group photograph, the participant’s attention was then redirected to the center of the screen by a fixation cross which was accompanied by an auditory stimulus. Once the auditory stimulus was complete, the fixation cross was replaced by a sequence of letters in the middle of the screen.

Participants were instructed to indicate whether or not the sequence of letters which appeared on the screen formed a word in French by pressing one of two buttons on an external button box. To help participants remember which button was which, the button associated with a word was colored in green and the button associated with a non-word was colored in red. Participants were encouraged to respond as quickly as possible in this lexical decision task, without sacrificing accuracy. In order to encourage both speed and accuracy, each button press response was followed by visual feedback which indicated to the participant whether their response was correct or incorrect, their response time, and their cumulative accuracy across trials.

The four blocks (each consisting of a speaker familiarity task and a cross-modal priming task) were ordered according to group photograph in the following four different combinations: E-C-F-S, C-F-S-E, F-S-E-C, and S-E-C-F. These four combinations were
evenly distributed across participants, thereby ensuring that each photograph occurred in each of the four positions with equal frequency, and that younger and older groups were always alternating.

6.2.3 Results

Of the 1116 lexical decision times collected, 31 (2.8%) were errors (i.e. participants answered no to a real-word). A further 10 (0.1%) extreme values, defined as reaction times less than 200ms or greater than 1200ms, were also excluded. Reaction times for both types of errors were removed and then replaced by the mean of the item and participant means for the relevant condition (Winer, Brown, & Michel, 1991).

<table>
<thead>
<tr>
<th></th>
<th>Younger Speaker</th>
<th>Older Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>StDev</td>
<td>% Correct</td>
</tr>
<tr>
<td>Liaison</td>
<td>158</td>
<td>96%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>146</td>
<td>97%</td>
</tr>
</tbody>
</table>

Table 6.9: Exp4a StDev and lexical decision accuracy as a function of liaison and age

The reaction time standard deviations and the percentages of correct word responses, calculated after data replacement, were consistent across liaison and age conditions, as indicated in Table 6.9. Reaction time means, after data replacement, are presented in Figure 6.1, below.
The appropriate model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Age (younger ‘Y’ vs. older ‘O’), and their interaction as predictors. P-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.10.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>500.2199</td>
<td>470.58</td>
<td>530.29</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison (NL)</td>
<td>0.5837</td>
<td>-19.33</td>
<td>20.02</td>
<td>0.9704</td>
</tr>
<tr>
<td>Age(Y)</td>
<td>27.4338</td>
<td>6.95</td>
<td>46.36</td>
<td>0.0070</td>
</tr>
<tr>
<td>Liaison(NL):Age(Y)</td>
<td>-11.7161</td>
<td>-38.82</td>
<td>17.06</td>
<td>0.4186</td>
</tr>
</tbody>
</table>

Table 6.10: Estimates, confidence intervals, and p-values for Experiment 4a. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.
Reaction times were shorter when participants expected older speakers, and longer when they expected younger speakers. There was no effect of liaison, and no interaction between liaison and age.

6.2.4 Discussion

The manipulation of speaker age in Experiment 4a did not produce the predicted results (i.e. shorter reaction times following liaison when expecting older speakers, and shorter reaction times following non-liaison when expecting younger speakers). However, these results are not inconsistent with the Experiment 3 results, since the predicted interaction between liaison and estimated age was not consistently found in Experiment 3 (i.e. the interaction was significant in the first task of Experiment 3c, but not in either of the Experiment 3a tasks). In fact, the Experiment 4a results can be explained as a rather simple complement to the combined results of the first two age estimation tasks in Experiment 3a. That is, participant reaction times were shorter overall when participants expected speech from older individuals, as opposed to younger individuals, because the speech input that they heard was consistent with their expectations (i.e. the speakers were overall older, based on the age bias reported in Experiment 3a).

Since an effect of speaker gender was found in Experiment 3, an analysis of speaker gender was also investigated in the results of Experiment 4. In Experiment 3a, the age estimates for speakers differed by speaker gender, such that liaison targets by male speakers elicited older age ratings than targets by female speakers, regardless of
liaison or non-liaison. In addition, an analysis of the interaction between liaison and speaker gender for targets produced by female speakers indicated that liaison targets were more likely to result in younger estimates than non-liaison targets. This interaction between liaison and age estimation was an unexpected result, as it ran counter to the predicted interaction. The mean reaction times of Experiment 4a results, split by speaker gender, are given in Figure 6.2, below.

![Figure 6.2: Exp4a Mean reaction time as a function of liaison and age, by speaker gender](image)

The appropriate model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Age (younger ‘Y’ vs. older ‘O’), Speaker Gender (female ‘F’ vs. male ‘M’), and their interactions as predictors. P-values were estimated as the posterior probability of a
Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.11.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>478.208</td>
<td>446.987</td>
<td>511.463</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison(NL)</td>
<td>17.717</td>
<td>-8.861</td>
<td>47.2005</td>
<td>0.2114</td>
</tr>
<tr>
<td>Age(Y)</td>
<td>19.806</td>
<td>-7.802</td>
<td>48.3498</td>
<td>0.1686</td>
</tr>
<tr>
<td>Gender(M)</td>
<td>43.864</td>
<td>16.230</td>
<td>72.6566</td>
<td>0.0026</td>
</tr>
<tr>
<td>Liaison(NL):Age(Y)</td>
<td>-10.934</td>
<td>-50.165</td>
<td>28.0584</td>
<td>0.5836</td>
</tr>
<tr>
<td>Liaison(NL):Gender(M)</td>
<td>-38.667</td>
<td>-79.914</td>
<td>0.0003</td>
<td>0.0538</td>
</tr>
<tr>
<td>Age(Y):Gender(M)</td>
<td>12.314</td>
<td>-25.241</td>
<td>52.3639</td>
<td>0.5502</td>
</tr>
<tr>
<td>Liaison(NL):Age(Y):Gender(M)</td>
<td>8.366</td>
<td>-45.963</td>
<td>65.0021</td>
<td>0.7716</td>
</tr>
</tbody>
</table>

Table 6.11: Estimates, confidence intervals, and p-values for Experiment 4a, by speaker gender. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Reaction times were shorter when participants expected female speakers, and longer when they expected male speakers. There was also an interaction between liaison and speaker gender. Inspection of Figure 6.2 indicates that reaction times were shorter following liaison targets produced by female speakers, but shorter following non-liaison targets produced by male speakers.

While there was no reported interaction between gender and age, visual inspection of Figure 6.2 suggests that the bias towards shorter reaction times following the targets produced by male speakers, whether or not liaison was produced, may have contributed to the main age effect observed in Figure 6.1. This would be consistent with the gender analysis of Experiment 3a (see Figure 5.5), in which age ratings for liaison phrases produced by male speakers were more than twice as likely to be classified as older, as opposed to younger.
Since the liaison consonants /t/ and /z/ resulted in different reaction time patterns in Experiment 1, and in different associations to social identity in Experiment 3, analyses of liaison consonant identity were also pursued in Experiment 4. The Experiment 4a results were split according to the 18 /z/ liaison target pairs and 16 /t/ liaison target pairs, and are shown in Figure 6.3, below. The 2 /p/ liaison target pairs were not included in this analysis.

![Figure 6.3: Exp4a Mean reaction time as a function of liaison and age, /t/ vs. /z/](image)

The appropriate model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Age (younger ‘Y’ vs. older ‘O’), Liaison Consonant (‘T’ vs. ‘Z’), and their interactions as predictors. P-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.12.
<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>494.036</td>
<td>461.36</td>
<td>527.49</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison(NL)</td>
<td>-1.741</td>
<td>-32.56</td>
<td>27.51</td>
<td>0.9058</td>
</tr>
<tr>
<td>Age(Y)</td>
<td>41.324</td>
<td>11.29</td>
<td>69.22</td>
<td>0.0068</td>
</tr>
<tr>
<td>Lcons(Z)</td>
<td>15.979</td>
<td>-13.84</td>
<td>45.54</td>
<td>0.2770</td>
</tr>
<tr>
<td>Liaison(NL):Age(Y)</td>
<td>-21.445</td>
<td>-62.00</td>
<td>21.76</td>
<td>0.3212</td>
</tr>
<tr>
<td>Liaison(NL):Lcons(Z)</td>
<td>-4.188</td>
<td>-46.10</td>
<td>36.87</td>
<td>0.8352</td>
</tr>
<tr>
<td>Age(Y):Lcons(Z)</td>
<td>-27.356</td>
<td>-66.98</td>
<td>13.78</td>
<td>0.1930</td>
</tr>
<tr>
<td>Liaison(NL):Age(Y):Lcons(Z)</td>
<td>22.486</td>
<td>-36.39</td>
<td>79.28</td>
<td>0.4560</td>
</tr>
</tbody>
</table>

Table 6.12: Estimates, confidence intervals, and p-values for Experiment 4a, by /t/ vs. /z/ liaison. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Reaction times were shorter when participants expected older speakers, and longer when they expected younger speakers. There was no effect of liaison, no effect of liaison consonant, and no interaction between any of the three factors.

While there was no reported interaction between liaison consonant and age, visual inspection of Figure 6.3 suggests that the short reaction times to /t/ liaison phrases, with or without liaison, may have contributed to the main age effect observed in Figure 6.1. This would be consistent with the liaison consonant analysis of Experiment 3a (see Figure 5.6), in which age ratings for /t/ liaison phrases (a disproportionate number of which were produced my men) were twice as likely to be classified as older, as opposed to younger.
6.3 Experiment 4b

6.3.1 Method

6.3.1.1 Participants

Thirty-six native French speakers participated in Experiment 4b and were each paid 10 Euros. Participants were recruited from the same Parisian universities as those who took part in Experiment 4a. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.

6.3.1.2 Materials and design

6.3.1.2.1 Auditory stimuli

The two lists of Target, Control, and Filler stimuli which were constructed for Experiment 4a were also used for Experiment 4b. See section 6.2.1.2.1 for auditory stimuli details, Appendix G for the complete set of Target phrases, and Appendix I for the complete set of Filler phrases.

6.3.1.2.2 Visual stimuli

The visual targets which appeared on the screen following each auditory stimulus were the same in Experiment 4b as they were in Experiment 4a. See section 6.2.1.2.1 for
details, and Appendix I for the complete set of visual target words and non-words that were paired with each auditory stimulus.

Participants in Experiment 4b were introduced to a series of individuals in a set of four group photographs, two of which represented a set of lower class individuals, and two of which represented a set of upper class individuals. Four of the eight photographs which were selected for Experiment 3b were once again chosen for Experiment 4b. Their selection was based on the age and social class rankings from the Absolute Norming and Relative Norming tasks in Experiment 2, which indicated that these photographs varied in estimated social class but were fairly constant in estimated age.

For each of the four group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest) of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 6.13, below. Also included is the likelihood that each group photograph was selected as the oldest group or as the highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 4 group photographs (G, M, Q, and T) used to create the portraits for Experiment 4b.
<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Upper SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>4.5</td>
<td>56.5</td>
<td>2.5</td>
<td>61.2</td>
</tr>
<tr>
<td>M</td>
<td>3.6</td>
<td>54.4</td>
<td>1.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Higher SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q</td>
<td>5.3</td>
<td>51.2</td>
<td>3.5</td>
<td>86.0</td>
</tr>
<tr>
<td>T</td>
<td>4.9</td>
<td>76.7</td>
<td>3.6</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Table 6.13: Experiment 4b visual stimuli based on Experiment 2 group photograph results

As shown in Table 6.13, both the social class level averages and likelihood of being selected as the higher social class photograph were lower for the two lower social class group photographs G and M than for the two higher social class group photographs Q and T. The average age and likelihood of being selected as the older photograph, on the other hand, were roughly equivalent across all four group photographs.

As was the case in Experiment 4a, each of the 37 speakers who contributed auditory stimuli to the experimental lists in Experiment 4 was associated with one individual from a lower social class group photograph (G or M), and also with one individual from a higher social class group photograph (Q or T). The objective of pairing each speaker with two separate individuals was to create the basis for two distinct social identities, differing only in social class level, but associated with identical speech characteristics. Each identity was assigned a specific occupation and then personified by a name. Given that these social identities would be presented to participants as actual individuals in the real world, it was important for each combination of speaker, photograph, and occupation to be as plausible as possible.

Results from the Absolute Norming Task in Experiment 2, in which participants were presented with photographs of individuals and then estimated their social class
levels, were leveraged in order to ensure that the occupations assigned to the social identities in Experiment 4b were appropriate for those individuals. Results from the first task in Experiment 3b, in which participants listened to auditory stimuli and then estimated the social class level of the speaker, were leveraged in order to assign a plausible lower class occupation and a plausible higher social class occupation to a given speaker. Results from the second task in Experiment 3b, in which participants listened to auditory stimuli and then identified the speaker from a selection of portraits, were leveraged in order to assign each speaker to a lower social class individual and to a higher social class individual which would be the best fits given the group photographs.

The same four experimental lists used in Experiment 4a were once again used in Experiment 4b. Table 6.14 indicates the speakers, speaker gender, and experimental conditions for each list.

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Gender</th>
<th>List 1a</th>
<th>List 1b</th>
<th>List 2a</th>
<th>List 2b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 44, 36, 24, 11</td>
<td>W</td>
<td>Lower SC</td>
<td>Higher SC</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>22, 8, 47, 6, 9</td>
<td>M</td>
<td>Lower SC</td>
<td>Higher SC</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>35, 32, 33, 16</td>
<td>W</td>
<td>Higher SC</td>
<td>Lower SC</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>18, 19, 14, 21, 5</td>
<td>M</td>
<td>Higher SC</td>
<td>Lower SC</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>26, 12, 4, 34</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>Higher SC</td>
<td>Lower SC</td>
</tr>
<tr>
<td>3, 42, 13, 48, 15</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>Higher SC</td>
<td>Lower SC</td>
</tr>
<tr>
<td>40, 7, 17, 46</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>Lower SC</td>
<td>Higher SC</td>
</tr>
<tr>
<td>39, 41, 45, 30, 27</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>Lower SC</td>
<td>Higher SC</td>
</tr>
</tbody>
</table>

Table 6.14: Experiment 4b lists

Whereas a clear and objective separation between the younger and older social identities in Experiment 4a was established by maintaining a 20 year difference in age across each pair of identities for a given speaker, the separation between lower and higher
social class groups was accomplished by assigning two different occupations to each speaker, one for their lower social class identity and one for their higher social class identity. The short caption which accompanied each group photograph during the speaker familiarity task, and the occupations which were included in the speaker descriptions during the cross-modal priming task, were designed to create a social class contrast such that the individuals in photographs G and M were associated with a lower social class, relative to the individuals in photographs Q and T. Photograph G was introduced in the talker familiarity task by the description *Ces employés travaillent pour une agence d’interim dans le Val-de-Marne.*, ‘These employees work for a temp agency in the Val-de-Marne’. The occupations which were associated to individuals in this photograph included: receptionist, secretary, technical support, and accountant. Photograph M was introduced in the talker familiarity task by the description *En l’été 2005, cette équipe de travailleurs était chargée de la construction d’un entrepôt dans la banlieue Nord de Paris.*, ‘In the summer of 2005 this team of workers was responsible for building a warehouse in a suburb north of Paris’. The occupations which were associated to individuals in this photograph included: carpenter, plumber, painter, electrician, and mason. Photograph Q was introduced in the talker familiarity task by the description *Ce groupe fait partie de l’équipe enseignante d’un college privé.*, ‘The members of this group are a part of the teaching staff of a private middle school’. The occupations which were associated to individuals in this photograph included: supervisor, science professor, school director, math professor, French professor, and geography professor. Photograph

---

30 The Val-de-Marne is a French department located to the southeast of the city of Paris.
T was introduced in the talker familiarity task by the description Ce cliché réunit les animateurs d’une conférence de bioéthique donnée en septembre 2003., ‘The organizers of a 2003 bioethics conference are assembled in this picture’. The occupations which were associated to individuals in this photograph included: geneticist, journalist, Member of the Order of Doctors, lawyer, and doctor. The short group photograph captions that were used in the talker familiarity task, and the occupations which approximated social class level in the cross-modal priming task, were shared across experimental lists. For the complete list of speaker descriptions used in Experiment 4b, see Appendix K.

To complement the speaker descriptions, and to complete the visual presentation of speaker social identities, a series of individual photographs was derived from each of the 4 group photographs. Each individual photograph consisted of the group photograph along with the addition of a single bright red circle around the individual. See Appendix E for an example of an individual circled within a group context.

6.3.2 Procedure

Experiment 4b was nearly identical to Experiment 4a, in that the experiment began with a practice session followed by four blocks which consisted of the same speaker familiarity task and the same cross-modal priming task. The experiment took roughly one hour to complete.

Whereas the individuals in Experiment 4a belonged to either younger or older groups, in Experiment 4b they belonged to either lower social class groups (photographs G and M) or higher social class groups (photographs Q and T). The four group
photographs that were introduced in the speaker familiarity task were therefore different, as were the social descriptions which accompanied the individual portraits (e.g. “Caroline, Secrétaire.”). The four blocks (each consisting of a speaker familiarity task and a cross-modal priming task) were ordered according to group photograph in the following four different combinations: Q-G-T-M, M-Q-G-T, T-M-Q-G, and G-T-M-Q. These four combinations were evenly distributed across participants, thereby ensuring that each photograph occurred in each of the four positions with equal frequency, and that lower and higher social class groups were always alternating.

6.3.3 Results

Of the 1296 lexical decision times collected, 27 (2.1%) were errors (i.e. participants answered no to a real-word). A further 6 (0.5%) extreme values, defined as reaction times less than 200ms or greater than 1200ms, were also excluded. Reaction times for both types of errors were removed and then replaced by the mean of the item and participant means for the relevant condition (Winer, Brown, & Michel, 1991).

<table>
<thead>
<tr>
<th></th>
<th>Lower Social Class</th>
<th></th>
<th>Higher Social Class</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>StDev</td>
<td>% Correct</td>
<td>StDev</td>
<td>% Correct</td>
</tr>
<tr>
<td>Liaison</td>
<td>139</td>
<td>98%</td>
<td>142</td>
<td>97%</td>
</tr>
<tr>
<td>No Liaison</td>
<td>127</td>
<td>98%</td>
<td>118</td>
<td>99%</td>
</tr>
</tbody>
</table>

Table 6.15: Exp4b StDev and lexical decision accuracy as a function of liaison and social class
The reaction time standard deviations and the percentages of correct word responses, calculated after data replacement, were consistent across liaison and age conditions, as indicated in Table 6.15. Reaction time means, after data replacement, are presented in Figure 6.4, below.

A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Class (lower ‘L’ vs. higher ‘H’) and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.16.
Estimate | Lower Bound | Upper Bound | p (MCMC)
--- | --- | --- | ---
Intercept | 532.32 | 508.29 | 555.141 | 0.0001
Liaison (NL) | -23.08 | -39.89 | -5.098 | 0.0102
SocialClass (L) | -27.94 | -44.65 | -9.717 | 0.0022
Liaison (NL):SocialClass(L) | 37.97 | 13.57 | 63.511 | 0.0022

Table 6.16: Estimates, confidence intervals, and p-values for Experiment 4b. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Results indicate significant contributions from both social class and liaison. Inspection of Figure 6.4 shows that the reaction times after liaison phrases were shorter when participants were expecting lower social class speakers, but shorter after non-liaison phrases when participants were expecting higher social class speakers.

6.3.4 Discussion

The manipulation of speaker social class in Experiment 4b did not produce the predicted results. In fact, the opposite interaction was found such that reaction times were shorter following liaison phrases when participants expected lower social class speakers, but shorter after non-liaison phrases when participants expected higher social class speakers. This result is unexpected, given the Experiment 3 results which indicated a strong preference for participants to associate liaison with higher social class speakers and non-liaison with lower social class speakers.

The Experiment 4b results were split according to speaker gender, and the reaction time means are presented in Figure 6.5 below.

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A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Class (younger ‘Y’ vs. older ‘O’), Speaker Gender (female ‘F’ vs. male ‘M’), and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.17.
Table 6.17: Estimates, confidence intervals, and p-values for Experiment 4b, by speaker gender. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>524.2146</td>
<td>497.8438</td>
<td>550.201</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison (NL)</td>
<td>-13.9600</td>
<td>-39.0246</td>
<td>12.719</td>
<td>0.2942</td>
</tr>
<tr>
<td>SocialClass(L)</td>
<td>-19.4952</td>
<td>-45.3933</td>
<td>8.233</td>
<td>0.1620</td>
</tr>
<tr>
<td>Gender(M)</td>
<td>14.6690</td>
<td>-12.6816</td>
<td>39.243</td>
<td>0.2658</td>
</tr>
<tr>
<td>Liaison(NL):SocialClass(L)</td>
<td>35.8153</td>
<td>-0.0315</td>
<td>71.579</td>
<td>0.0506</td>
</tr>
<tr>
<td>Liaison(NL):Gender(M)</td>
<td>-17.5287</td>
<td>-53.6000</td>
<td>18.072</td>
<td>0.3376</td>
</tr>
<tr>
<td>SocialClass(L):Gender(M)</td>
<td>-13.9991</td>
<td>-51.6000</td>
<td>20.742</td>
<td>0.4406</td>
</tr>
<tr>
<td>Liaison(NL):SocialClass(L):Gender(M)</td>
<td>0.8104</td>
<td>-48.1931</td>
<td>52.607</td>
<td>0.9614</td>
</tr>
</tbody>
</table>

Results indicate significant contributions from an interaction between liaison and speaker gender. Inspection of Figure 6.5 shows that reaction times were shorter following liaison phrases when participants expected lower social class speakers, but shorter after non-liaison phrases when participants expected higher social class speakers. The interaction was consistent for reaction times to both female and male speakers.

The gender analysis of Experiment 4b is an elegant complement to the Experiment 3b results, in that the observed interactions were consistent across gender in both cases. Furthermore, inspection of Figure 5.10 is a reminder that the interaction between liaison and social class in Experiment 3b was driven by participants’ strong associations with liaison to higher social class individuals, whereas non-liaison targets had little effect on participant estimations of social class. Although the pattern isn’t quite as clear in the Experiment 4b reaction time results, inspection of Figures 6.4 and 6.5 suggests that once again it may have been the liaison targets, and not the non-liaison targets, which were driving the observed interaction. This was especially true for targets produced by male speakers.
It is also worth noting that the gender effect observed in Experiment 4a results, whereby reaction times were shorter following female targets as opposed to male targets regardless of liaison, was not reproduced in Experiment 4b. This suggests that there was nothing qualitatively different about the targets across gender that would indicate that the utterances selected from male speakers were for some reason more difficult to process than those produced by female speakers. Instead, the gender effect observed in Experiment 4a is more likely tied to the age bias observed in Experiment 3a, in which male speakers were estimated to be older than the female speakers.

The Experiment 4b results were also split according to the 18 /z/ liaison target pairs and 16 /t/ liaison target pairs, and are shown in Figure 6.6, below. The 2 /p/ liaison target pairs were not included in this analysis.

![Figure 6.6: Exp4b Mean reaction time as a function of liaison and social class, /t/ vs. /z/](image)
A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Class (lower ‘L’ vs. higher ‘H’), Liaison Consonant (‘T’ vs. ‘Z’) and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.18.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>536.438</td>
<td>510.53</td>
<td>563.302</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison (NL)</td>
<td>-36.602</td>
<td>-64.80</td>
<td>-9.961</td>
<td>0.0106</td>
</tr>
<tr>
<td>SocialClass (L)</td>
<td>-14.614</td>
<td>-41.63</td>
<td>11.642</td>
<td>0.2736</td>
</tr>
<tr>
<td>Lcons (Z)</td>
<td>-3.228</td>
<td>-29.30</td>
<td>23.387</td>
<td>0.8098</td>
</tr>
<tr>
<td>Liaison(NL):SocialClass(L)</td>
<td>27.479</td>
<td>-10.66</td>
<td>65.810</td>
<td>0.1496</td>
</tr>
<tr>
<td>Liaison(NL):Lcons(Z)</td>
<td>21.904</td>
<td>-16.19</td>
<td>59.967</td>
<td>0.2490</td>
</tr>
<tr>
<td>SocialClass(L):Lcons(Z)</td>
<td>-26.435</td>
<td>-64.21</td>
<td>9.769</td>
<td>0.1660</td>
</tr>
<tr>
<td>Liaison(NL):SocialClass(L):Lcons(Z)</td>
<td>19.079</td>
<td>-35.89</td>
<td>69.267</td>
<td>0.4880</td>
</tr>
</tbody>
</table>

Table 6.18: Estimates, confidence intervals, and p-values for Experiment 4b, by /t/ vs. /z/ liaison. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Results indicate a significant contribution from liaison. Inspection of Figure 6.6 nevertheless confirms that the pattern of interaction between liaison and social class which was observed in the initial Experiment 4b analysis, as well as across female and male speakers, is once again maintained across /t/ and /z/ liaison, despite the non-significance of the result in the model that includes liaison consonant as a predictor of lexical decision times.

As was the case with the gender analysis, the liaison consonant analysis of Experiment 4b complements the Experiment 3b results well, in that the liaison
consonants /t/ and /z/ were consistent with respect to their effect on estimating speaker social class, and consistent in the directionality of their reaction time results.

The consistency in reaction time patterns across Figures 6.4, 6.5, and 6.6 suggests that listeners were sensitive to liaison in a manner inconsistent with the initial hypothesis. That is, instead of shorter reaction times following the combinations of liaison and social class which were consistent with Experiment 3b results (i.e. liaison and higher social classes, non-liaison and lower social classes), the opposite pattern emerged in Experiment 4b. This interaction was present in the initial analysis (see Table 6.16), as well as in the gender analysis when variation due to speaker gender was built into the model (see Table 6.17). This result is nevertheless tempered by the absence of a significant interaction in the liaison consonant analysis, in which variation due to liaison consonant identity was built into the model (see Table 6.18a).

6.4 Experiment 4c

6.4.1 Method

6.4.1.1 Participants

Forty native French speakers participated in Experiment 4c and were each paid 10 Euros. Participants were recruited from the same Parisian universities as those who took part in Experiments 4a and 4b. None of these participants reported any speech or hearing problems in the language questionnaire that they filled out prior to participating in the experiment.
6.4.1.2 Materials and design

6.4.1.2.1 Auditory stimuli

The two lists of Target, Control, and Filler stimuli which were constructed for Experiment 4c were also used for Experiments 4a and 4b. See section 6.2.1.2.1 for auditory stimuli details, Appendix G for the complete set of Target phrases, and Appendix I for the complete set of Filler phrases.

6.4.1.2.2 Visual stimuli

The sequences of letters which formed words and non-words, and which appeared on the screen following each auditory stimulus, were the same in Experiment 4c as they were in Experiments 4a and 4b. See section 6.2.1.2.1 for details, and Appendix I for the complete set of visual target words and non-words that were paired with each auditory stimulus.

Participants in Experiment 4c were introduced to a series of individuals in a set of four group photographs, two of which represented a set of younger and lower class individuals, and two of which represented a set of older and upper class individuals. Four of the six photographs which were selected for Experiment 3c were once again chosen for Experiment 4c. Their selection was based on the age and social class estimations from the Absolute Norming and Relative Norming tasks in Experiment 2.

For each of the four group photographs, the average age (on a scale from 1 to 8, where 1 was youngest) and social class level (on a scale from 1 to 4, where 1 was lowest)
of the individual photographs in the Absolute Norming task of Experiment 2 is reported in Table 6.19, below. Also included is the likelihood that each group photograph was selected as the oldest group or as the highest social class group, when compared to each of the other 19 group photographs in Experiment 2. See Appendix D for the 4 group photographs (E, I, H, and T) used to create the portraits for Experiment 4c.

<table>
<thead>
<tr>
<th>Group Photograph</th>
<th>Age Average</th>
<th>% Selected Older</th>
<th>Social Class Average</th>
<th>% Selected Upper SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger &amp; Lower SC</td>
<td>E 4.0</td>
<td>46.3</td>
<td>2.4</td>
<td>45.6</td>
</tr>
<tr>
<td></td>
<td>I 3.1</td>
<td>38.3</td>
<td>2.4</td>
<td>49.7</td>
</tr>
<tr>
<td>Older &amp; Higher SC</td>
<td>H 6.3</td>
<td>93.2</td>
<td>3.5</td>
<td>89.8</td>
</tr>
<tr>
<td></td>
<td>T 4.9</td>
<td>76.7</td>
<td>3.6</td>
<td>84.9</td>
</tr>
</tbody>
</table>

Table 6.19: Experiment 4c visual stimuli based on Experiment 2 group photograph results

As shown in Table 6.19, both the average age and likelihood of being selected as the older group photograph were lower for the two younger and lower social class group photographs, than for the older and higher social class group photographs. Also, the average social class level and likelihood of being selected as the higher social class photograph were lower for the two younger and lower social class group photographs, than for the older and higher social class group photographs.

As was the case in Experiments 4a and 4b, each of the 37 speakers who contributed auditory stimuli to the experimental lists in Experiment 4 was associated with one individual from a younger and lower social class group photograph (E or I), and also with one individual from an older and higher social class group photograph (H or T). The objective of pairing each speaker with two separate individuals was to create the basis for
two distinct social identities, one characterized by two social traits associated with non-liaison use (i.e. younger age + lower social class), and the other characterized by two social traits associated with liaison use (i.e. older age + higher social class). Each identity was assigned a specific age, occupation, and name. Given that these social identities would be presented to participants as actual individuals in the real world, it was important for each combination of speaker, photograph, and occupation to be as plausible as possible.

Results from the Absolute Norming Task in Experiment 2, in which participants were presented with photographs of individuals and then estimated their age and social class levels, were leveraged in order to ensure that the ages and occupations assigned to the social identities in Experiment 4c were within the range of age and social class judgments for those individuals. Results from the first tasks in Experiments 3a, 3b and 3c, in which participants listened to auditory stimuli and then estimated the age or social class level of the speaker, were leveraged in order to assign plausible younger/older ages and lower/higher social class occupations to each speaker. Results from the second tasks in Experiments 3a, 3b, and 3c, in which participants listened to auditory stimuli and then identified the speaker from a selection of portraits, were leveraged in order to assign each speaker to a younger and lower social class individual, and to an older and higher social class individual, each of which would be the best fits given the group photographs.

The same four experimental lists used in Experiments 4a and 4b were once again used in Experiment 4c. Table 6.20 indicates the speakers, speaker gender, and
experimental conditions for each list (i.e. younger and lower social class, ‘YL’ vs. older and higher social class, ‘OH’).

<table>
<thead>
<tr>
<th>Speakers</th>
<th>Gender</th>
<th>List 1a</th>
<th>List 1b</th>
<th>List 2a</th>
<th>List 2b</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 44, 36, 24, 11</td>
<td>W</td>
<td>YL</td>
<td>OH</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>22, 8, 47, 6, 9</td>
<td>M</td>
<td>YL</td>
<td>OH</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>35, 32, 33, 16</td>
<td>W</td>
<td>OH</td>
<td>YL</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>18, 19, 14, 21, 5</td>
<td>M</td>
<td>OH</td>
<td>YL</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>40, 7, 17, 46</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>YL</td>
<td>OH</td>
</tr>
<tr>
<td>39, 41, 45, 30, 27</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>YL</td>
<td>OH</td>
</tr>
<tr>
<td>26, 12, 4, 34</td>
<td>W</td>
<td>n/a</td>
<td>n/a</td>
<td>OH</td>
<td>YL</td>
</tr>
<tr>
<td>3, 42, 13, 48, 15</td>
<td>M</td>
<td>n/a</td>
<td>n/a</td>
<td>OH</td>
<td>YL</td>
</tr>
</tbody>
</table>

Table 6.20: Experiment 4c lists

In order to establish a clear age separation between the two social identities, each speaker was assigned two ages which differed by an average of 18.8 years. The smallest and largest age differences were 15 and 24 years, respectively. Younger social identities fell within an 11-year range, from age 25 to 36, and averaged 29.1 years. Older social identities spanned 13 years, from age 42 to 55, and averaged 48.0 years. The age ranges and average ages per list were comparable across younger and lower social class lists (YL) and older and higher social class lists (OH), as shown in Table 6.21, below. For the complete list of speaker descriptions used in Experiment 4c, see Appendix L.
<table>
<thead>
<tr>
<th>List Type</th>
<th>List</th>
<th>Minimum Age</th>
<th>Maximum Age</th>
<th>Average Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>YL</td>
<td>1a</td>
<td>26</td>
<td>36</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>26</td>
<td>36</td>
<td>30.9</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>25</td>
<td>32</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>2b</td>
<td>25</td>
<td>30</td>
<td>27.2</td>
</tr>
<tr>
<td>OH</td>
<td>1a</td>
<td>45</td>
<td>55</td>
<td>49.1</td>
</tr>
<tr>
<td></td>
<td>1b</td>
<td>43</td>
<td>55</td>
<td>48.0</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>43</td>
<td>54</td>
<td>46.6</td>
</tr>
<tr>
<td></td>
<td>2b</td>
<td>42</td>
<td>54</td>
<td>48.0</td>
</tr>
</tbody>
</table>

Table 6.21: Experiment 4c speaker ages by list

The short caption which accompanied each group photograph during the speaker familiarity task, and the occupations which were included in the speaker descriptions during the cross-modal priming task, were designed to create a social class contrast such that the individuals in photographs E and I were associated with a lower social class, relative to the individuals in photographs H and T. Photograph E was introduced in the talker familiarity task by the description *Ce groupe, qui partage ensemble les joies de la randonnée dans la nature, se réunit pour une photo-souvenir.*, ‘This group, which shares an enjoyment for nature walks, is gathered for a group photo’. The occupations which were associated to individuals in this photograph included: building security guard, administrator, street sweeper in the 20th district of Paris, receptionist in a youth hostel, and high school hall monitor. Photograph I was introduced in the talker familiarity task by the description *Ce groupe se réunit pour fêter l’anniversaire de l’un d’entre eux.* ‘This group is gathered to celebrate one of their birthdays’. The occupations which were associated to individuals in this photograph included: cashier in a grocery store, pizza delivery person, restaurant waiter/waitress, household electronics salesperson, and
salesperson in a bakery. Photograph H was introduced in the talker familiarity task by the
description *Ce groupe se réunit pour la remise du prix Goncourt.*, ‘This group is gathered
for the awarding of the Goncourt prize’. The occupations which were associated to
individuals in this photograph included: author, writer, editor, member of the French
Academy, novelist, and poet. Photograph T was introduced in the talker familiarity task
by the description *Ce cliché réunit les animateurs d’une conférence de bioéthique donnée
en septembre 2003.* ‘The organizers of a 2003 bioethics conference are assembled in
this picture’. The occupations which were associated to individuals in this photograph
included: geneticist, journalist, Member of the Order of Doctors, lawyer, and doctor. The
short group photograph captions that were used in the talker familiarity task, and the
occupations which approximated social class level in the cross-modal priming task, were
shared across experimental lists. For the complete list of speaker descriptions used in
Experiment 4c, see Appendix L.

To complement the speaker descriptions, and to complete the visual presentation
of speaker social identities, a series of individual photographs was derived from each of
the 4 group photographs. Each individual photograph consisted of the group photograph
along with the addition of a single bright red circle around the individual. See Appendix
E for an example of an individual circled within a group context.

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31 Le prix Goncourt is a prize in French literature.
6.4.2 Procedure

Experiment 4c was nearly identical to Experiments 4a and 4b, in that the experiment began with a practice session followed by four blocks which consisted of the same speaker familiarity task and the same cross-modal priming task. The experiment took roughly one hour to complete.

Whereas the individuals in Experiment 4a belonged to either younger or older groups, and the individuals in Experiment 4b belonged to either lower or higher social groups, in Experiment 4c they belonged to either younger and lower social class groups (photographs E and I) or older and higher social class groups (photographs H and T). The four group photographs that were introduced in the speaker familiarity task were therefore different from those in either Experiment 4a or 4b, as were the social descriptions which accompanied the individual portraits (e.g. “Véronique, 51 ans, Poète.”).

The four blocks (each consisting of a speaker familiarity task and a cross-modal priming task) were ordered according to group photograph in the following four different combinations: H-I-T-E, I-T-E-H, T-E-H-I, and E-H-I-T. These four combinations were evenly distributed across participants, thereby ensuring that each photograph occurred in each of the four positions with equal frequency, and that younger + lower social class groups and older + higher social class groups were always alternating.
6.4.3 Results

Of the 1440 lexical decision times collected, 28 (1.9%) were errors (i.e. participants answered no to a real-word). A further 8 (0.6%) extreme values, defined as reaction times less than 200ms or greater than 1200ms, were also excluded. Reaction times for both types of errors were removed and then replaced by the mean of the item and participant means for the relevant condition (Winer, Brown, & Michel, 1991).

<table>
<thead>
<tr>
<th>Liaison</th>
<th>Younger &amp; Lower Social Class</th>
<th>Older &amp; Higher Social Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>StDev</td>
</tr>
<tr>
<td>Liaison</td>
<td>510ms</td>
<td>132</td>
</tr>
<tr>
<td>No Liaison</td>
<td>506ms</td>
<td>140</td>
</tr>
</tbody>
</table>

Table 6.22: Exp4c StDev and lexical decision accuracy as a function of liaison and age/social class

The reaction time standard deviations and the percentages of correct word responses, calculated after data replacement, were consistent across liaison and age conditions, as indicated in Table 6.22. Reaction time means, after data replacement, are presented in Figure 6.7, below.
A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Bias (younger and lower social class ‘YL’ vs. older and higher social class ‘OH’) and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.23.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>p (MCMC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>504.563</td>
<td>481.38</td>
<td>527.12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Liaison (NL)</td>
<td>-2.784</td>
<td>-19.56</td>
<td>12.80</td>
<td>0.7340</td>
</tr>
<tr>
<td>SocialBias(YL)</td>
<td>5.783</td>
<td>-10.24</td>
<td>22.11</td>
<td>0.4820</td>
</tr>
<tr>
<td>Liaison(NL):SocialBias(YL)</td>
<td>-1.699</td>
<td>-24.88</td>
<td>21.19</td>
<td>0.8848</td>
</tr>
</tbody>
</table>

Table 6.23: Estimates, confidence intervals, and p-values for Experiment 4c. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.
Reaction times results indicated no main effect of liaison, no main effect of social bias, and no interaction between liaison and social bias.

6.4.4 Discussion

The manipulation of speaker age and social class in Experiment 4c did not produce the predicted interaction of shorter reaction times following liaison targets and expectations of higher social class individuals, but shorter reaction times following non-liaison targets and expectations of lower social class individuals. However, the third task in Experiment 3c used similar photographs in order to convey speaker age and social class, and the results from that experiment also did not yield the anticipated results. The Experiment 3c results did, however, pattern very similarly to the results in Experiment 3a in which participants judged speaker age based on auditory stimuli.

Experiment 4c results were split according to speaker gender, as shown in Figure 6.8, below.
A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Bias (younger and lower social class ‘YL’ vs. older and higher social class ‘OH’), Speaker Gender (female ‘F’ vs. male ‘M’), and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.24.
Table 6.24: Estimates, confidence intervals, and p-values for Experiment 4c, by speaker gender. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Results indicate significant contributions from an interaction between liaison and speaker gender. Inspection of Figure 6.8 indicates shorter reaction time responses after liaison targets when participants were expecting female speakers, but shorter reaction time responses after non-liaison targets when participants were expecting male speakers. This interaction was also found in the equivalent analysis of Experiment 4a results (see Figure 6.2 and Table 6.11), which suggests that the manipulation of social identity in Experiment 4c was more effective in communicating information about speaker age than about speaker social class.

Experiment 4c results were also split according to the 18 /z/ liaison target pairs and 16 /t/ liaison target pairs, and are shown in Figure 6.9 below. The 2 /p/ liaison target pairs were not included in this analysis.
A mixed linear model included Liaison (liaison ‘L’ vs. no liaison ‘NL’), Social Bias (younger and lower social class ‘YL’ vs. older and higher social class ‘OH’), Liaison Consonant (‘t’ vs. ‘z’), and their interaction as predictors of lexical decision times. Resulting p-values were estimated as the posterior probability of a Markov Chain Monte Carlo (MCMC) simulation with 10000 runs. The results are summarized in Table 6.25.
Table 6.25: Estimates, confidence intervals, and p-values for Experiment 4c, by /t/ vs. /z/ liaison. Positive estimates indicate the amount of increase in log-RT relative to the Intercept.

Responses indicate significant contributions from social bias, as well as from an interaction between social bias and liaison consonant. Inspection of Figure 6.9 indicates that these effects can be attributed to shorter reaction times to /t/ liaison targets when participants were expecting individuals of older and higher social class, regardless of whether or not liaison was produced. This result is analogous to the liaison consonant identity analysis of Experiment 3c (see Figure 5.16), in which participants selected older and higher social class portraits following /t/ liaison targets, whether or not liaison was produced. The Experiment 3c results were consistent with Experiment 3a results, in which /t/ liaison targets were also rated as older, and this pattern was accounted for by the observation that a disproportionate amount of /t/ targets were contributed by male speakers who were consistently estimated to be older than female speakers. Similarly, the shorter reaction times to /t/ liaison in Experiment 4c were also found in Experiment 4a (see Figure 6.3). Shorter reaction times to /t/ liaison (whether or not liaison was produced) when participants were expecting older and higher social class individuals, relative to when they were expecting younger and lower social class individuals, resulted from
consistency in participant expectations and the ensuing auditory stimuli. That is, reaction times were shorter when participants anticipated speech from older (and higher social class) individuals and then heard speech from older individuals, and longer when participants anticipated speech from younger (and lower class) individuals and then heard speech from older individuals.

6.5 General discussion

Although the initial hypotheses for Experiments 4a, 4b, and 4c were not borne out, the results were largely explained by synthesizing the Experiment 4 analyses with the Experiment 3 results. In short, the association between liaison use and speaker age, as evaluated in Experiment 3a, was not as robust as had been anticipated, and consequently the Experiment 4a results were more reflective of the estimated age bias than of any interaction between liaison and speaker age. The association between liaison use and speaker social class, on the other hand, was clearly established in Experiment 3b, but surprisingly resulted in an interaction that was inconsistent with the predicted reaction time results in Experiment 4b. The manipulation of speaker age and social class in Experiment 4c yielded similar results to the age manipulation in Experiment 4a, which was again analogous to the results in Experiments 3c and 3a.

The increased use of liaison with age is reported in multiple studies of French speech corpora (e.g. Booij and De Jong, 1987; De Jong, 1988; Malécot, 1975; Moisset, 2000), and yet the predicted increase in age estimation with liaison use was not consistently found across Experiment 3 tasks. Similarly, the manipulation of participants’
expectations for younger vs. older speakers in Experiments 4a and 4c did not reveal any evidence of processing facilitation nor delay as a result of matching or mismatching age expectations and liaison use. A probable explanation for the absence of anticipated effects was offered in the discussion of Experiment 3, and also applies to Experiment 4 results. That is, the relative youth of the participants likely imposed a myopic filter on the attempt to evaluate the average French listener’s association to and processing of liaison use by speakers of various ages. The distribution of age estimates in Figures 5.1 and 5.12, for example, suggest not only that the pattern of age estimates by liaison may have differed between the lowest two age groups (those which correspond to the participants’ ages) and the higher six age groups, but more importantly that the speakers presented to the participants were overwhelmingly older than the participants themselves.

It is well documented that as a speaker’s chronological age increases, listeners tend to judge their voice as belonging to an older individual (e.g. Ptacek & Sander, 1966; Shipp & Hollien, 1969; Oyer & Deal, 1983; Lehman, 1985). However, it has also been found that age estimation by young listeners increases with difficulty as the speaker’s chronological age increases. This was reported by Lehman (1985), for example, who presented participants with a short reading sample produced by 24 subjects balanced by gender and evenly distributed from 44 to 82 years of age. Lehman suggested that the increased difficulty in age estimation in the older age ranges may have been a reflection of young listeners’ (median age 22) reduced experience with speakers in the higher age groups (ages 61-70 and 71-82). Given the age of participants in Experiment 3a and 3c, as well as the observed age bias towards older male speakers, and finally the additional
subtlety of testing whether participants have learned to associate variation in liaison use among speakers who are all older than they are themselves, it is perhaps not surprising that the predicted interaction between liaison and estimated age was inconsistent. A follow-up study to evaluate listeners’ associations between speaker age and liaison use (or any linguistic phenomenon) would benefit significantly from sampling participants across a wider age range than was done in this study.

Contrary to the age estimation tasks in Experiment 3, the social class estimation tasks yielded consistent results indicating that listeners associate the use of liaison with older speakers. Experiments 2 and 3 were carefully designed in order to set up Experiment 4, which would measure the reaction time differences when listeners expect speech from certain individuals and then hear speech patterns that are either consistent or inconsistent with their expectations. Yet, despite the predicted interaction between liaison and estimated social class in Experiment 3 (found three times using two different tasks), and despite the use of identical auditory stimuli, similar presentation of speakers with photographs, and the same participant pool, the results of the subsequent cross-modal priming task in Experiment 4 indicated an interaction between liaison and social class that suggests increased processing difficulty when the listener receives input that matches expectations.

It is a distinct possibility that the interaction between liaison and expected social class level that was found in Experiment 4b is in fact the result of the very opposite process that it was intended to test. That is, despite setting participant expectations of the speaker’s social identity by using an explicit speaker familiarity task that presented a
series of carefully synthesized social identities (using a combination of voices, photographs, and age / social class estimates), it may be that the authenticity of the artificially created social identities was compromised at some level of processing by the participants. Only a few participants out of all of those who took part in Experiment 4 reported in the post-experiment questionnaire (see Appendix M) that they suspected that the voices they heard were not in fact produced by the photographed individuals with which they were associated. However, some or even many participants may have picked up on the mismatching auditory and visual cues, even if they never became fully aware of the mismatches. And perhaps it is precisely those mismatches which account for the unexpected interaction between liaison and expected speaker social class.

As an example, suppose that a participant is first introduced to an individual whose occupation the participant identifies as relatively low social class and whose appearance in a photograph matches that occupation. The linguistic patterns that the participant may expect from such an individual will not only include the likelihood of liaison use, but it will also include basic vocal characteristics based on the speaker’s appearance in the photograph. For instance, the participant will have expectations for acoustic cues that relate to the speaker’s gender and age, such as fundamental frequency (F0), the primary acoustic correlate of pitch. While hearing a female voice when expecting a male voice (or vice versa) could be a dead giveaway that the voice and photographed speaker do not match, hearing a male voice that isn’t the actual voice of the photographed male individual is less likely to throw off the listener. In the case of Experiment 4, it is possible that participants sometimes heard a voice that didn’t match
the photographed individual particularly well, and that this mismatch resulted in a processing delay without consciously alarming the participant. While this scenario is but speculation at this stage, it could explain both the unexpected interaction of reaction time results from Experiment 4b, as well as the faster processing of targets when participants expected older (and higher social class) speakers in Experiments 4a and 4c.

Of course, the possibility remains that the interaction found in Experiment 4b is in fact the result of the intended experimental task, whereby participants do not question – consciously or unconsciously - whether or not the acoustic information has been produced by the speaker whose social identity was previously established. One way to ensure that the voice and photograph pairing is authentic to the participant in a follow-up study would be to simply use photographs of the actual speakers. The results from Experiments 3 and 4 warrant further exploration of the relationship between listeners’ associations of speech variation and speaker social identity, and the impact that these linguistic expectations have on speech processing.
7. Summary and Conclusion

7.1 Summary of findings

When a liaison consonant is pronounced, its resyllabification to the onset of the following syllable and word can produce for the listener a temporary ambiguity in the identity of the following word. For example, as the listener segments and recognizes the words in the phrase *un petit éléphant* ‘a little elephant’, the latent word-final liaison consonant /t/ in the word *petit* ‘little’ can create competition between the activation of the vowel-initial word *éléphant* and the consonant-initial word *téléphone*. Native French listener draws upon a variety of linguistic and extralinguistic cues in order to effortlessly resolve this ambiguity. The primary contribution of this thesis is to explore the relationship between the factors that influence the likelihood of liaison production and their impact on the processing of phrases containing liaison environments. A series of psycholinguistic experiments investigate how the presence or absence of liaison consonants impacts word recognition.

In Experiment 1, participants listened to liaison phrases which were pronounced with or without liaison, and repeated the last word that they heard as quickly as they could. Target phrases ended with the word following the potential liaison consonant, and reaction time measurements compared the time it took for participants to repeat the last word that they heard if it was preceded by a liaison consonant or not. Four different
liaison environments were tested, in which the likelihood of liaison production was considered obligatory, optional but infrequent, optional but rare, and prohibited. Results indicated that French listeners are sensitive to the presence or absence of liaison consonants, as well as to the likelihood of liaison in a given syntactic environment. Importantly, the presence of liaison consonants never resulted in any processing delays, despite any temporary lexical ambiguities, and in some cases the presence of liaison actually facilitated repetition times. The facilitatory effects of liaison were most apparent when comparing results of /t/ vs. /z/ liaison, as participant reaction times were significantly shorter following /z/ liaison but not following /t/ liaison. Together, these results were consistent with the growing body of research that indicate that resyllabification due to liaison does not delay word recognition, and contributed new evidence that listeners are sensitive to liaison context and to liaison consonant identity.

Experiments 2-4 addressed the role of social factors on liaison perception using a unique combination of auditory and visual stimuli in a series of offline and online tasks. These experiments tested the hypothesis that listeners internalize the use of liaison according to the perceived age and social class of the speaker, and that they make use of this information during speech perception. The visual stimuli used in Experiments 2-4 consisted of a series of photographs containing multiple individuals who varied in age and social class. The auditory stimuli were selected from a corpus of spontaneous speech utterances that included over 5500 liaison phrases. More than 80 different speakers contributed to this database, either as hosts or as guests on 149 different radio interviews from 14 programs on the Radio France network. These recordings provided a dynamic,
unscripted, and spontaneous alternative to the carefully recorded phrases that were used in Experiment 1.

Experiment 2 confirmed the high intelligibility of the spontaneous utterances collected for these experiments, thanks to high accuracy in transcription scores from one of the Experiment 2 tasks. Photographs of groups and individuals were presented to participants in Experiment 2, whose age and social class level estimations were correlated across two separate tasks. The photographs, along with their age and social class estimates, were essential in that they were carefully paired with the auditory stimuli in order to facilitate social manipulations in Experiments 3 and 4.

Experiment 3 was designed to assess listeners’ associations of liaison use with speaker age and speaker social class. Participants listened to phrases normed in Experiment 2 and estimated speakers’ ages and social class levels by means of two separate tasks. The first task required participants to provide explicit age and social class judgments along age and social class scales, while the second task collected a more implicit judgment based on the participant’s selection of one of four portraits balanced by age and/or social class. Experiment 3 revealed the predicted interaction between liaison and speaker social class, whereby liaison was associated with higher social classes and non-liaison was associated with lower social classes. Although the anticipated interaction between speaker age and liaison was also significant in one of the tasks, such that liaison targets elicited higher age estimates relative to non-liaison targets, this effect was tempered by interactions between liaison and speaker gender, as well as by an interaction between liaison and consonant identity. Together, these results indicate that French
listeners have strong and complex associations between liaison use and speaker social identity, which then set the stage for investigating how these associations influence speech perception.

In Experiment 4, participants’ expectations of the social identities of individual speakers were established by means of a speaker familiarity task that consisted of introducing participants to a series of photographed individuals. Participants then engaged in a cross-modal priming task in which they listened to short liaison phrases and performed a lexical decision task. The objective of this experiment was to test whether listener expectations of speaker social identity would impact the processing of liaison phrases by manipulating expected speaker age, social class, or both. The manipulation of expected speaker age did not result in the predicted interaction between speaker age and liaison, but instead reflected the estimated age bias that had been reported in the Experiment 3 age estimation tasks. The manipulation of expected speaker social class did result in an interaction between social class and liaison, but the direction of the interaction was surprisingly contrary to the anticipated results. Although the Experiment 4 predictions were not borne out, the manipulation of participants’ expectations of speaker social identity did impact participant responses, and the results were interpreted in relation to the age and social class estimations established in Experiment 3. The ways in which variation in speech patterns influence the listener’s perception of the speaker’s social identity, and the impact which this has on how the listener processes speech produced by different speakers, is a rich area for further exploration.
7.2 Conclusion

The ultimate aim of a psycholinguistic model of speech processing is to account for the universal characteristics of human language production and perception. The starting point for studies in speech production has been that no two utterances are ever acoustically identical, and so the so-called ‘lack of invariance’ problem has motivated research to understand the encoding process of the (stable) lexical representation in the speaker’s mind into the highly variable acoustic output of the speaker. The starting point for speech perception, on the other hand, has been to address how listeners decode the ever-variable speech input and map it onto lexical representations, in order to retrieve the speaker’s intended message.

Segmenting the acoustic stream into the sequence of words that correspond to the speaker’s intent is a critical component to speech perception. The Syllable Onset Segmentation Hypothesis (SOSH) proposes that French listeners rely on syllable onsets for speech segmentation, and that the segmentation of syllable onsets is given priority over the segmentation of syllable offsets when there is a conflict in resolving the location of word boundaries (Frauenfelder & Content, 1999; Content, Dumay, & Frauenfelder, 2000; Content, Kearns, & Frauenfelder, 2001; Content, Meunier, Kearns, & Frauenfelder, 2001; Dumay, Frauenfelder, & Content, 2002). Since syllable onsets regularly align with word onsets, the initiation of lexical searches at syllable onsets is an efficient initial heuristic.

Although the French language has a relatively clear syllable structure, syllable and word onsets nevertheless misalign frequently as a result of resyllabification processes
such as liaison. For instance, Bannert (1998) and Stridfeldt (1996) found that liaison occurred 3–4.4 times and 4.1 times per minute in their corpora, respectively. In a study on pronunciation variants in French, Adda-Decker, Boula de Mareüil, & Lamel (1999) found that /z/ liaison was produced in over 25% of the words in the 26,000 word lexicon of the BREF corpus of read speech (Lamel, Gauvain, & Eskénazi, 1991). In addition to liaison, resyllabification in French also takes place as a result of other common processes such as enchaînement, which involves the resyllabification of a word-final consonant that is pronounced in all phonological contexts (e.g. *chaque avion ‘each aircraft’ [ʃa.kə.vjɔ̃]), and elision, which involves the deletion of a word-final vowel before a vowel-initial word (e.g. *le avion, but l’avion ‘the aircraft’, [la.vjɔ̃]). In their corpus of semi-structured interview speech, Green & Hintze (1990) found that resyllabification in French occurred once every 1.66 seconds. The frequency with which syllable and word onsets misalign as a result of resyllabification suggests that listeners must have an effective way for processing the frequent misalignments, if their primary segmentation heuristic is indeed dependent on syllable onsets as a reliable cue to word onsets.

Contrary to SOSH’s predictions that the resyllabification of consonants will hinder word recognition of vowel-initial words due to the misalignment of syllable and word onsets, experimental evidence suggests that resyllabification does not slow down recognition (Gaskell, Spinelli, & Meunier, 2002; Spinelli, McQueen, & Cutler, 2003). Results from the cued shadowing task in Experiment 1 of this study are consistent with these findings, and even contribute evidence to suggest that resyllabification may in some cases actually speed up recognition of vowel-initial words. That is, reaction times were
shorter after /z/ liaison targets as opposed to /z/ non-liaison targets. Results from the cross-modal priming task in Experiment 4 provided additional evidence that liaison consonants are not processed equally, although these differences may have resulted from an age bias (i.e. the /t/ liaison phrases produced by older speakers than the speakers who produced the /z/ liaison phrases). Reaction times to non-liaison targets were shorter than those to liaison targets in some of the Experiment 4 analyses, although the opposite effect was also found. An interaction between liaison and speaker gender may account for these differences, given shorter reaction times following liaison targets by female speakers, but shorter reaction times following non-liaison targets produced by male speakers. These results suggest that the discussion of resyllabification and its impact on word recognition should not be constrained to lexical access of competing vowel-initial vs. consonant-initial words, as there are many additional linguistic and sociolinguistic factors that must also be taken into account.

One of the strategies which have been proposed to account for listeners’ abilities to process resyllabified sequences so effortlessly are the subphonemic differences in the acoustic properties between liaison consonants and word-initial consonants (e.g. Content, Dumay, & Frauenfelder, 2000). Evidence for these acoustic differences consists primarily of analyses in segment durations, and the results are not conclusive. Several studies have found that resyllabified consonants are generally 10-15% shorter than the equivalent word-initial consonants (Dejean de la Bâtie, 1993; Spinelli, McQueen, & Cutler, 2003; Yersin-Besson & Grosjean, 1996), while other studies only report duration differences for certain consonants (Wauquier-Gravelines, 1996; Gaskell, Spinelli, & Meunier, 2002).
or for none at all (Bannert, 1998). The inconsistency in these reports suggests that listeners can only use differences in segment durations as probabilistic cues for distinguishing resyllabified consonants from word-initial consonants, and that listeners must be making use of yet additional information in order to facilitate the processing of resyllabification and potential resyllabification sequences.

Given the complex interactions of linguistic and sociolinguistic factors that influence both the likelihood of liaison production, as well as the processing of liaison in continuous speech, any model of speech perception that attempts to account for the liaison process will require the flexibility to integrate a large variety of interacting cues. The results from Experiments 3 and 4 indicate that the interactions between liaison, liaison consonant identity, speaker age, speaker social class, and speaker gender are complex, and these experiments provide a good starting point for further investigation. Future studies which explore the connections between speech variants, sociolinguistic markers, and speech perception will undoubtedly also be rewarded by similar challenges and discoveries.
Appendix A: Mapping of the last orthographic consonant in French to the last phoneme in the word

<table>
<thead>
<tr>
<th>Last Phone In Word</th>
<th>Last Orthographic Consonant In Word</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s</td>
<td>x</td>
</tr>
<tr>
<td>/i/</td>
<td>1843</td>
<td>13</td>
</tr>
<tr>
<td>/e/</td>
<td>10974</td>
<td>5</td>
</tr>
<tr>
<td>/œ/</td>
<td>2602</td>
<td>465</td>
</tr>
<tr>
<td>/œ/</td>
<td>18</td>
<td>517</td>
</tr>
<tr>
<td>/y/</td>
<td>545</td>
<td>4</td>
</tr>
<tr>
<td>/u/</td>
<td>118</td>
<td>18</td>
</tr>
<tr>
<td>/o/</td>
<td>487</td>
<td>568</td>
</tr>
<tr>
<td>/œ/</td>
<td>1238</td>
<td>7</td>
</tr>
<tr>
<td>/œ/</td>
<td>2039</td>
<td>6485</td>
</tr>
<tr>
<td>/œ/</td>
<td>5031</td>
<td>1128</td>
</tr>
<tr>
<td>/œ/</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>/œ/</td>
<td>948</td>
<td>115</td>
</tr>
<tr>
<td>/j/</td>
<td>263</td>
<td>141</td>
</tr>
<tr>
<td>/w/</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>/p/</td>
<td>178</td>
<td>63</td>
</tr>
<tr>
<td>/b/</td>
<td>88</td>
<td>20</td>
</tr>
<tr>
<td>/t/</td>
<td>2234</td>
<td>520</td>
</tr>
<tr>
<td>/d/</td>
<td>604</td>
<td>1</td>
</tr>
<tr>
<td>/k/</td>
<td>1653</td>
<td>67</td>
</tr>
<tr>
<td>/g/</td>
<td>211</td>
<td>29</td>
</tr>
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<td>/œ/</td>
<td>439</td>
<td>25</td>
</tr>
<tr>
<td>/œ/</td>
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<td>83</td>
</tr>
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<td>/œ/</td>
<td>1497</td>
<td>77</td>
</tr>
<tr>
<td>/œ/</td>
<td>1770</td>
<td>12</td>
</tr>
<tr>
<td>/œ/</td>
<td>1687</td>
<td>1</td>
</tr>
<tr>
<td>/œ/</td>
<td>786</td>
<td>79</td>
</tr>
<tr>
<td>/œ/</td>
<td>1296</td>
<td>343</td>
</tr>
<tr>
<td>/œ/</td>
<td>3691</td>
<td>2231</td>
</tr>
<tr>
<td>Grand Total</td>
<td>42640</td>
<td>1210</td>
</tr>
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</table>
Appendix B: Target Stimuli for Experiments 1a and 1b

<table>
<thead>
<tr>
<th>Auditory Stimuli for Experiment 1a</th>
<th>Auditory Stimuli for Experiment 1b</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASG condition</td>
<td>AN condition</td>
</tr>
<tr>
<td>NAPL condition</td>
<td>NV condition</td>
</tr>
<tr>
<td>1. le bateau abrite</td>
<td>les bateau abrites</td>
</tr>
<tr>
<td>2. le medecin accompli</td>
<td>les medecins accomplis</td>
</tr>
<tr>
<td>3. le jardin accueillant</td>
<td>les jardins accueillants</td>
</tr>
<tr>
<td>4. le combat acharne</td>
<td>les combats acharnes</td>
</tr>
<tr>
<td>5. le dessin anime</td>
<td>les dessins animes</td>
</tr>
<tr>
<td>6. le temoin anonyme</td>
<td>les temoins anonymes</td>
</tr>
<tr>
<td>7. le bandit arrete</td>
<td>les bandits arretes</td>
</tr>
<tr>
<td>8. le diamant authentique</td>
<td>les diamants authentiques</td>
</tr>
<tr>
<td>9. le chemin eclore</td>
<td>les chemins eclores</td>
</tr>
<tr>
<td>10. le sermon edifiant</td>
<td>les sermons edifiant</td>
</tr>
<tr>
<td>11. le circuit efficace</td>
<td>les circuits efficaces</td>
</tr>
<tr>
<td>12. le courant electrique</td>
<td>les courants electriques</td>
</tr>
<tr>
<td>13. le bijou elegent</td>
<td>les bijoux elegants</td>
</tr>
<tr>
<td>14. le recit eloquent</td>
<td>les recits eloquents</td>
</tr>
<tr>
<td>15. le drapeau etendu</td>
<td>les drapeaux etendus</td>
</tr>
<tr>
<td>16. le moment etonnant</td>
<td>les moments etonnants</td>
</tr>
<tr>
<td>17. le pays etudie</td>
<td>les pays etudies</td>
</tr>
<tr>
<td>18. le danger ignore</td>
<td>les dangers ignores</td>
</tr>
<tr>
<td>19. le client impatient</td>
<td>les clients impatients</td>
</tr>
<tr>
<td>20. le contrat imprécis</td>
<td>les contrats imprecis</td>
</tr>
<tr>
<td>21. le sentier interdit</td>
<td>les sentiers interdits</td>
</tr>
<tr>
<td>22. le tyran obstiné</td>
<td>les tyrans obstines</td>
</tr>
<tr>
<td>23. le banquier occupé</td>
<td>les banquiers occupes</td>
</tr>
<tr>
<td>24. le produit organique</td>
<td>les produits organiques</td>
</tr>
</tbody>
</table>

266
25. la mission accomplie les missions accomplishies
26. la nation affectée les nations affectées
27. la galerie artistique les galeries artistiques
28. la souris attentive les souris attentives
29. la fonction avancée les fonctions avancées
30. la station égarée les stations égarées
31. la tribu éloignée les tribus éloignées
32. la photo émouvante les photos émouvantes
33. la notion empruntée les notions empruntées
34. la poupée enfantine les poupées enfantines
35. la durée établie les durées établies
36. la beauté éternelle les beautés éternelles
37. la fumée étouffante les fumées étouffantes
38. la portion évidente les portions évidentes
39. la rançon excessive les rançons excessives
40. la statue expressive les statues expressives
41. la sanction imminente les sanctions imminentes
42. la région incertaine les régions incertaines
43. la tension incessante les tensions incessantes
44. la question indirecte les questions indirectes
45. la façon injuste les façons injustes
46. la revue inquiétante les revues inquiétantes
47. la journée orageuse les journées orageuses
48. la corvée ordonnée les corvées ordonnées
# Appendix C: Filler Stimuli for Experiments 1a and 1b

<table>
<thead>
<tr>
<th>Filler</th>
<th>Type</th>
<th>Experiment 1 Filler Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Gender</td>
<td>La grand bureau se trouve dans un coin.</td>
</tr>
<tr>
<td>2.</td>
<td>Gender</td>
<td>Le petite marmite est sur le comptoir.</td>
</tr>
<tr>
<td>3.</td>
<td>Gender</td>
<td>Sur le machine à laver il y a du habits sales.</td>
</tr>
<tr>
<td>4.</td>
<td>Gender</td>
<td>Depuis le guerre le pays est très pauvre.</td>
</tr>
<tr>
<td>5.</td>
<td>Gender</td>
<td>Le gateau dans le vitrine coûte cher.</td>
</tr>
<tr>
<td>6.</td>
<td>Gender</td>
<td>La maison ancien sera vendu bientôt.</td>
</tr>
<tr>
<td>7.</td>
<td>Gender</td>
<td>La vielle chaise de mon grande tante s'est cassée.</td>
</tr>
<tr>
<td>8.</td>
<td>Gender</td>
<td>La lapin de ma petite soeur mange dans sa cage.</td>
</tr>
<tr>
<td>9.</td>
<td>Gender</td>
<td>Pendant une mois on essayait de gagner la loterie.</td>
</tr>
<tr>
<td>10.</td>
<td>Number</td>
<td>Les animals agressifs sont gardés en cages.</td>
</tr>
<tr>
<td>11.</td>
<td>Number</td>
<td>Les beaux corails se voient de très loin.</td>
</tr>
<tr>
<td>12.</td>
<td>Number</td>
<td>Les beaux vitraux permettent à la lumière d'entrer.</td>
</tr>
<tr>
<td>13.</td>
<td>Number</td>
<td>Le jardinier mangeront les fruits du verger.</td>
</tr>
<tr>
<td>14.</td>
<td>Number</td>
<td>Le chevaux traversent la riviére lentement.</td>
</tr>
<tr>
<td>15.</td>
<td>Number</td>
<td>Une menottes empêchent le prisonnier de s'échapper.</td>
</tr>
<tr>
<td>17.</td>
<td>Number</td>
<td>Avant la concert je veux que chacun nettoie sa chambre.</td>
</tr>
<tr>
<td>18.</td>
<td>Number</td>
<td>Le végétaux qui se vendent au marché sont frais</td>
</tr>
<tr>
<td>19.</td>
<td>NASG-L</td>
<td>La forêt Z enchantée du roi est pleine d'animaux sauvages.</td>
</tr>
<tr>
<td>20.</td>
<td>NASG-L</td>
<td>La pensée Z affective du professeur a beaucoup touché l'élève.</td>
</tr>
<tr>
<td>21.</td>
<td>NASG-L</td>
<td>Le garçon Z imprudent qui joue près de l'étang gelé pourrait tomber dedans.</td>
</tr>
<tr>
<td>22.</td>
<td>NASG-L</td>
<td>Le patron Z affolé a prévenu ses employés des réductions de salaire.</td>
</tr>
<tr>
<td>23.</td>
<td>NASG-L</td>
<td>Le gérant Z énervé du grand restaurant insulte ses employés.</td>
</tr>
<tr>
<td>24.</td>
<td>NASG-L</td>
<td>La section Z indiquée sur la carte correspond au forêts.</td>
</tr>
<tr>
<td>25.</td>
<td>NASG-NL</td>
<td>La fourmi écrasée est reine de la fourmilière.</td>
</tr>
</tbody>
</table>

268
26. NASG-NL  La leçon appliquée du maître n'est pas bien comprise par l'élève.
27. NASG-NL  Le dragon effrayant qui fait peur au enfants fait aussi peur aux adultes.
28. NASG-NL  Le cahier instructif offert par la gentille maîtresse a enchanté l'enfant.
29. NASG-NL  La montée apparente du chemin au sommet est un défi.
30. NASG-NL  Le soldat épuisé et très malade rentre enfin chez lui.
31. NAPL-L  Les plongées Z audacieuses au fond du lac sont très risquées.
32. NAPL-L  Les soirées Z antérieures sans alcool sont les plus ennuyeuses.
33. NAPL-L  Les débats Z oratoires qu’organise le comité ont lieu demain.
34. NAPL-L  Les projets Z incomplets retardent le fonctionnement satisfaisant de l'entreprise.
35. NAPL-L  Les sorties Z exclusives concernent toutes les personnes de la bonne société.
36. NAPL-L  Les colliers Z argentés et très brillants sont chers.
37. NAPL-NL Les vallées (Z) isolées du pays sont d'une beauté incomparable.
38. NAPL-NL  Les chansons (Z) amusantes que chante ma mère me font rire.
39. NAPL-NL Les métiers (Z) exigeants qui contrôlent nos vies sont une source de stress.
40. NAPL-NL Les travaux (Z) épuisants fatiguent les ouvriers courageux et travailleurs.
41. NAPL-NL Les villas (Z) habitées par les jeunes étudiants sont en mauvais état.
42. NAPL-NL Les camions (Z) excellents et chers qui consomment beaucoup d'essence sont obsolètes.
43. N/A  Le sorcier puissant a créé une illusion spectaculaire.
44. N/A  Les alpinistes casse-cou s'adaptent à l'altitude en grimpant lentement.
45. N/A  Les changements récents ont créé des liens fructueux entre la recherche et l'industrie.
46. N/A  Les complexes sportifs abritent des patinoires et des piscines.
47. N/A  Des citoyens concernés ont réexaminé la proposition.
48. N/A  Le Consulat général délivre les nouvelles cartes d'identité.
49. N/A  Les exercices quotidiens favorisent la flexibilité des muscles.
50. N/A  Le photographe professionnel a fait un portrait de famille.
51. N/A  Les patisseries exceptionnelles vendent des galettes croustillantes.
52. N/A  Une allergie respiratoire empêche la respiration normale.
53. N/A  Les grands théâtres montrent des comédies dramatiques chaque mardi soir.
54. N/A  Certaines bibliothèques fournissent des salles lumineuses.
55. N/A  Les magasins annoncent leurs promotions au début de l'été.
<table>
<thead>
<tr>
<th>Numéro</th>
<th>Phrase</th>
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<tr>
<td>56.</td>
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<tr>
<td>57.</td>
<td>Le boulanger prépare la pâte tôt le matin.</td>
</tr>
<tr>
<td>58.</td>
<td>Les chromosomes contiennent tout le matériel héréditaire des êtres vivants.</td>
</tr>
<tr>
<td>59.</td>
<td>Les éléphants transportent des arbres avec des chaînes.</td>
</tr>
<tr>
<td>60.</td>
<td>Les acrobates exécutent des sauts stupéfiants.</td>
</tr>
<tr>
<td>61.</td>
<td>La punition a duré deux longues semaines.</td>
</tr>
<tr>
<td>62.</td>
<td>Le maître appelle son jeune apprenti avec beaucoup de patience.</td>
</tr>
<tr>
<td>63.</td>
<td>Plusieurs infirmières soignent les autres malades à l'hôpital.</td>
</tr>
<tr>
<td>64.</td>
<td>Les terroristes apprennent des nouvelles méthodes très discrètement.</td>
</tr>
<tr>
<td>65.</td>
<td>Le cuisinier prépare des petits champignons pour la salade.</td>
</tr>
<tr>
<td>66.</td>
<td>Les employeurs discutent des contrats négociables avec leurs ouvriers.</td>
</tr>
<tr>
<td>67.</td>
<td>La natation fortifie le système cardiovasculaire.</td>
</tr>
<tr>
<td>68.</td>
<td>Mes pilules contiennent des aliments importants qui sont bons pour la santé.</td>
</tr>
<tr>
<td>69.</td>
<td>Un biologiste observe les parasites dans le microscope.</td>
</tr>
<tr>
<td>70.</td>
<td>Les enfants refusent de mettre leur pyjamas.</td>
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<tr>
<td>71.</td>
<td>Les officiers du roi portent un uniforme impressionnant.</td>
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<tr>
<td>72.</td>
<td>Les égyptiens doués ont construit des monuments qui sont connus à travers le monde.</td>
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<tr>
<td>73.</td>
<td>Les embargos commerciaux ont duré dix longues années.</td>
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<tr>
<td>74.</td>
<td>Les fabricants de tabac contournent la loi.</td>
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<tr>
<td>75.</td>
<td>Nos anciens élèves se souviennent de l'école secondaire.</td>
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<tr>
<td>76.</td>
<td>Le logiciel gratuit nous permet d'imprimer nos fichiers.</td>
</tr>
<tr>
<td>77.</td>
<td>Le récital de poésie attire un public nombreux.</td>
</tr>
<tr>
<td>78.</td>
<td>Un premier ministre a survécu un attentat chimique.</td>
</tr>
<tr>
<td>79.</td>
<td>Ces entrepreneurs ont accompli un succès remarquable en peu de temps.</td>
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<tr>
<td>80.</td>
<td>Les chimistes ont découvert un mélange supérieur qui produit un matériel plus résistant.</td>
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<td>81.</td>
<td>Les phares ont averti le bateau norvégien que la côte était proche.</td>
</tr>
<tr>
<td>82.</td>
<td>Les parents fâchés ont grondé leur fille paresseuse parce qu'elle ne fait pas d'effort.</td>
</tr>
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<td>83.</td>
<td>Chaque avocat a délivré un grand discours persuasif.</td>
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<td>84.</td>
<td>Les voyages en bateaux offrent des visites pittoresques aux touristes.</td>
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<td>85.</td>
<td>Le virus a malheureusement causé une infection respiratoire.</td>
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Appendix D: Group Photographs used in Experiments 2-4

Photograph A

Photograph B
Photograph K

Photograph L
Appendix E: Example of an Individual Photograph used in Experiment 2
# Appendix F: Speakers for Experiments 2, 3, and 4

<table>
<thead>
<tr>
<th>Speaker</th>
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<th>Experiments</th>
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<td>Guest</td>
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<td>Guest</td>
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<td>48</td>
<td>Le Téléphone Sonne</td>
<td>Dec 05 - Jan 06</td>
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Appendix G: Target Stimuli for Experiments 2, 3 and 4

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<td>c'est extrêmement (t) émouvant</td>
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<tr>
<td>faut jamais Z oublier</td>
<td>faut jamais (z) oublier</td>
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<td>pluralité des mondes Z habités</td>
<td>pluralité des mondes (z) habités</td>
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<td>des noyaux Z exotiques</td>
<td>des noyaux (z) exotiques</td>
<td>2, 3</td>
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<tr>
<td>je me suis Z aperçu</td>
<td>je me suis (z) aperçu</td>
<td>2, 3, 4</td>
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<td>j'étais Z enceinte</td>
<td>j'étais (z) enceinte</td>
<td>2, 3</td>
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<tr>
<td>on peut T imaginer</td>
<td>on peut (t) imaginer</td>
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<tr>
<td>m'a beaucoup P étonné</td>
<td>m'a beaucoup (p) étonné</td>
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<td>il est T arrivé</td>
<td>il est (t) arrivé</td>
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<td>nous sommes Z intéressés</td>
<td>nous sommes (z) intéressés</td>
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<td>huit cents Z îles</td>
<td>huit cents (z) îles</td>
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<td>et mieux Z encore</td>
<td>le mieux (z) encore</td>
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<td>quelque chose d'assez Z étrange</td>
<td>une femme assez (z) étrange</td>
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<td>de ne pas Z avoir</td>
<td>ne va pas (z) avoir</td>
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<td>il faisait T allusion</td>
<td>elle faisait (t) allusion</td>
<td>2, 3</td>
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<td>il devait T être</td>
<td>ça devait (t) être</td>
<td>2, 3, 4</td>
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<tr>
<td>papa complètement T agnostique</td>
<td>pas complètement (t) assuré</td>
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<td>c'est relativement T irrationnel</td>
<td>étaient relativement (t) accessibles</td>
<td>2, 3, 4</td>
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<tr>
<td>pas tellement T attiré</td>
<td>pas tellement (t) éloigné</td>
<td>2, 3, 4</td>
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<tr>
<td>recherche totalement T appliquée</td>
<td>c'est totalement (t) impossible</td>
<td>2, 3, 4</td>
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<tr>
<td>sont parfaitement T adapté</td>
<td>trouve parfaitement (t) exacte</td>
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<td>aux questions Z économiques</td>
<td>ces questions (z) ouvertes</td>
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<tr>
<td>les pays Z émergents</td>
<td>les pays (z) arabes</td>
<td>2, 3, 4</td>
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<tr>
<td>il faudrait T ajouter</td>
<td>il faudrait (t) assurer</td>
<td>2, 3, 4</td>
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<tr>
<td>vous avez Z échappé</td>
<td>vous avez (z) assisté</td>
<td>2, 3, 4</td>
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26. tout à fait T indiscrète tout a fait (t) exhaustive 2, 3, 4
27. c'est trop P injuste c'est trop (p) enfantin 2, 3, 4
28. des échanges Z assassins les échanges (z) amicaux 2, 3, 4
29. se sont T amassé se sont (t) inquiète 2, 3, 4
30. qui ont T influencé qui ont (t) orienté 2, 3, 4
31. on pourrait T appeler il pourrait (t) emmener 2, 3, 4
32. qui voudrait T utiliser on voudrait (t) essayer 2, 3, 4
33. il faut T écrire il faut (t) ajouter 2, 3, 4
34. vous êtes Z opposé vous êtes (z) engagé 2, 3, 4
35. sur d’autres Z appréciations pas d’autres (z) explications 2
36. leurs propres Z études leurs propres (z) espaces 2
37. qu’il aurait T aidé qu’il aurait (t) aimé 2
38. les médias Z américains deux professeurs (z) américains 2, 3
39. des lignes Z entières des cahiers (z) entiers 2, 3, 4
40. des terres Z étrangères des langues (z) étrangères 2, 3, 4
41. aux affaires Z humanitaires des valeurs (z) humanitaires 2, 3
42. de travaux Z antérieurs les rencontres (z) antérieurs 2, 3, 4
43. des descendants Z africains ces objets (z) africains 2, 3
44. les trains Z électriques des signaux (z) électriques 2, 3, 4
45. par nos gènes Z humains que les clones (z) humains 4
46. des suffrages Z exprimés les discours (z) intelligents 2, 3, 4
47. des poèmes Z homériques les parcours (z) historiques 2, 3, 4
48. ces convictions Z esthétiques des conditions (z) effroyables 2, 3, 4
Appendix H: Examples of Individual Portraits in Experiment 3a

Example of Younger Individual Portrait derived from Photograph E

Example of Younger Individual Portrait derived from Photograph F

Example of Older Individual Portrait derived from Photograph C

Example of Older Individual Portrait derived from Photograph S
Appendix I: Filler Stimuli for Experiment 4, Lists 1 and 2

Filler Stimuli for Experiment 4, List 1

<table>
<thead>
<tr>
<th>Phrase Type</th>
<th>Boundary</th>
<th>Phrase</th>
<th>Lexical Status</th>
<th>Visual Stimuli</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>L</td>
<td>livres politiquement T interdits</td>
<td>W</td>
<td>agnostique</td>
</tr>
<tr>
<td>2. Control</td>
<td>L</td>
<td>des noyaux Z exotiques</td>
<td>W</td>
<td>assassins</td>
</tr>
<tr>
<td>3. Control</td>
<td>L</td>
<td>l'homme avait T inventé</td>
<td>W</td>
<td>échappe</td>
</tr>
<tr>
<td>4. Control</td>
<td>L</td>
<td>des affinites Z electives</td>
<td>W</td>
<td>emergents</td>
</tr>
<tr>
<td>5. Control</td>
<td>L</td>
<td>deux frères Z ennemis</td>
<td>W</td>
<td>exprimés</td>
</tr>
<tr>
<td>6. Control</td>
<td>L</td>
<td>feuillage moins Z inflammable</td>
<td>W</td>
<td>injuste</td>
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<tr>
<td>7. Control</td>
<td>L</td>
<td>il était T amoureux</td>
<td>W</td>
<td>opposé</td>
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<tr>
<td>8. Control</td>
<td>NL</td>
<td>bleu absolument (t) éclatant</td>
<td>W</td>
<td>accessibles</td>
</tr>
<tr>
<td>9. Control</td>
<td>NL</td>
<td>il aimerait (t) inviter</td>
<td>W</td>
<td>appeler</td>
</tr>
<tr>
<td>10. Control</td>
<td>NL</td>
<td>assez facilement (t) habillé</td>
<td>W</td>
<td>applique</td>
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<tr>
<td>11. Control</td>
<td>NL</td>
<td>trouver justement (t) enfermé</td>
<td>W</td>
<td>attire</td>
</tr>
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<td>12. Control</td>
<td>NL</td>
<td>les milieux (z) artistiques</td>
<td>W</td>
<td>économiques</td>
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<td>13. Control</td>
<td>NL</td>
<td>des religions (z) officielles</td>
<td>W</td>
<td>effroyables</td>
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<tr>
<td>14. Control</td>
<td>NL</td>
<td>des pressions (z) ethniques</td>
<td>W</td>
<td>entiers</td>
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<td>15. Control</td>
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<td>vous êtes également (t) occupé</td>
<td>W</td>
<td>exacte</td>
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<td>16. Control</td>
<td>NL</td>
<td>meme assez (z) écrasante</td>
<td>W</td>
<td>exhaustive</td>
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<td>17. Control</td>
<td>NL</td>
<td>des chanteurs (z) amateurs</td>
<td>W</td>
<td>historiques</td>
</tr>
<tr>
<td>18. Control</td>
<td>NL</td>
<td>elle soit (t) entendu</td>
<td>W</td>
<td>inquiète</td>
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<td>19. Control</td>
<td>NL</td>
<td>vous étiez (z) adolescent</td>
<td>W</td>
<td>orienté</td>
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<td>20. Control</td>
<td>NL</td>
<td>il fallait (t) empêcher</td>
<td>W</td>
<td>utiliser</td>
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<tr>
<td>21. Filler</td>
<td>C_C</td>
<td>améliorer leur condition</td>
<td>NW</td>
<td>améliantes</td>
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<td>22. Filler</td>
<td>C_C</td>
<td>une petite mise</td>
<td>NW</td>
<td>anecdamel</td>
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<tr>
<td>23. Filler</td>
<td>C_C</td>
<td>de travailleurs sociaux</td>
<td>NW</td>
<td>appropel</td>
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<td>24. Filler</td>
<td>C_C</td>
<td>la très grande bibliothèque</td>
<td>NW</td>
<td>bibliodromes</td>
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<tr>
<td>No.</td>
<td>Role</td>
<td>Value</td>
<td>Part of Speech</td>
<td>Definition</td>
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<td>-----</td>
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<td>------------</td>
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<tr>
<td>25.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>on ne retrouve rien NW connuguez</td>
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<tr>
<td>26.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>à plusieurs reprises NW conten tionnent</td>
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<tr>
<td>27.</td>
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<td>C_ C</td>
<td></td>
<td>son petit vocabulaire populaire NW contu ies</td>
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<td></td>
<td>cent livres différents NW différelles</td>
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<td>29.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>cette anecdote genial NW exitord</td>
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<tr>
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<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>quelques pages glorieuses NW glorie ches</td>
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<tr>
<td>31.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>et en meme temps NW habifusion</td>
</tr>
<tr>
<td>32.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>ma mère disait NW interniquains</td>
</tr>
<tr>
<td>33.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>des belles maisons NW maissants</td>
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<tr>
<td>34.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>un énorme respect NW maressairement</td>
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<tr>
<td>35.</td>
<td>Filler</td>
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<td></td>
<td>au dix-neuvieme siècle NW metha nation</td>
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<tr>
<td>36.</td>
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<td></td>
<td>une couleur crue NW nota hension</td>
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<td>37.</td>
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<td></td>
<td>un cloître forestier NW nourreil ler</td>
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<tr>
<td>38.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>j'ai choisi cette période NW oscappées</td>
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<tr>
<td>39.</td>
<td>Filler</td>
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<td></td>
<td>une méprise considérable NW pinsi dérables</td>
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<tr>
<td>40.</td>
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<td>C_ C</td>
<td></td>
<td>un profil bas NW relament</td>
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<tr>
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<td>Filler</td>
<td>C_ C</td>
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<td>le régime moderne NW represseau</td>
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<tr>
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<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>on cherche simplement NW simplotot</td>
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<td>une forme vivant e NW sovante</td>
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<td>des rituels religieux W bouteille</td>
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<td>qu'on puisse dire W censurer</td>
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<td>46.</td>
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<td>C_ C</td>
<td></td>
<td>la seule difficulté W certitude</td>
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<tr>
<td>47.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>ça peut faire mal W chômage</td>
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<td>48.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>une structure sociale W continuer</td>
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<tr>
<td>49.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>sans support visuel W danses</td>
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<tr>
<td>50.</td>
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<td>C_ C</td>
<td></td>
<td>toute l'aide sociale W declaration</td>
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<td></td>
<td>de la bonne conduite W décourag é</td>
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<td>52.</td>
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<td></td>
<td>aux êtres vivants W engagé</td>
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<td></td>
<td>un usage systématique W enthousiasme</td>
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<td>54.</td>
<td>Filler</td>
<td>C_ C</td>
<td></td>
<td>une lente remontée W favorable</td>
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</table>
55. Filler C_C de la nouvelle machine W groupe
56. Filler C_C les super canapés W jours
57. Filler C_C la matière brute W notamment
58. Filler C_C des paysages nocturnes W partenaires
59. Filler C_C dans la fausse pauvreté W pouvoir
60. Filler C_C des surfaces gigantesques W revanche
61. Filler C_C du sol gaulois W santé
62. Filler C_C qui tranche cruellement W semaine
63. Filler C_C à tel endroit W susceptibles
64. Filler C_C ses propres mains W télévision
65. Filler C_C sans savoir dessiner W touristiques
66. Filler L qui nous Z échappent NW antippent
67. Filler L nous changeons sans Z arrêt NW arrriérié
68. Filler L les premiers Z essais NW automantres
69. Filler L facilement leurs Z émotions NW babiphère
70. Filler L avec d'autres Z espèces NW contrafins
71. Filler L colle trois Z étiquettes NW étiquationnée
72. Filler L pris de chez Z elle NW intuiments
73. Filler L une ou deux Z armoires NW islitiers
74. Filler L moyenne et longues Z ondes NW somnitude
75. Filler L les mêmes Z intérêts NW spectuellement
76. Filler L fondé il y a dix Z ans NW suggomètres
77. Filler NL mes deux parents (z) étaient NW acélte
78. Filler NL qui paraissent (t) élémentaires NW antimentaires
79. Filler NL des situations (z) extrêmes NW cérétique
80. Filler NL dans les périodes (z) interglaciaires NW chantoglaciers
81. Filler NL avec les yeux (z) ouverts NW diffubule
82. Filler NL des individus (z) adultes NW discriminent
83. Filler NL des grandes familles (z) aristocrates NW éminocrates
84. Filler NL dans les textes (z) anciens NW ensuissen
85. Filler NL des drames (z) épouvantables NW epouvansontes
86. Filler NL ces appareils (z) extraordinaire NW extraorsyndat
87. Filler NL des corrélations (z) entre NW finalessent
88. Filler NL de nos théories (z) actuelles NW gendilo
89. Filler NL des parcs (z) homogènes NW homonome
90. Filler NL trois fois (z) autours NW idenrime
91. Filler NL ces problèmes rencontrés (z) aujourd'huiNW indisquant
92. Filler NL qui aiment (t) inventer NW inventrans
93. Filler NL qui devenait (t) insurmontable NW materiations
94. Filler NL les relations (z) interpersonnelles NW modifil
95. Filler NL les successeurs (z) auront NW obborter
96. Filler NL aux origines (z) obscures NW obscudre
97. Filler NL les voyages (z) organisés NW organignes
98. Filler NL les lettres (z) ornées NW parethodes
99. Filler NL il sait (t) effectivement NW parfale
100. Filler NL un de ces collègues (z) écrivains NW pertirait
101. Filler NL nos amis (z) anglais NW prosonelle
102. Filler NL elle savait (t) exactement NW quelquitions
103. Filler NL des vins (z) historiques NW rashquette
104. Filler NL leurs vérités (z) intérieures NW regiande
105. Filler NL des comparaisons (z) intentionnelles NW silases
106. Filler NL des objets (z) usuels NW suggime
107. Filler V_C le vrai luxe NW autousibles
108. Filler V_C qui est maintenant considéré NW cartations
109. Filler V_C un peu dispersé NW controlent
110. Filler V_C à aucun moment NW décourassé
111. Filler V_C surtout du quartier latin NW entouné
112. Filler V_C on est obligé finalement NW finalesont
113. Filler V_C c'est le côté superbe NW justisement
114. Filler V_C c'est un lieu social NW mancernant
Filler V_C de se montrer misérable NW miserelles
Filler V_C très souvent repris NW modimiere
Filler V_C la philosophie grecque NW reglauche
Filler V_C j'ai plutôt travaillé NW visuarpes
Filler V_C le budget contrôlé W désormais
Filler V_C on cuit bien W douze
Filler V_C et puis parfois W évidemment
Filler V_C qui est censé rendre W fonction
Filler V_C ce qui est nouveau maintenant W hypothèse
Filler V_C un développement personnel W loisirs
Filler V_C son beau père W responsables
Filler V_C la passion coupable W restent
Filler V_C une description réelle W sortie
Filler V_C (pot L) qui me font rire NW accreuster
Filler V_C (pot L) tous les événements politiques NW bolitiques
Filler V_C (pot L) nous pouvons percevoir NW borcevoir
Filler V_C (pot L) des amitiés belges NW ersoyable
Filler V_C (pot L) une histoire que me plait bien NW expredennent
Filler V_C (pot L) un joyeux combat NW filtranches
Filler V_C (pot L) que l'on pouvait faire NW grussieuse
Filler V_C (pot L) prise par mon père NW impouffées
Filler V_C (pot L) j'ai toujours eu peur NW infogements
Filler V_C (pot L) ce petit tableau NW inverféré
Filler V_C (pot L) des beaux fantassmes NW materchaux
Filler V_C (pot L) les trois déesses NW moyasse
Filler V_C (pot L) deux raisons principales NW oriencheux
Filler V_C (pot L) les ateliers suivent NW pendome
Filler V_C (pot L) il s'en mettait soigneusement NW poigneusement
Filler V_C (pot L) il y a d'autres problèmes NW problustes
Filler V_C (pot L) que vous pouvez dire NW rechette
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145. Filler V_C (pot L) c'est parfois très surprenant NW surprêtons
146. Filler V_C (pot L) des quartiers disensibles NW tempoule
147. Filler V_C (pot L) vous pouvez toujours NW toujards
148. Filler V_C (pot L) en fait il est tout tendu NW utileux
149. Filler V_C (pot L) les plus profonds W climat
150. Filler V_C (pot L) quatre-vingt dix pour cent W confiance
151. Filler V_C (pot L) nous nous refusons rien W convaincu
152. Filler V_C (pot L) les lapins sauvages W éducation
153. Filler V_C (pot L) je me souviens surtout W manifestants
154. Filler V_C (pot L) voir quelques concerts W personne
155. Filler V_C (pot L) tout le monde parlait français W prudent
156. Filler V_C (pot L) ca faisait référence W réforme
157. Filler V_C (pot L) du comportement bourgeois W symbole
158. Filler V_C (pot L) je la suivais partout W vendeur
157. Filler V_C (pot L) du comportement bourgeois W symbole
158. Filler V_C (pot L) je la suivait partout W vendeur
## Filler Stimuli for Experiment 4, List 2

<table>
<thead>
<tr>
<th>Phrase</th>
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<th>Phrase</th>
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<th>Visual Stimuli</th>
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<td>1.</td>
<td>Control</td>
<td>L</td>
<td>la palme d’or fut T attribuée</td>
<td>W</td>
<td>amasse</td>
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<td>2.</td>
<td>Control</td>
<td>L</td>
<td>mon père eut T atteint</td>
<td>W</td>
<td>écrire</td>
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<tr>
<td>3.</td>
<td>Control</td>
<td>L</td>
<td>qu’ils trouvent T enfin</td>
<td>W</td>
<td>emmener</td>
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<tr>
<td>4.</td>
<td>Control</td>
<td>L</td>
<td>des sociétés Z animales</td>
<td>W</td>
<td>esthétiques</td>
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<td>5.</td>
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<td>beaucoup moins Z imposé</td>
<td>W</td>
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<td>qui sont terriblement T impressionants</td>
<td>W</td>
<td>irrationel</td>
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<td>Control</td>
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<td>sur pattes Z arrières</td>
<td>W</td>
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<td>9.</td>
<td>Control</td>
<td>NL</td>
<td>pas uniquement (t) écouté</td>
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<td>adapte</td>
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<td>NL</td>
<td>les marins (z) anglais</td>
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<td>Control</td>
<td>NL</td>
<td>nous allons (z) entendre</td>
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<td>éloigné</td>
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<td>Control</td>
<td>NL</td>
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<td>NL</td>
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<td>NL</td>
<td>a également (t) introduit</td>
<td>W</td>
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<td>17.</td>
<td>Control</td>
<td>NL</td>
<td>des méthodes (z) explicatives</td>
<td>W</td>
<td>intelligents</td>
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<td>18.</td>
<td>Filler</td>
<td>C_C</td>
<td>cette référence paternelle</td>
<td>NW</td>
<td>babiphère</td>
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<td>C_C</td>
<td>ce petit film de treize minutes</td>
<td>NW</td>
<td>beaujain</td>
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<td>C_C</td>
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<td>C_C</td>
<td>des termes conceptuels</td>
<td>NW</td>
<td>contrellent</td>
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<td>Filler</td>
<td>C_C</td>
<td>le système populaire</td>
<td>NW</td>
<td>ensuissier</td>
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<tr>
<td>23.</td>
<td>Filler</td>
<td>C_C</td>
<td>les anciennes cours royales</td>
<td>NW</td>
<td>habifusion</td>
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<td>24.</td>
<td>Filler</td>
<td>C_C</td>
<td>il y a cette jeune fille</td>
<td>NW</td>
<td>intonable</td>
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<tr>
<td>25.</td>
<td>Filler</td>
<td>C_C</td>
<td>doit comprendre nécessairement</td>
<td>NW</td>
<td>maressairement</td>
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</table>
de se tenir debout

du tennis contrairement

ce regard scrutateur

la première génération

la malheureuse femme

continuer à me faire plaisir

il y a des craintes sérieuses

une lourde responsabilité

qui est sans cesse sollicitée

d'être plus savant

deux auteurs dramatiques

qui s'énervent facilement

avec la fameuse boîte

un paysage de primitifs flamand

leurs apparences physiques

sur plusieurs plans

les découvertes scientifiques

une part manquante

ma plage normande

cet espace précieux

une sorte d'épais silence

mais en même temps

les côtes françaises

des interventions sous Z anesthésie

les cinquantes dernières Z années

les différentes Z approches

de certaines Z informations

de ses propres Z intentions

devant leurs Z opinions

de nombreux Z étages
56. Filler L ces gens là sans Z arrêt NW entoune
57. Filler L ont fait de meilleures Z études NW exponge
58. Filler L la bataille des prochaines Z élections NW filtranches
59. Filler L les fameux Z arbres NW impouffées
60. Filler L pas un gros Z effet NW interniquains
61. Filler L de bonnes Z essences NW intuiments
62. Filler L des autres Z éditeurs NW isliteurs
63. Filler L tout les grands Z hommes NW materiations
64. Filler L de très bons Z élèves NW quelquitions
65. Filler L les nouveaux Z entrants NW reglauche
66. Filler L il ne viendrait pas quelques Z heures NW sémornes
67. Filler L un foyer de personnes Z âgées NW silases
68. Filler NL votre père doublement (t) absent NW accélè
69. Filler NL je n'ai strictement (t) aucune NW acurde
70. Filler NL beaucoup de moments (z) avec NW arrilière
71. Filler NL tout les tissus (z) animaux NW bloquattre
72. Filler NL quand vous dites (z) accident NW chatisfaire
73. Filler NL qui donneront (t) accès NW conterionnent
74. Filler NL en voyant (t) évoluer NW décourrissons
75. Filler NL ca me parrait (t) évident NW discraminent
76. Filler NL de toutes actions (z) intentionelles NW droissimuli
77. Filler NL des collaborations (z) internationales NW élémoste
78. Filler NL des moments silencieux (z) énormément NW énormagine
79. Filler NL ça lui semblait (t) incroyable NW ersoyable
80. Filler NL elles ne se trompent (t) absolument NW exitord
81. Filler NL que des films (z) intelligents NW expredennent
82. Filler NL ca les rendait (t) intouchables NW finallessent
83. Filler NL des candidats (z) admis NW fragtaires
84. Filler NL je la trouvais (t) idéale NW gendilo
85. Filler NL et puis mais (z) aussi NW grussieuse
faire des projets (z) ensemble

dans les jardins (z) arabes

d'immigres (z) italiens

j'ai toujours (z) aimé

et profondément (t) envie

nos camarades (z) allemands

les personnages (z) écrivains

je voulais (z) apporter

des livres (z) impossibles

je suis effectivement (t) allé

les enfants (z) adorent

les inégalités (z) entre

nos repères (z) habituels

dans les quartiers (z) ouvriers

des autorités (z) américaines

les gens riches (z) ayant

il faut naturellement (t) aider

à quoi bon tout ça

c'était modérément plaisant

contradiction totale

une allusion rapidement

d'une façon merveilleuse

de l'eau minérale

de l'éducation nationale

le premier a été proposé

c'est un vrai mystère

qui avait si bien connu

le fonctionnement interne

un billet vendu

il parle de lui surtout
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116. Filler V_C la vrai vie commence W reforme
117. Filler V_C j'ai fini par W restent
118. Filler V_C vous pouvez trouver W semaine
119. Filler V_C (pot L) d'avoir fondamentalement changé NW ainseau
120. Filler V_C (pot L) les établissements scolaires NW décourasse
121. Filler V_C (pot L) il a notamment sagit NW indisquant
122. Filler V_C (pot L) avec les populations locales NW justisement
123. Filler V_C (pot L) les opérations concernant NW mancernant
124. Filler V_C (pot L) c'est prodigieusement beau NW modifil
125. Filler V_C (pot L) qui m'offrait déjà NW oscappées
126. Filler V_C (pot L) qui devient rare NW paréthodes
127. Filler V_C (pot L) les crétins ruraux NW prosonelle
128. Filler V_C (pot L) entre guillemets normal NW rashquette
129. Filler V_C (pot L) avec dix mètres NW régiande
130. Filler V_C (pot L) et il c'était spécialisé NW spécioforme
131. Filler V_C (pot L) nos problèmes philosophiques W confiance
132. Filler V_C (pot L) auquel doit satisfaire W continuer
133. Filler V_C (pot L) vous voulez poser W désormais
134. Filler V_C (pot L) la on va réellement diversifier W éducation
135. Filler V_C (pot L) toujours tres discrète W évidemment
136. Filler V_C (pot L) des quatres tournois W groupe
137. Filler V_C (pot L) on voit passer W hypothèse
138. Filler V_C (pot L) une création assez récente W pouvoir
139. Filler V_C (pot L) mes capacités mentales W revanche
140. Filler V_C (pot L) qui ont considérablement bénéficié W santé
141. Filler V_C (pot L) les assemblées générales W touristiques
142. Filler V_C (pot L) des précédents sommets W vendeur
Appendix J: Experiment 4a Speaker Descriptions, Lists 1a, 1b, 2a, 2b

Experiment 4a Speaker Descriptions, Lists 1a and 1b

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Photo</th>
<th>Description</th>
<th>Speaker</th>
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<td>F.8</td>
<td>Émilie, 32 ans</td>
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<td>Bruno, 27 ans</td>
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<td>C.2</td>
<td>Josyane, 50 ans</td>
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Note that numbers associated to Speakers in Appendices J, K, and L correspond to the Speaker numbers assigned in Appendix F.
## Experiment 4a Speaker Descriptions, Lists 2a and 2b

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<td>E.15</td>
<td>Wilfried, 32 ans</td>
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<td>C.5</td>
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<td>Agathe, 30 ans</td>
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<td>F.9</td>
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<td>F.14</td>
<td>Joel, 26 ans</td>
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<td>Anne, 53 ans</td>
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Appendix K: Experiment 4b Speaker Descriptions, Lists 1a, 1b, 2a, 2b

Experiment 4b Speaker Descriptions, Lists 1a and 1b

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Appendix L: Experiment 4c Speaker Descriptions, Lists 1a, 1b, 2a, 2b

Experiment 4c Speaker Descriptions, Lists 1a and 1b

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<td>François, 46 ans, Juriste</td>
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3. François, 47 ans, Juriste
1. Alexis, 32 ans, Vendeur en électroménager
2. Matthieu, 48 ans, Journaliste
3. Damien, 32 ans, Balayeur dans le XXe
4. Gyslaine, 45 ans, Membre de l’Ordre des Médecins
5. Amélie, 28 ans, Agent administratif
6. Jean, 49 ans, Écrivain
7. Bernard, 29 ans, Gardien d’immeuble
8. Claudine, 52 ans, Novéliste
9. Gisèle, 36 ans, Réceptioniste dans une auberge de jeunesse
10. Véronique, 46 ans, Poète
11. Émilie, 26 ans, Caissière dans un supermarché
12. Georges, 55 ans, Éditeur
13. Philippe, 35 ans, Serveur dans un restaurant
14. Caroline, 52 ans, Membre de l’Académie Française
15. Suzanne, 32 ans, Vendeuse dans une boulangerie
## Experiment 4c Speaker Descriptions, Lists 2a and 2b

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48 2a H.1 Jean, 48 ans, Écrivain
2b E.12 Bernard, 28 ans, Gardien d'immeuble
4 2a H.2 Caroline, 43 ans, Membre de l'Académie Française
2b E.10 Anne, 28 ans, Surveillante de collège en ZEP
42 2a H.4 Georges, 54 ans, Éditeur
2b E.4 Damien, 30 ans, Balayeur dans le XXe
12 2a H.10 Véronique, 47 ans, Poète
2b I.1 Suzanne, 27 ans, Vendeuse dans une boulangerie
34 2a H.8 Claudine, 45 ans, Novéliste
2b I.12 Émilie, 25 ans, Caissière dans un supermarché
Appendix M: Post Experiment Questionnaire (Experiment 4)

1) During the experiment, did you develop a strategy to facilitate the task?
   a. Describe your strategy
   b. At what point in the experiment did you begin to use this strategy?

2) Did you notice anything unusual or unexpected about the pronunciations? If yes, what did you notice?

3) What do you think the objective of this study is?
Bibliography


