THE PROCESSING AND MENTAL REPRESENTATION OF ING VARIATION

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Dedicated to Prof. Rosemary Orr.

"I think you'll find, sausage, that the answer in Linguistics is usually 'Well, it depends..' "

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ABSTRACT

THE PROCESSING AND MENTAL REPRESENTATION OF ING VARIATION

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This dissertation examines the processing and mental representation of the sociolinguistic variable ING (*thinking*∼*thinkin'*). Sociolinguists have asked questions about the locus of the ING variable using naturalistic speech data, which has resulted in a debate on whether the variable is phonological or morphological. These accounts of ING are not well-defined, and it is hard to isolate these representational properties in conversational data.

I propose that locus of variation questions can be thought of as questions about the mental representation of variation, and that it would be fruitful to explore them using a highly-controllable tool from psycholinguistic research: primed lexical decision experiments. This tool is used to show that semantic, phonological, and morphological aspects of representation facilitate processing in different ways. I integrate sociolinguistic knowledge of variable ING with psycholinguistic knowledge on researching mental representations to ask: how are the socially meaningful variants -ing and -in' mentally represented, and which aspects of shared representation contribute to how they are processed?

Based on a framework of relevant aspects of representation, I establish a baseline understanding of the mental representation of -ing and -in' across six experiments. Chapter 4 shows that -ing and -in' prime both themselves and each other in words with unrelated stems (e.g. *jumping-thinking*), and uncovers an asymmetrical priming pattern between -ing and -in' targets; -in'-in' prime-target pairs enjoy a processing boost over -ing-ing, -in'-ing, and -ing-in' pairs. Chapter 5 finds that this "-in' boost" is temporally weak. Chapter 6 establishes that surface phonology does not contribute to the -in' boost. Chapter 7 shows that the -in' boost is insensitive to shared representation between prime-target stems.

The results show robust and replicable affix priming for -ing and -in'. They also show a processing difference between the variants, and demonstrate properties of the -in' boost.

Taken together, the -in' boost can be interpreted under a representation-based account, which suggests that -ing is the underlying phonological form, and that this can change to -in' via application of a phonological rule. Finally, I propose future avenues of research that test this account and elaborate our understanding of the mental representation of variable ING.

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Chapter 1

Introduction

Through studies in variationist sociolinguistics we know that speakers can and do vary their speech in different ways, and that such intraspeaker variation can be conditioned by both linguistic and social contexts. Decades of quantitative work on variation in conversational speech make it clear that linguistic variation is systematic. Speakers do not vary their speech at random, variation is systematically conditioned. Variability can be conditioned by language internal factors, such as surrounding phonological context, or by language external factors like a speaker's sex or gender, socioeconomic status, or geographic background (Labov, 2001b). Furthermore, features of the communicative situation, such as formality, interlocutor, or stance can make a speaker alter their speech (Labov, 2001a).

From a cognitive perspective, variation poses a set of challenges. In particular, how is variation represented in the mental lexicon, and at which level of the grammar it is processed (Embick, 2008)? In recent years, researchers studying the perception and production of sociolinguistic variation have turned to cognitive science to ask questions about how the processing of variation works in real-time, what cognitive representations underlie this variation, and how the processing of social and linguistic information works in tandem to influence the perception and production of speech. The quantitative research approach of variationist sociolinguists and the recent movement in the cognitive sciences from studying the individual as an isolated being to considering the impact of social factors on cognition more generally make convergence between these fields a natural fit (Chevrot et al., 2018). Campbell-Kibler (2010) introduces the term *sociolinguistic cognition* to refer to the area of study concerning itself with these questions.

1.1 Rationale

The current dissertation focuses on the processing and mental representation of the sociolinguistic variable ING (*thinking*∼*thinkin'*). The question of how to integrate variation into the grammar, or what the *locus of variation* is, is not an unfamiliar question in the sociolinguistic literature: the nature of the sociolinguistic variable and relationships between variants have been explored using naturalistic speech data (Lignos et al., 2016). ING is perhaps the most well-studied sociolinguistic variable in this literature (i.a. Houston, 1985; Campbell-Kibler, 2006; Hazen, 2008; Tamminga, 2014), and although this has given us a comprehensive understanding of how -ing and -in' are sociostylistically conditioned, these methods have made it hard to resolve complex questions on the mental representation of the ING variable. More specifically, the use of -ing and -in' has been found to differ systematically between verbal words (like *thinking*) and nominal words (like *awning*). This has led to a debate that asks what the locus of this variation is, or put differently, whether variable ING is morphological, phonological, or perhaps both (Tamminga, 2016). How these different accounts of variable ING are realised is not always well-defined and it is difficult to isolate these types of representational properties of a variable in hard to control naturalistic speech data.

As I see it, these questions about the locus of variation can be considered to be questions about how the variants -ing and -in' are mentally represented. In this dissertation I therefore adopt a methodology from the psycholinguistic literature to explore these questions in a novel way. Primed lexical decision experiments are a commonly used psycholinguistic tool for asking questions about how words are represented, and more specifically, whether different aspects of shared representation between words can lead to processing facilitation. Further still, researchers have been able to use this tool to show how semantic, phonological, and morphological aspects of representation facilitate processing, and what some of the properties of this **priming** are. For example, a word like *purse* that shares surface phonology with a word like *nurse* will facilitate the processing of *nurse* if they are presented sequentially. However, this priming effect is relatively short-lived, and does not persist across an intervening word (e.g. if presented in the sequence *purse - table - nurse*) (Creemers et al., 2020). By contrast, a complex word like *baker* will facilitate its stem *bake*, even if there is one or multiple intervening words (e.g. in the sequence *baker - table - bake*) (Wilder et al., 2019).

In this dissertation I combine insights from the sociolinguistic discussions of the locus of variation and of the properties of variable ING with a method from psycholinguistics that can be used to tease apart aspects of shared representation to ask a novel question: how are the socially meaningful variants -ing and -in' mentally represented, and which aspects of shared representation contribute to how they are processed?

In order to approach this question I first establish the relevant ways in which -ing and -in' are or could be related to each other. For example, *jumping* and *thinkin'* do not share a stem, nor do they share surface phonology of their ING variants, or social meaning of the variants, but they are both interpreted as progressive/gerundive. By contrast, *awning* and *thinking* do not share a progressive/gerundive interpretation, but do share surface phonology of the ING variable (i.e. the -ing variant), and the social meaning that is associated with the -ing variant. It is too large of an undertaking to systematically compare most of the relevant relationships between words ending with [ɪŋ] and [ɪn] in a single dissertation. I therefore determine the critical comparisons that will provide a baseline understanding of the mental representation of ING, from which other fine-grained aspects of shared representation can be systematically tested. In this dissertation I ask the following three research questions:

1. Can I reliably detect affix priming for both pronunciation variants of variable ING?
2. Can I detect which aspects of shared representation contribute to processing facilitation of the ING variants?
3. Can I detect differences in processing between -ing and -in'?

A detailed breakdown of the chapters of this dissertation is provided below.

1.2 Dissertation outline

Chapter 2 of this dissertation provides an overview of the sociolinguistic enquiry of variable ING and the locus of variation debate. It also discusses the way that primed lexical decision experiments have been used to study the processing and mental representation of, in particular, complex words. In Chapter 3 I explain how I propose to integrate questions about the mental representation of variable ING with the psycholinguistic method of experimental priming. I lay out the relevant ways in which words ending with -ing or -in' could be related, and pair this large set of relationships down to a critical subset that I propose to test in this dissertation. Chapter 4 details an affix priming experiment that establishes that -ing and -in' prime themselves and each other with unrelated stems (i.e. *jumping* and *jumpin'* both prime both *thinking* and *thinkin'*). This chapter also shows that there is a processing asymmetry between the -ing target conditions and the -in' target conditions: an -ing target is facilitated equally by -ing and -in' primes, but an -in' target is facilitated better by a same-variant (i.e. -in') prime than by a cross-variant (i.e. -ing) prime. I call this asymmetrical pattern the **ing/in' asymmetry**, and call the specific boost for the -in'-in' condition over the other conditions the **-in' boost**. The properties of the -in' boost are then probed further in the remainder of the dissertation. Chapter 5 explores the temporal properties of the -in' boost by introducing an intervening item between the primes and targets (e.g. *jumpin'* - *truck* - *thinkin'* and finds that the -in' boost does not persist across an intervening item. It also probes whether the ing/in' asymmetry is affected by using a different proportion of -ing to -in' words in the experiment, and finds that it is not. Chapter 6 explores the possibility that shared surface phonology between *jumpin'* and *thinkin'* is responsible for the -in' boost by asking whether *dolphin* primes *thinkin'* (since they share the [ɪn] but no other representational aspects), and finds that this shared surface phonology does not contribute to the priming effects seen in Chapters 4 and 5 of the dissertation. Chapter 7 tests whether shared representation between the prime and target stems interacts with the ing/in' asymmetry and modulates the -in' boost. By using repeated stems (e.g. *thinking-thinking*) and rhyming stems (*drinking-thinking*), this chapter shows that the -in' boost is unaffected by stem-type. Finally, Chapter 8 gives a general discussion of the abovementioned research questions, provides implications of the research in this dissertation for our understanding of the mental representation of variable ING, and details fruitful avenues for future research on this topic.

1.3 Experimental work in the dissertation

The methodologies used in the experiments in this dissertation were developed in the Language Variation & Cognition Lab (PI: Meredith Tamminga) and in the Embick Lab (PI: David Embick). Before each experiment, the participant provided written informed consent, and each participant was debriefed on completion of the experiment. The University of Pennsylvania's Institutional Review Board (IRB) approved these experimental protocols under the protocol identification number #820633.

Chapter 2

Background

2.1 Naturalistic data and the locus of variation

Intraspeaker variation is a well-documented part of the variationist literature (Labov, 1994; Guy, 1980; Labov, 1966). The systematicity of this type of variation raises a number of questions. For example, how does variation fit into models of the grammar? What are similarities and differences between variables that operate at different levels of the grammar? For variables that are situated at an interface such as the morphology/phonology interface, how are these mentally represented?

Quantitative analysis of naturalistic data has been used to look at these questions. For example, Kroch (1989) asked whether the use of a new syntactic variant that is entering the grammar, but is favoured more or less in different contexts, is one single variable that is context sensitive, or multiple variables linked to context. As a diagnostic, he asked whether the frequency of use of the variable increases at the same rate in the different contexts over time. He finds that this is indeed the case (and calls it the *Constant Rate Effect*). It is later supported by work from Pintzuk (1991) and Santorini (1992). This finding suggests that there is a single incoming rule that is unspecified for context, as opposed to multiple rules that are context-specific. Fruehwald et al. (2009) find the same for a phonological variable, concluding that this Constant Rate Effect holds across different levels of the grammar. A related strand of research looks into how variation fits in with the notion of strict modularity, which suggests that each module of the grammar receives input from a higher module, and outputs into a lower module (Bermúdez-Otero, 2010). For example, if the phonology outputs a string of segments such as [mɪst], then the phonetics must just implement the string, and cannot tell whether there was a morphological boundary (as in *missed*) or not (as in *mist*). This modularity has proven crucial in considering questions about the identity of different sociolinguistic variables. A variable such as coronal stop deletion (CSD), whereby a coronal stop such as the /t/ in [mɪst] can be lenited, has been claimed to be phonetic. However, its morphological conditioning (or more deletion in monomorphemes such as *mist* compared to past tense forms like *missed*) means that CSD cannot be purely phonetic, since the phonetics should not be able to 'see' morphological structure. This suggests that CSD must involve a phonological component (Purse, 2021).

This kind of work questions what the units at play are in variation, whether there is a single unitary variable, or whether there are several variables at different levels of the grammar. The sound change literature considers how a rule can be both lexical and morphological simultaneously, a concept encompassed under the term **rule scattering**, or "a process in which one component of the grammar gives rise to a new rule at a higher level [...] without ceasing to apply at a lower level" (Bermudez-Otero, 2015) . Tamminga (2018) finds that the following segment is important for CSD: a speaker is more likely to delete a coronal stop if it is followed by a consonant, than if it is followed by a vowel. However, this effect gets weaker the stronger the syntactic boundary between the words is (e.g. CSD is less likely on [mɪst] in *"The mist is shrouding everything."*, than it is in *"Look at the mist. It's shrouding everything."* due to the strength of the utterance boundary). This notion is formalised in the Production Planning Hypothesis (Tanner et al., 2017) or the locality of production planning (Kilbourn-Ceron et al., 2016), that suggest that contextual following segment effects can only affect variant choice if the following segment is already available, which means production planning has prepared the upcoming word. A strong syntactic boundary corresponds with a lower likelihood of the upcoming segment being planned and therefore able to influence variant choice. A similar argument has been made for the [ɪŋ] ∼ [ɪn] alternation: *ing* is more likely to be pronounced as [ɪn] when a coronal segment follows, but only if the identity of the following segment is known at the time of encoding (Wagner, 2011). These findings from naturalistic speech data show that pinning down the underlying representation of a variable is a complex enterprise.

Thinking about these locus of variation questions explicitly in terms of the psycholinguistic processes involved in producing intraspeaker variation is relatively recent. In her 2012 dissertation MacKenzie explores the grammatical operations that are involved in the production of variation above the level of phonology, and suggests that a partially probabilistic grammar, but also language use system that incorporates psycholinguistic and sociostylistic constraints are involved (MacKenzie, 2012). This idea is extended by Tamminga, Mackenzie, and Embick (2016) who posit three types of conditioning for the dynamics of intraspeaker variation: sociostylistic conditioning, internal linguistic conditioning, and psychophysiological conditioning (Tamminga et al., 2016). The former two of these roughly correlate with the extralinguistic (e.g. age, gender, class, etc.) and language internal factors that have traditionally been the focus of variationist research, often at the community level (Labov, 1989). Psychophysiological conditioning (or *p-conditioning*) corresponds to factors stemming from cognitive or physiological systems. As examples, Tamminga et al. (2016) give working memory capacity, and resting state activation levels of words.

Effects of p-conditioning have been exploited to look at a broader question of the locus of variation. Sociolinguists have contributed evidence to this discussion from different sources, such as findings of persistence (or priming) across variable instances in naturalistic speech (i.a. Szmrecsanyi, 2006; Abramowicz, 2007; Cameron and Flores-Ferrán, 2004). This manifests as an increased likelihood that a speaker will use a specific variant if they used it very recently. One often-discussed reason why persistence may occur is that residual activation from a recent instance of a specific variant can bias a speaker to use that variant again in a subsequent instance. Persistence has been used to contribute to the debate about the phonological or morphological nature of sociolinguistic variables. Tamminga (2016) finds that for both the variable ING and for CSD, persistence only arises when the prime and target both belong to the same grammatical category. For CSD, persistence is limited to cases of lexical repetition for monomorphemes, whereas for polymorphemic words a generalised persistence effect is found. For ING, the same pattern is found (although the monomorphemic ING-final word class is too small to draw strong conclusions). This suggests that perhaps these variables are both morphological and phonological, whereby persistence is generalised in the former instance of the variable, and limited to lexical repetition for the latter. Persistence effects are not limited to the phonology/morphology interface. Estival (1985) finds similar effects of generalised persistence for transformational but not lexical passives in English, showing persistence in the domain of syntactic variation. Ecay and Tamminga (2017) provide similar evidence of persistence in syntactic variation through a corpus study of Middle English negation.

Any theoretical account will benefit from evidence from more than a single source. One drawback to using naturalistic speech data to consider the underlying representation of variables is that conversational speech is messy, largely uncontrolled, and there are many extra-linguistic factors that make it hard to tease apart what is caused by underlying representation and what is not. It has therefore been suggested that this field could benefit greatly from priming done in a controlled experimental setting (Tamminga, 2016). Psycholinguists use experimental priming paradigms to tap into mental representations and to inform models of spoken word recognition by disentangling semantic, morphological, and phonological aspects of shared representation. Not only is this a potentially helpful methodology to add to the sociolinguistic toolkit for exploring the mental representation of variation, the debate on the phonological or morphological identity of variables could benefit from certain psycholinguistic insights.

In this dissertation I will use priming experiments to elucidate the processing and mental representation of variable ING. In the remainder of this chapter I will first give a detailed background on variable ING, its conditioning, and its role in the sociolinguistic debate on the locus of variation (Section 2.2). Then I will go into how priming in particular is used in the psycholinguistic literature to study mental representations of in particular morphologically complex words (section 2.3). Finally, I lay out the basic parameters of primed lexical decision experiments (section 2.4).

2.2 Variable of interest: ING

Variable ING (*thinking* ∼ *thinkin'*) is one of the most well-researched sociolinguistic variables in English. It is a highly salient variable that is often the topic of meta-linguistic commentary, particularly regarding social evaluations of those who frequently use the non-canonical variant -in'. The use of the variants is also known to show robust style-shifting patterns and to be stratified by class. The social and stylistic salience of this variable set it apart from other variables frequently studied in the variation processing literature, like schwa-deletion or flapping. No doubt due in part to its salience, sociolinguists have been studying ING since the 1970s, describing its origins, use in different social and stylistic contexts, and the perception of it as a sociolinguistic variable (i.a. Labov et al., 1972; Houston, 1985; Campbell-Kibler, 2006; Labov et al., 2011; Forrest, 2015; Hazen, 2008; Kendall, 2010; Vaughn and Kendall, 2018; Wald and Shopen, 1981).

The goal of this dissertation is to build on the substantial body of sociolinguistic work on variable ING, by offering insights into how ING is represented mentally through the experimental probing of the possible relationships (phonological, morphological, semantic, and perhaps social/stylistic) between the variants and how these relationships influence how they are processed. Besides the mental representation angle of the work in this dissertation, it makes an important and welcome contribution to the sociolinguistic literature on the locus of variation of ING. Conversely, the fact that ING is sociostylistically conditioned sets it apart from other variables and must be taken into account when we consider how it is processed. For both of those reasons, this section gives an overview of the wealth of knowledge that variationist studies have given us about variable ING.

2.2.1 Linguistic features and conditioning

Variable ING is generally described as the alternation between the velar nasal [ɪŋ] (I will henceforth use -ing for this variant) and the alveolar nasal [ɪn] (for which I will use -in')[1]. The

[1]There is a third pronunciation that has been reported in Ottawa, in the United Kingdom, and more recently in the Western United States: [in] (Houston, 1985; Woods, 1979). Woods (1979) states that this

realisation of in particular the -in' variant can vary in speech, for example being produced with a schwa preceding the [n] or even just as a syllabic [n] in some cases Trudgill (1974). Interestingly, variable ING is one of the few variables in English whereby both variants have an accepted orthographic realisation: for ING, the -in' variant, written as -in with a following apostrophe, is recognisable in many written genres as a variant of ING.

There are very few phonological constraints on variable ING, the simplest of which is that ING is only variable in unstressed syllables (such that words like *king* and *sing* can never be pronounced with an -in'). Besides this, ING has been said to show progressive dissimilation whereby upcoming alveolars favour -ing and upcoming velar stops favour -in', and regressive assimilation in the opposite pattern (Campbell-Kibler, 2006; Houston, 1985; Cofer, 1972; Roberts and Labov, 1995). However, Tagliamonte (2004) argues that the linguistic conditioning of ING is not this straightforward. In a corpus analysis of variable ING in British English spoken in the northern city of York, she finds that nouns are conditioned by preceding and following segments, but verbs are not. The fact that ING is conditioned differently when it is found in a noun compared to a verb is a simplified example of the fact that variable ING is conditioned perhaps first and foremost by grammatical category.

The grammatical category conditioning is the most discussed and most prominent factor involved in ING variation (Vaughn and Kendall, 2018). Defining the grammatical categories that words ending in ING fall into is, however, not easy and can be contentious (Houston, 1985; Tamminga, 2014). Tamminga uses five categories for her persistence work: monomorphemes, root-attached items, quantifiers, gerunds, and progressives. Monomorphemes are nouns such as *morning, awning*, and *ceiling*, whereby the -ing is part of the root (Embick, 2015). Root-attached items are nouns or adjectives that consist of a root plus -ing as a nominal or adjectival suffix (e.g. *housing* and *lining*). Quantifiers are words such as *nothing* and *anything.* Gerunds are roots with a verbal head that receive a nominal suffix -ing. For example, in *"The neighbour's singing kept her awake."* the word *singing* consists of the root *sing* with a verbal head that has been nominalised using -ing. Finally, progressives are

pronunciation largely goes unnoticed and is perceived as [ɪŋ].

roots with the verbal progressive suffix -ing, such *singing* as in *"The neighbour is singing opera"*. In general, the pattern found in the literature is that -in' is more common in verbs and similar words, compared to more nominal words (Tamminga, 2014).

2.2.2 Social conditioning of ING

Besides the internal conditioning of ING, its status as one of the most well-studied sociolinguistic variables naturally stems from the finding that it is socially and stylistically conditioned. In this section I discuss the key language external factors that have been studied in the context of ING variation: region of origin, socioeconomic status, age, and style.

2.2.2.1 Macro-demographic conditioning

In the United States, high usage of the -in' variant is consistently meta-linguistically associated with Southern and African American English. Labov (2001b) and Cofer (1972) all suggest that -in' is used more frequently in Southern states than elsewhere. This commentary is supported by experimental evidence from matched guise tasks. Campbell-Kibler (2007) asked listeners to judge how accented they thought three speakers from North Carolina were by playing them clips of their speech. The clips that listeners heard only differed in whether they contained -in' or -ing variants. Listeners consistently rated the speakers as sounding more accented when -in' was used rather than -ing. In a later study that paired a similar experiment with interviews about the speech clips listeners heard, Campbell-Kibler (2009, 145) states that "interview participants almost universally described West Coast speakers as likely to use -ing in their everyday speech, and they described -in' as the more natural form for the Southerners."

There is, interestingly, not a lot of clear evidence that these regional accent expectations about high users of -in' are based in actual usage differences in overall ING variant rates in different regions. Hazen (2008) finds that speakers of Appalachian English (a dialect that shares linguistic features and social characteristics with Southern English), use -in' on average 67% of the time in progressive verbs (92% for working class speakers, vs. 49% for upper middle class speakers). Forrest (2015) similarly finds that speakers from Raleigh, North Carolina, have an average -in' rate of 56% for progressive verbs (70-85% for working class vs 25-40% for college-educated speakers). By contrast, white upper working to lower middle class speakers from Philadelphia use -in' on average 63% in progressive verbs (Tamminga, 2014), and -in' usage rates in New York City range from 80% for working class speakers to 10% for upper middle class speakers.

In the United Kingdom, high use of the -in' variant has traditionally been associated with the north of England, and with Scotland (Labov, 2001b; Houston, 1985; Levon and Fox, 2014). This difference arose because the conflation of the Middle English suffixes *-inde* and *-ynge*, as discussed in Section 2.2.1, happened much later in the north of England than in the south, meaning that the *-inde* suffix (which gave rise to the modern day -in') remained in use for much longer. This divide led to very little stratification by socioeconomic status in the north of England compared to the South (Tagliamonte, 2004; Houston, 1985; Levon and Fox, 2014; Trudgill, 1974). Besides this regional difference within the UK, a major contrast with America is that in Britain, there is less social evaluation on the basis of ING usage. Historically, -in' has been associated with prestige in both speech and written works (Tagliamonte, 2004; Bailey and Tillery, 1996), even though in the modern day, -ing is more associated with formal speech and a higher socioeconomic status. The notion that in Britain the social evaluation of ING is much less clear-cut than it is in the USA is supported by a recent study by Levon and Fox (2014) that uses the method from Labov et al. (2006, 2011) with speakers of London English. They find that listeners do not judge a newsreader to sound less professional if she uses more -in'.

It is clear from these data that besides region, socioeconomic status is a key factor in ING variation, with -in' being strongly associated with lower socioeconomic status (Labov, 1966; Campbell-Kibler, 2009; Forrest, 2015; Trudgill, 1974; Shuy et al., 1968). This is the case for many varieties of English. That being said, it is worth considering that socioeconomic status, or class, is often defined by a complex interaction of occupation, education, and income, and sometimes other factors such as neighbourhood or kind of housing (Trudgill, 1974). Although overall, we can see a broad correlation between socioeconomic status and ING usage, it is important to realise that the contributions of these factors may not be equivalent. For example, Labov (2001b) finds that in more formal speech, both education and occupation influence how much Philadelphians use ING, whereas in informal speech only occupation seems to be a contributing factor.

Youth is another factor that is thought to correlate with high -in' usage, and that does across dialects of English. Wagner (2012) finds that 18-year-old white Philadelphian women use -in' 84% of the time in casual speech, whereas Kendall (2008) finds that African American English adolescent girls use -in' 90% of the time in progressive verbs. Also, many studies report that men are more likely to use -in' than women, although the dynamics of gender identity and interaction of gender with other social factors does complicate this correlation (Labov, 1966, 2001b; Kiesling, 1998; Hazen, 2008; Wagner, 2013; Forrest, 2015; Wald and Shopen, 1985). It is important to realise here that there are large individual differences in ING usage that are obviously not seen when using averages across broad demographic categories. When looking at individual speakers' ING usage, researchers will find speakers who use -ing or -in' exclusively, and every ratio in between, and also find that individuals shift their ING usage based on stylistic and social contexts (Tamminga, 2014; Forrest, 2015).

2.2.2.2 Stylistic conditioning

Style is another well-studied factor that is known to influence ING usage, but in this case within individual speakers. This is often defined as the formality of the conversational context, and Labov (1966) operationalises this into four broad styles: casual speech, formal speech, reading aloud, and word lists. In general, researchers find that the more formal the context, the higher the -ing usage (Fischer, 1958; Trudgill, 1974; Cofer, 1972; Wald and Shopen, 1985). Although studies have used a range of different methods for eliciting more casual and more formal speech, including shifting topics in interviews, changing the interviewer from a friend to a stranger, and others, the majority find the stable pattern of more -ing in formal contexts. This finding also often correlates with socioeconomic status, and means that these factors are often shown together (Campbell-Kibler, 2006). For example, Trudgill (1974) shows that in Norwich in the United Kingdom, working-class speakers gradiently shift their ING usage from mostly -ing in formal contexts to almost exclusively -in' in casual speech, whereas middle class speakers exclusively use -ing in most contexts except casual speech in which they use 20-40% -in'.

Important for the current dissertation is the observation that an experiment being completed for the purpose of academic research is most likely a style that people will consider to be relatively formal, and in which they will not expect to hear high numbers of -in'. Furthermore, in the experiments in this dissertation words are presented in isolation, much like the word list style category, the most formal of Labov's (1966) styles. This will be discussed further in section 3.4.5, in Chapter 3.

2.2.3 The phonology versus morphology debate

The ING variable is perhaps one of the most well-documented sociolinguistic variables because of the central role that it plays in the discussion of the locus of variation for different variables. The discovery that ING variation differs between nominal and verbal words has led to a decades long unresolved discussion as to the locus of ING variation, or, put more simply, whether variable ING is a phonological or a morphological variable. This can be substantiated as the question of whether the variants of -ing and -in' have morphological structure in the mental lexicon: is their processing more akin to how roots and suffixes are processed, perhaps as morphological pieces, or are they processed more similarly to phonological alternants? What this comes down to is the question of what the relationship is between -ing and -in', from a mental representation perspective. I would therefore argue that at its heart, what sociolinguists call questions about the locus of variation can in essence be understood as questions about the mental representation of variables, in a psycholinguistic sense.

In much of the literature on variable identity questions, sociolinguists will make claims that a variable 'is phonological' or 'is morphological' without making it precise what those statements mean. To take ING as an example, Abramowicz (2007) claims "[ING] is subject to little or no phonological conditioning, which led Labov (2001b) to observe that the variable is more of a morphological alternation than a case of phonological reduction". Interestingly, Labov (2001b) in the same work being referenced by Abramowicz states both that "... it must be defined as a phonological alternation that affects all unstressed /ing/ syllables" and that "...*something* and *nothing* are excluded from the nominal sub-group because they exhibit much higher levels of apical realisation, and appear to form a different sociolinguistic variable". Fifty years of research on ING have yet to yield any consensus on this topic, and many studies therefore simply choose not to address it.

Abstracting away from ING, briefly, we can think of one of the most used views on the morphology/phonology debate as follows. Let's say we have a variable that involves some unpredictable phonological alternation that appears in both suffixes and in monomorphemes. One possibility is that this variable consists of an abstract underspecified morpheme that has two allomorphs, or two phonological ways of realising that abstract morpheme, and that different contexts make the choice of one allomorph over the other more or less likely. Another option is that the variable has one phonological realisation underlyingly, but that there is a probabilistic phonological rule that generates different allophones at different probabilities based on different contexts. The former of these places the locus of variation in the morphology, whereas the latter suggests that it is phonological. The difference between the analyses is both complex and subtle, and what they mean representationally for the variable remains an interesting question.

It is important to note here that in particular the morphological analysis here is remarkably undefined. Some describe this side of the debate as I did above, using allomorphy, but others describe -ing and -in' as being completely independent morphemes. Adding an extra layer of complexity, how morphological processing works, and even whether morphology exists at all, is still being debated (Embick et al., forthcoming). Approaches denying morphology argue that morphology emerges from the semantic and phonological representations of a word. I discuss this further in section 2.3.5, but for the purpose of the sociolinguistic debate at hand (on morphology versus phonology) it suffices to bear in mind that the morphological side of this discussion is ill-defined and that there are multiple ways in which a morphological variable could be realised. The most common description used in the literature aligns with an allomorphy theory of morphology, which is why I use this terminology in the remainder of this discussion.

Returning to the case of variable ING, historically, the variable arose from the conflation of two different Old English suffixes *-inde* and *inge* (Houston, 1985; Labov, 1989). Tagliamonte (2004) discovered a quote by Marsh in 1866, who says "The ancient termination in -end survived in popular speech long after it became extinct in literature, and the vulgar pronunciation goin', livin', and the like is a relic of that form, not a dropping of the nasal g final in the modern inflexion" (Marsh, 1866). Although this suggests that originally ING consisted of two independent suffixes, which suggests that -ing and -in' may have historically been separate morphological pieces, early sociolinguists posited a phonological account for ING variation since, at the time, they were attempting to unify analyses of sociolinguistic variables under a set of comparable variable rules.

Following the abovementioned view on the debate, a phonological account of ING variation would suggest that there is one underlying ING piece, that canonically is pronounced as -ing, and that -in' is derived from -ing phonologically by changing the nasal place of articulation whenever an -in' is called for. In early sociolinguistic work, the alternation was thought to be phonological, whereby a variable rule could be used as an explanation for how -ing final words could end up with a surface -in' (Houston, 1985; Labov, 1989). Under this analysis, the probability of getting -ing or -in' can change based on the grammatical category of the word, but each ING final word undergoes the same phonological process whereby -ing can be changed to -in'. It just happens at different rates for words in different grammatical categories.

A morphological account of ING suggests that -ing and -in' are in fact two morphological pieces (or **allomorphs)** that share the same syntax and semantic but that compete for usage. Although attractive from a historical perspective, the problem with this account is that it does not neatly explain how ING variation occurs in nouns like *morning*, because monomorphemes do not consist of a root and an ING morpheme. This means that there must be a separate account for verbs versus nouns.

This has in fact been suggested by Tagliamonte (2004), who finds in the York corpus that the variable differs substantially in nature for verbs versus nouns. She suggests that nouns have an underlying [ɪŋ] that can be changed but that for verbs a more morphological analysis is necessary. She also states that an independent phonological process reducing [ɪŋ] to [ɪn] could operate over the two grammatical categories. Tagliamonte is suggesting here that perhaps ING variation is neither phonological nor morphological but is a combination of multiple different processes. The persistence data for ING discussed in Section 2.1 show that speakers will choose to reuse a variant they used recently, but only within grammatical categories, and not across them (Tamminga, 2014). These data suggest that there must be a difference in processing between ING variables from different grammatical categories, since priming can only occur across words that share primeable processes. Furthermore, it is even possible that a speaker selects from the two allomorphs -ing and -in', but that the choice for -ing could be changed later in processing to -in' through a phonological change in nasal place of articulation. It is therefore important to realise that there may not be a straightforward unified solution to this debate. As Hazen suggests, "Thus, as a sociolinguistic variable, (ING) is a coherent whole with two variants; however, (ING) is not the result of a single linguistic process" (2008, 121).

The experiments in this dissertation will inform discussions on the phonology/morphology debate, and in doing so, will make it clear that these questions are actually indeed quite complex. I will therefore be in no position to resolve the issue, at least not in the terms in which it has been framed so far. The experiments in this dissertation focus on ING as a suffix, so as a semantically and morphologically distinct unit from adjoining roots. I ask in this work whether the -ing and -in' variants of the suffix are processed in the same way, or differently, and if so differently in which way. My experiments should at least give insight into whether, for suffixal ING, there are two distinct pieces (or allomorphs, as some may want to call them) for -ing and -in', or whether they are interrelated in a more complex way.

2.3 Priming as a window onto the mental lexicon

Experimental psycholinguists explore and debate the structure of the mental lexicon, and one of the most commonly employed tools for this is the primed lexical decision task. This task is attractive as it has been successfully used to probe how linguistic structures and units are related in the mental lexicon, and, although statistical power is a major confound in early priming work, it in modern-day times has been found to be a reliable and highly controllable methodology. In this dissertation I employ auditory primed lexical decision to probe questions about how -ing and -in' are mentally represented. In order to understand how this tool can be used to do this, I must a) explain how the task is used to probe mental representations of linguistic units in general (sections 2.3.1 and 2.3.2), b) the difference between doing this in visual and auditory modalities (section 2.3.3), c) what auditory priming tells us about the mental representation and processing of complex words (sections 2.3.4 and 2.3.5), and d) basic experimental priming parameters that are crucial to consider when setting up novel priming experiments (section 2.4).

2.3.1 The primed lexical decision task

The lexical decision task is a frequently used experimental method used to probe questions about relations in the mental lexicon. During an experiment of this kind, participants are presented with words and must decide whether each word is a real word of English (or whichever language or language variety the experiment is being done in), or a nonsense word, or nonword, that has been made up by the researcher (e.g. BLARK or RABBISK - note, nonwords come in many different types, a crucial parameter that will be discussed further in section 2.4.3). In most lexical decision experiments the participant sits in front of a screen, with their left and right index fingers over two different keys on the keyboard (e.g. the F key and the J key), and they must press one of the keys if they think that the word they were presented with is real, and the other if they think that it is a nonword. The speed with which they make this lexical decision is called the response time (RT) and is interpreted as the amount of time that it takes a person to perceive a string of letters or phonemes, process them, and either retrieve the corresponding word from the mental lexicon or determine that there is no entry for that string in the lexicon. Words that are particularly frequent or salient may be easier to access than obscure words, and this is reflected participant RTs (Grainger, 1990). In a sense, then, RTs can be seen as a measure of ease of accessibility in the mental lexicon.

The ease with which a word can be retrieved from the mental lexicon is not a stable or set feature of individual words. Certain words will be easier to retrieve based on their frequency of occurrence, or by certain people (e.g. a marine biologist may be quick to retrieve the word *beluga* compared to an historian), but also time, and setting can change the ease with which the same person will retrieve a word (e.g. before the marine biologist became a marine biologist, they may have found retrieving the word *beluga* just as hard as their peers).

Besides these factors, the ease with which a word can be retrieved can be directly influenced by the word that precedes it. In the literature that focuses on semantic priming (for reviews, see Neely, 1991; Lucas, 2000; McNamara, 2005; Hutchison, 2003), it has been repeatedly shown that a word like *nurse* is retrieved faster by participants when it is preceded with a related word like *doctor* than an unrelated word like *table*. Similarly, rhyme-prime studies show that a word like *nurse* is retrieved faster when it is preceded by a phonologically similar word such as *purse* compared to a phonologically unrelated word, again such as *table*. In a lexical decision experiment, words can be strategically placed one before the other - called primes and targets - and RTs to targets when preceded by a related versus unrelated prime can be compared. The speedup in RT to a target preceded by a related prime in comparison to an unrelated prime is called a priming effect (PE). In a primed lexical decision experiment, significant priming effects are interpreted as evidence for shared representation between two words in the brain. The retrieval of a word like *doctor* activates its semantic representation which includes conceptual links to hospitals, healthcare, etc. If the next word a participant encounters is *nurse*, then lingering activation of those concepts facilitates the retrieval of this semantically similar word *nurse*. Note that multiple aspects of representation can cause a priming effect, such that it can be complicated to tease apart which aspects contribute to a priming effect in which ways.

As with many experimental methodologies, there is a danger of over-interpreting results from primed lexical decision experiments. It is important to highlight that a button-press lexical decision involves more mental processing than just lexical access: it involves the visual or auditory processing of a stimulus, a judgement on the existence of a word (which in principle could involve extra-linguistic factors weighing in), and then a sequence of motor commands to press the right button. An RT is therefore not a direct reflection of the time it takes to retrieve a word from the lexicon, although it is often used as a proxy for this: they reflect a number of different processes. Concurrently, priming effects are informative of shared representation in the lexicon, but the latency of the lexical decision response means that they could be influenced by factors outside of the lexicon, such as top-down task-related processing effects, social or stylistic biases, etc. This is particularly important when looking at variation using priming methods.

2.3.2 Prime-target relationship types

Primed lexical decision experiments have been used to explore phonological, morphological, and semantic relationships between words. This is mostly done using what I will refer to as full or partial identity priming experiments. These experiments involve the facilitation of a certain target word due to a partially or completely shared identity between a prime and target. In other words, if a target shares partial identity with a preceding prime, then residual activation of that shared part of the prime will, all else equal, facilitate a subsequent response to a target.

Full identity experiments, also called repetition priming experiments, use primes and targets that are completely identical (e.g. *think-think*). These experiments are useful to tease apart how factors such as phonetic details and speaker characteristics affect the processing of words (Wilder, 2016). This type of priming universally (at least, until Chapter 7 of this dissertation!) is found to be the strongest form of priming. This makes sense, as the two words share complete phonological and semantic overlap (Forster and Davis, 1984).

Partial identity experiments are more relevant to this dissertation and are used to tease apart more specific aspects of shared representation between linguistic units. For example, researchers can explore whether words that overlap phonologically but not semantically are related to each other in the mental lexicon (e.g. Norris et al., 2003). For example, is *drink* related to *think* due to the shared syllable-rhyme? But also, is *drinking* related to *think* through the rhyming stems, despite the fact that *drinking* has a suffix? How about word pairs such as *awning* (monomorphemic noun) and *dawning* (multimorphemic verbal item), or *chicken* and *lickin'*?

In a parallel fashion, partial identity experiments can be used to isolate semantic overlap (e.g. *think* and *muse* share semantics but not morphology or phonology), and has been used extensively to explore what types of semantic information connects words in the mental lexicon. For example, are only words with synonymous meanings connected (like *think* and *muse*), or are there other types of semantic relatedness that connect words, like antonymity (e.g. *hot-cold*), perceptual similarity (e.g. *pen-carrot*), categorical relatedness (e.g. *lion-tiger*), or associative relationships like, likelihood to occur together in the world (e.g. *dog-leash*) (i.a. McNamara, 2005; Lucas, 2000; Hutchison, 2003).

Finally, and newest to the priming literature, researchers have started to use this method to consider morphological relatedness, and to garner experimental evidence that could inform the long debate about the existence of morphemes as linguistic units. The main debate in this area centres around theories of word recognition that include representations for morphological structure, and those that do not (see Taft and Forster, 1975; Schriefers et al., 1992; Baayen et al., 2011). Theories that do not posit morphological structure attribute the effects of morphology to phonology and semantics, and thereby typically suggest that complex words are stored as whole units. As an example, a word like *thinking* is related to *think* through partial overlap in semantics (i.e. they share a meaning related to pondering, musing, or ruminating on something) and phonology (the phonological string for *think* is present in *thinking*). Theories that do posit morphological structure suggest that complex words consist of separable morphological units (e.g. *thinking* can be split into a root, namely *think*, and a suffix -ing), and are two words like *thinking*, and *think*, can therefore be related morphologically, since they share the stem *think*, as well as semantically and phonologically. The most extreme models of this type are called **full-decomposition** models. At its heart, this debate seeks evidence that there is a level of shared representation that goes beyond phonological and semantic overlap. For a detailed overview of this debate, see Embick et al. (ming).

The goal of this dissertation is not to provide evidence for either side of this debate. In fact, the experiments in this dissertation do not allow me to disentangle morphology from semantics, so I will not be able to speak in favour of either of the two above approaches to morphological representation. That being said, I am probing the mental representation of the variable suffix ING, and more specifically its phonological variants -ing and -in'. I isolate the suffix in a priming paradigm that uses primes and targets with unrelated stems (e.g. *jumping-thinking*), and will talk about these primes and targets as consisting of two pieces: a stem and a suffix. I am therefore using terminology from a decompositional framework in this project, but let it be clear that the results could also be compatible with a whole-word storage account, and that I have no intention of denying or arguing for the existence of morphology in this dissertation.

This note on the debate about morphological representation aside, there is a specific category of priming studies that informs this debate that is relevant to the current dissertation, and it pertains to the processing of spoken complex words.

2.3.3 Written versus spoken word recognition

First of all, a key assumption underlying priming research that studies the mental lexicon is that there is a single mental lexicon in which there are representations that can be retrieved through auditory or visual processing. One could extrapolate this assumption and say that it should therefore not matter whether priming experiments are done in the visual or auditory modality, since they are both tapping into the same set of mental representations. This overlooks a fundamental characteristic of priming that I pointed to in Section 2.3.1; response times in priming experiments reflect the processing of the stimuli as well as facilitation stemming from related mental representations.

The processing of visual compared to spoken words is inherently different (Ostrin and Tyler, 1993). The most important difference between visual and spoken word recognition is the **time-course** in which words are perceived and processed (Ferrand et al., 2018; Wurm, 2000). An orthographic word is presented to the reader all at once, with eye-tracking studies showing that words are often read with a single fixation point. This means that the beginning and end of written words are processed simultaneously, such that the perceiver immediately has all of the information needed to determine the word's identity (e.g. Bertram, 2011; Pollatsek and Hyönä, 2010). In contrast, spoken words are presented to a listener incrementally: they unfold over time (Cutler, 2012). As information is revealed sequentially in the acoustic signal, the set of words that match what has been heard is gradually narrowed down until a uniqueness point is reached, allowing the word to be recognised (Marslen-Wilson, 1984).

The temporal difference between reading and listening is reflected in the way that models of visual and spoken word recognition are set up. Most spoken word recognition models (e.g. Taft and Hambly, 1986) assume that lexical candidates are considered on a rolling basis as the acoustic signal unfolds, and are ruled out based on phonological similarity to the incoming signal. By contrast, since a visual stimulus is presented as a whole, and not processed incrementally from left to right (Rastle, 2016), most models of visual word recognition assume a letter-feature matching process that connects to an orthographic lexicon, which in turn interacts with phonological and semantic parts of the lexicon.

Besides the procedural discrepancies, there are other consequences of the time-course for lexical access. During spoken word recognition, for example, a listener has no control over the how soon they gain access to the full content of the word they are hearing. Although co-articulatory cues may give away the presence of an upcoming suffix to a certain extent (Goodwin Davies and Embick, 2020), the listener must start processing the word without knowing its ending. This is not at issue during visual word recognition, where reading words happens both with a single fixation point, so with the whole word at once, and can be done much faster than listening to words (Brysbaert, 2019). Finally, in spoken word recognition some have argued that echoic traces of recently perceived words are briefly retained, and can facilitate the recall of those or related words. This idea is supported by the discovery that often, auditory priming effects are larger in magnitude and more robust than visual priming effects (i.a. Hutchison, 2003; Wilder et al., 2019).

The above discussion is particularly important for researchers with an interest in priming effects caused by shared representation towards the end of a word, for example for suffixes (like ING, as in this dissertation). In the visual modality, stems and affixes are presented and processed simultaneously, whereas in the auditory modality, listeners will hear the stem first and suffix later (although co-articulation may cue an upcoming suffix (Goodwin Davies and Embick, 2020)). Further, in this dissertation I am not only interested in a suffix, but in the mental representation of two pronunciation variants of that suffix. This means that I must use auditory priming, and it is for that reason that I will focus on results from the auditory priming literature in the remainder of these background chapters.

2.3.4 Processing morphologically complex spoken words

The majority of the early priming studies use monomorphemic words. Although practical from a methodological perspective, this gives little insight into morphological processes and representations that occur in complex words. Researchers have suggested two ways in which multimorphemic words can be processed: **continuous** theories suggest that listeners process auditory input sequentially, regardless of the internal structure of the word (Norris and McQueen, 2008). **Decompositional** approaches, which I briefly touched upon earlier in section 2.3.2, pay attention to the morphological structure of words (Taft and Forster, 1975; Gwilliams et al., 2016). Like many theories, these approaches are not mutually exclusive. In fact, Wurm (1997) argues that complex words may be analysed in both ways simultaneously, such that one process takes the whole word into account, and the other simultaneously decomposes the word and matches the root of complex words to possible roots in the lexicon.

Work on this debate makes use of what is called a word's **uniqueness point** (UP), or the point during the processing of incoming auditory input at which there is only a single entry in the mental lexicon that matches the input (Marslen-Wilson, 1984). For complex words, Balling and Baayen (2008, 2012) suggest an extension of this concept for morphologically complex words to the Complex Uniqueness Point (CUP), or the point at which other morphologically similar words become incompatible with the incoming speech signal. These crucially differ in that the UP is the point after which a word can no longer be another stored root, such that the UP of *thinking* lies at the [k], the point after which the word can no longer be *thing*, but the CUP lies at the [ɪ], the point after which the word can no longer be *thinker* or *thinktank*.

An important concern for priming studies is the fact that since each word has its own uniqueness point, a response time measured from the offset of the target soundfile does not actually reflect the amount of time from the point at which a word can be recognised to the point at which it is actually recognised and a button is pushed to acknowledge this. A more accurate response time would start at the uniqueness point of a word (or perhaps complex uniqueness point when using complex words as stimuli). One way to deal with this is to artificially make the uniqueness point of stimuli in an experiment obsolete by making it such that a word can only be correctly identified at the end of the soundfile and not at its natural uniqueness point. To demonstrate this point, in the studies in this dissertation, participants are tasked with deciding whether a word they hear is real or a nonword. They could in principle do this at the complex uniqueness points of my ING-final stimuli. However, in the set of nonwords used in my experiments, I have included nonwords like RUNNINT and THROWINK, that are recognisable as real words right up until the final phoneme of the word. This means that if participants determine the realness of these words at the original UP, they will incorrectly recognise these as real. This forces participants, when they hear a word that seems to end in ING, to wait until the end of the word before they can recognise it as existing in their mental lexicon or not.

2.3.5 Complex word priming as a tool

Priming studies using morphologically complex words provide a tool that can be used to probe questions about whether and how semantics and phonology differ from morphological representation. Numerous studies have shown that morphologically complex prime-target pairs, for example *submit-permit*, or in Dutch *bieden* 'to offer' - *verbieden* 'to forbid', show priming effects in the absence of a semantic relationship between the prime-target pairs, where similar phonological controls, such as *bieden* 'to offer' - *bespieden* 'to spy on', do not (Emmorey, 1989; Creemers et al., 2020; Smolka et al., 2014). These studies suggest that processing facilitation here is coming from the morphological representations of the bound root *-mit* and for the Dutch example from *bieden*, because there is no semantic overlap between the primes and targets to yield priming on that basis. Further, the phonological controls provide evidence that the facilitation does not stem from a phonological echoic trace or something along those lines, as we would in that case expect to see facilitation in the phonological control conditions. These results provide support that words are decomposed in processing, and that processing facilitation as a result of this decomposition and the activation of morphological representations can occur.

Further evidence in support of this idea comes from *rhyme priming* studies. In these studies primes and targets usually share their syllable rhyme (e.g. *bunch-lunch*). However, Bacovcin et al. (2017) use monosyllabic primes such as *dough* paired with morphologically complex targets such as *snowed*, whereby the prime rhymes with the stem of the target (*dough* rhymes with *snow*). Rhyme priming of the form *dough-snow* is well-established (e.g. Slowiaczek et al., 1987, 2000; Radeau et al., 1995; Monsell and Hirsh, 1998). Bacovcin et al. (2017) posit that if complex words are decomposed into roots and suffixes then *dough* should prime *snow* even when it has a past tense suffix *-ed* attached to it. It is of course possible that the overlap of the vowel could cause processing facilitation, so to control for this, they included controls that paired *dough* with phonologically similar words like *grove* and *code*, but that are not decomposable. No facilitation was found in these two phonological control conditions, whereas it was in the *dough-snowed* condition. This suggests that *snowed* is decomposed into the root *snow* and suffix *-ed* and that the phonological overlap between the prime *dough* and the stem *snow* caused the observed facilitation.

A different line of evidence in this discussion comes from *pseudo-decomposition priming* (Beyersmann et al., 2016; Marslen-Wilson et al., 2008; Rastle et al., 2000, 2004; Creemers et al., 2019). It has been suggested in the past that words that seem complex might be aggressively (and erroneously) decomposed early in their processing, before being recombined into the monomorpheme that they are. For example, the word *corner* is not a combination of the root *corn* and a suffix -er, however, it could be erroneously decomposed into these parts. Pseudo-decomposition priming in the visual modality finds that *corner* facilitates *corn* in the same way that *teacher* facilitates *teach* (Rastle et al., 2004). However, in the auditory modality, Creemers et al. (2019) find that pseudo-decomposable words such as *pigment* do prime their pseudo-stems (here: *pig*), but they also find equivalent priming for a phonological condition in which decomposition is unlikely (e.g. *dogma* is not decomposable into *dog* and -ma, since -ma is not an existing morpheme in English).

Finally, affix priming provides evidence for decomposition, and is the most relevant priming type for the current dissertation. Under the assumption that complex words are decomposed into stems and affixes, if we assume that prime-target pairs with shared stems (e.g. *thinking-think*) can show priming effects (Amenta and Crepaldi, 2012; Marslen-Wilson, 2007; Wilder et al., 2019), then the same should be the case for prime-target pairs that share a suffix (e.g. *jump**ing**-think**ing***). This, however, has received much less attention than stem-priming, and in the few studies that have tackled it, has proven much harder to find stable evidence for. One contrast that arose in early priming work on affixes argued that derivational affixes will prime across otherwise unrelated prime-target pairs (e.g. *blackness-shortness*) (Duñabeitia et al., 2008; Marslen-Wilson et al., 1996; Giraudo and Grainger, 2003), but inflectional affixes (e.g. *jumping - thinking*) will not (Emmorey, 1989). This could be a difference between different types of affixes, or, as has been argued recently by Goodwin Davies and Embick (2020); Wilder et al. (2019), affixes are presented at the end of words, and are often short in duration and unstressed, which could make priming hard to detect. Indeed, in a well-powered priming experiment, Goodwin Davies and Embick (2020) find that the inflectional English plural suffix -s shows significant priming effects (e.g. *crimes-trees*).

Taken together, exploring aspects of morphological representation using auditory stimuli is relatively novel. Nonetheless, experimental priming paradigms have been creatively employed to get at questions of phonological, morphological, and semantic representation. In this dissertation I will use affix-priming to study the variable ING, and its two pronunciation variants. Using well-powered and highly controlled auditory experimental designs I will establish affix priming for -ing (e.g. *jumping-thinking*) and for the noncanonical pronunciation variant -in' (e.g. *jumpin'-thinkin'*). These experiments (Chapters 4 and 5) will show that -ing and -in' both prime themselves and each other. I will demonstrate how to test whether aspects of shared representation play a role in this processing facilitation by using a phonological control condition (*dolphin-thinkin'*) to ask whether facilitation seen between suffix variants reflects surface phonological overlap or not (see Chapter 6). These results contribute to the discussion of decomposition in the psycholinguistic literature, by showing robust and stable inflectional suffix priming.

That being said, my main goal in this dissertation is to ask whether -ing and -in' have related mental representations, which I can do by asking whether they cross-prime each other (e.g. *jumping-thinkin'*), and if they do, asking what facilitation pattern we see for same-variant versus cross-variant priming? It is worth noting here that affix priming using socially meaningful pronunciation variants has not been done before. The fact that pronunciation variants bear the same meaning, and are phonologically similar, combined with the fact that affix priming has been found to be hard to detect in the past means that any affix priming for either of the variants would be an important result in and of itself, and a stable detectable difference between -ing and -in' priming would be surprising and of great interest for both researchers of the mental lexicon and sociolinguistic cognition alike.

The detection of a stable affix priming difference between -ing and -in' will require considering how social information fits into processing. It is well-understood that the variants of ING are socially meaningful, and that in production, their use is conditioned by social and stylistic factors. An asymmetry in their facilitation in priming experiments could give insight into whether social information is involved in their mental representation, or in their processing during spoken word recognition. In order to explore these questions, I will use a controlled primed lexical decision design, that is adapted for use with noncanonical pronunciation variants. This adaptation involves carefully considering the parameter settings involved in regular primed lexical decision experiments done with canonically pronounced stimuli, but also considering the implications of using noncanonical pronunciations in this experimental paradigm. In Section 2.4 I discuss the further basic experimental parameters that pertain to primed lexical decision in general, and in Chapter 3 I detail the issues and solutions that are necessary when introducing noncanonical variants to this type of experiment.

2.4 Basic primed lexical decision parameters

The setup of a primed lexical decision task involves the careful setting of many parameters. In its most basic form, this kind of experiment involves presenting participants with a large (often up to 600) prime and target words in isolation, and asking them to decide whether the words are real or not by pressing a response key. In previous sections I have highlighted different types of stimuli relationships that can be used, and have discussed the implications of using a visual versus an auditory modality for those stimuli. In this section I will highlight three further methodological parameters that must be carefully considered when designing primed lexical decision experiments.

2.4.1 Continuous versus paired lexical decision task

Researchers must choose whether to ask participants to respond to every word in the experiment, a so-called **continuous** lexical decision task, or only to target words, a **paired** lexical decision task. The advantage of a paired design is that researchers can carefully control the amount of time that participants have between the presentation of a prime and target. The disadvantage is that participants often notice the pairing of related words, and will use this knowledge to try to improve their performance on the task, or will ignore the prime words altogether and focus only on the targets, neither of which gives insight into shared representations in the lexicon. For these reasons, many researchers use a continuous design, in which participants respond to every word in the experiment, and are therefore in principle unaware that any of the words are paired up for later RT analysis. The experiments presented in this dissertation all employ a continuous lexical decision design.

2.4.2 Experimental time-course parameters

Choosing to use exclusively auditory stimuli and a continuous design both have important consequences for the timing parameters in primed lexical decision experiments. A trial in a continuous primed lexical decision experiment in either modality consists of the presentation of a prime word, a response by the participant, then a short silence, followed by the target word and response to the target. In a visual design, the duration of presentation of the prime word and duration of the silence between prime and target can be set by the researcher. This time-period between the onset of the presentation of the prime and the onset of the presentation of the target word is called the **stimulus-onset asynchrony** (SOA). However, in an auditory design, each spoken stimulus has a unique token-specific duration. While duration can be manipulated, this does make stimuli sound highly unnatural, and stimuli with manipulated phonetics have been shown to yield unreliable priming effects (McGowan and Sumner, 2014). For this reason, in auditory primed lexical decision experiments researchers only set the time between the offset of the prime word and onset of the target word: the **inter-stimulus interval** (ISI). See Figure 2.1 for a depiction.

In auditory primed lexical decision paradigms, ISIs usually range between 200ms and 1000ms, although ISIs as short as 0ms are known to produce similar priming effects to a 200ms ISI (White et al., under review). In order to prevent participants from using rhythmic patterns caused by exactly the same length of silence between prime and target as a tool for cuing their responses, ISIs are usually randomly generated using using a 100-200ms window around a median ISI. The experiments in this dissertation all employ a 400-600ms ISI, and the ISI starts either at the end of the soundfile, or at the moment the participant responds to the stimulus, whichever of the two is later.

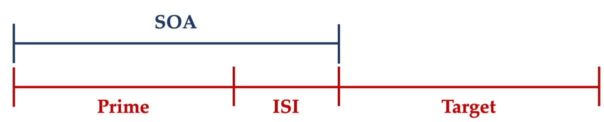

Figure 2.1: Timeline of a pair of stimuli in a primed lexical decision experiment. When using visual stimuli, the stimulus onset asynchrony (SOA) is set by the researcher. In an auditory paradigm, the inter-stimulus interval (ISI) is set by the researcher.

2.4.3 Nonword and filler structure

As discussed in section 2.3.1, the primed lexical decision task requires participants to decide whether a word is a real word or a nonword. Consequently, in order to avoid response bias, there must ideally be a balance of 50% real words and 50% nonwords in an experiment, if possible. If in a given experiment a participant is presented with 600 words in total, then, 300 will be nonwords. There are different types of nonwords, that vary in processing difficulty. In a visual paradigm, nonwords can consist of orthographically illegal strings (e.g. KSTSE), orthographically legal nonwords according to the language of inquiry (e.g. MEEST), and pseudohomophones (words that are orthographically legal nonwords, but that sound like existing words when pronounced aloud. E.g. LEEST). In an auditory paradigm, nonwords will be recorded by the same speaker who produces the real word stimuli. For pronouncability, the nonwords must therefore conform to the phonological parameters of the language of inquiry. For example, a nonword such as FBERT that includes a (for English) illegal consonant cluster will be hard to produce and can sound jarring to participants adding potential hard to control for processing burdens, versus a legal nonword such as MEEST.

An additional consideration is that the processing difficulty of nonwords can affect response latencies in lexical decision tasks (Lupker and Pexman, 2010), whereby the harder nonwords are to distinguish from the real words in an experiment, the slower participants respond in general in an experiment. This is not necessarily a bad thing, in fact, it is in many ways preferable that participants need to pay close attention to the stimuli in order to determine whether words are real or not, as giving participants a challenge often more easily keeps them focused on the experiment. Researchers will often not only create difficult nonwords to keep participants engaged, but also create nonwords that are similar to the real words in the experiment in characteristics such as syllable length, morphological structure, or even partial phonological similarity, to ensure that participants listen carefully to every word in the experiment. In a primed lexical decision task, what the researcher is trying to measure is the speed with which a participant retrieves words from their mental lexicon. However, this is not something you can ask participants to do, so instead researchers ask them to recognise words as real or not, and if given the chance, participants will intuitively (consciously or subconsciously) use any clues or patterns they can to enhance their performance on this task. Although a participant may think that enhancing their performance is what the researcher wants, these patterns may actually alter the processing speed of the words in the experiment, meaning that RTs no longer reflect the speed of word retrieval, but an under-specified combination of this with task-related strategic processing.

To demonstrate this point, in this dissertation, the focus is on the processing of the progressive suffix ING, which occurs at the end of disyllabic verbs. If all the nonwords in this experiment were recognisable as nonwords in the first syllable, either because they are monosyllabic (e.g. MEEST) or because the first syllable is not an existing onset in the language (e.g. MEESTEK), then instead of searching their lexicon to determine whether a word is real, participants can simply use the question of whether the first syllable of a word exists in their language or not to decide whether words are real or not. They can ignore the second syllables of all words in the experiment and still do the task successfully, which, when the variable of interest is at the end of a word, like it is for variable ING, is an undesired strategy. A solution to this problem is to use nonwords that have late disambiguation points: nonwords that start out sounding like real words, but are recognisable as nonwords by their last syllable or phoneme. Examples of this are RABBISK, BAKERT, and EATINT, all of which start out sounding like the real words *rabbit, baker*, and *eating* (or *eatin'*), but can be disambiguated from these at the end of each word. The latter two serve the additional purpose of ensuring that there are both morphologically complex real words and nonwords and that not every word with a word-final ING variant is a real word (both are patterns that participants could pick up on and use to enhance their performance of recognising real words and nonwords).

To summarise, nonwords serve the following purposes:

- Using 50% real words and 50% nonwords ensures that participants are not biased towards pressing either the "real word" or "nonword" button.
- Creating nonwords that are similar in linguistic characteristics to the real words in an experiment ensures that participants cannot use obvious structural differences between the real and nonwords to determine the realness of a word
- Creating nonwords that directly share linguistic features with the real words in an experiment ensures that participants do not pick up on the researcher's linguistic feature of interest (by noticing it exclusively occurs in real words), and use this to quickly respond "real word" whenever they encounter a word with this feature (which can influence priming effects).

As is perhaps apparent, researchers using primed lexical decision want to tap into a participant's spoken word recognition processing time that is unaffected by other processing mechanisms. Besides minimising differences between real and nonwords, researchers try to disguise the purpose of their experiment for similar reasons. If participants know that a researcher only cares about their RTs to words with a specific linguistic feature, then they can just pay attention and put effort into responding quickly to words with that feature, another performance enhancing strategy. In order to mask the linguistic feature of interest, researchers use a set of real words as filler words to distract away from their critical experimental stimuli. In an experiment on ING, a researcher can include filler words ending in the agentive -er suffix, or nominalising -ment suffix, to draw attention away from words ending in ING. An informal rule of thumb is to aim for less than 20% of the total number of items in an experiment (real and nonwords combined) to contain the linguistic feature of interest.

One final way to draw attention away from the linguistic feature of interest is to ensure that words containing that feature do not always occur in pairs in the experiment. Naturally, since these are priming experiments, critical stimuli occur in prime-target pairs. However, participants may notice it if every ING final word is followed by another ING final word, and use that information to quickly press the "real word" button immediately for the stimulus following an ING word. This is undesirable, since it means that the participant does not need to listen to the target word to identify it as real, which again means we are not measuring the spoken word recognition process. Real filler words and nonwords can therefore be used to ensure that occasionally a word with the linguistic feature of interest is followed by a nonword, which would cause the participant to make an error and in future force them to listen to the end of each word before determining its realness.

All of the experiments in this dissertation follow the abovementioned procedures to reduce strategy use by participants that could influence the measured RTs. The nonwords and real filler words used in all experiments in this dissertation can be found in Appendix A.

Chapter 3

Approaching ING experimentally

Much of what we know about the locus of variation comes from naturalistic data sources, as was discussed in Section 2.1. The use of experimental methods to study how variation is mentally represented, and how social information influences language processing is fairly new. The novel field of **sociolinguistic cognition**, as it was named by Campbell-Kibler (2010),is dedicated to questions of this type. In this field, researchers adopt and adapt methodologies that have been used in psycholinguistics for decades to study language processing, and apply them to questions about the integration of social and linguistic information (Loudermilk, 2013). Among other methodologies, researchers have studied the link between social and linguistic representations by adapting perceptual categorisation paradigms to study how prior dialect exposure influences speakers' perception of regional dialects (Preston, 1993; Plichta and Preston, 2005; Wagner et al., 2014). Matched-guise paradigms are used to study how nonstandard linguistic features impact social evaluations of speakers (i.a. Labov et al., 2011). Perceptual learning methodologies have been used to study how sociolinguistic representations can be influenced by exposure to phonetic variation, and thereby how listeners learn variation (Clopper and Pisoni, 2004; Trude and Brown-Schmidt, 2012).

Of greatest importance for the current dissertation is the use of priming paradigms to study questions of sociolinguistic cognition. It is important to point out here that there are a number of different types of "priming" in this literature that this term can refer to: linguistic priming, social priming, and accent priming, to name but a few. Social priming does not necessarily use words as stimuli, and focuses on social processing. For example, social priming studies show that after exposure to a certain social group, people behave in ways that reflect the social stereotypes of that group (Campbell-Kibler, 2010). In a concrete demonstration of this, Hay et al. (2019) used a creative method that made participants do a lexical decision task (sorting words into real words and nonwords) and an implicit association task (sorting images into a specific category) simultaneously. Participants performed better if socially congruent images were sorted with the same hand as the socially skewed real words (e.g. stereotypically feminine words and female faces).

Accent priming studies ask whether accents more broadly affect lexical access. Clopper and Walker (2017) found that multi-dialectal speakers were more flexible at processing variation, and encountered both less facilitation and less inhibition when processing variable vowel pairs, than mono-dialectal speakers did. Cai et al. (2017) found that listeners processed the semantic meaning of words faster if the word was spoken by a speaker who was more likely to use that word (e.g. *trousers* spoken by a British rather than American English speaker). These studies indicate that social information seems to play a role in word recognition.

These priming types aside, the most relevant type of priming for the current dissertation is linguistic priming that studies the mental representation of specific variables. In the next section of this chapter I will discuss two lines of research that have studied the mental representation of specific variables. The first line of research is what I will call the **canonicality advantage** literature. This body of work consists of a large set of linguistic priming studies of variables that are not socially meaningful. The core debate in this area is whether there is a processing advantage for canonical pronunciation variants over noncanonical variants. This is of clear relevance to discussions of ING, for which we know from the sociolinguistic literature (see section 2.2) that -ing is the canonical and -in' the noncanonical variant. The second line of research is the integration of linguistic and social priming to study how social background impacts the perception of local variants.

In this chapter, I will first go over these two lines of research, before turning to focus on how we can study the mental representation of ING specifically using highly controlled primed lexical decision experiments.

3.1 The canonicality advantage

The way in which variation, socially meaningful or not, is accounted for and processed by the brain's language system is an important question for researchers of the mental lexicon (i.a. Connine et al., 2008; Gaskell and Marslen-Wilson, 1998; Pitt, 2009). If variation creates a mismatch between a form that is stored in the mental lexicon and what a person produces or perceives, then it would make sense that the resolution of this mismatch is a time-costly process. This relies on the assumption that we store a single form of words in the mental lexicon. It has been suggested that it is likely that the form of words that the brain stores is their canonical, or "dictionary" pronunciation (i.e. in the case of ING, the -ing variant is considered "canonical" and the -in' variant "non-canonical") (i.a. Andruski et al., 1994; LoCasto and Connine, 2002). Note here that the way the term "canonical" is used in this literature does *not* mean that that variant is necessarily the underlying phonological representation (although this is a way that the term is used in some research). Here canonical refers to the citation form, which reflects social constructs more so than underlying representations. In this dissertation, when I use the term "canonical" I am using it in its social sense, and not in its underlying sense.

From a lexical access, or spoken word processing perspective, researchers posited that, under this hypothesis, canonical forms should enjoy a processing advantage over non-canonical forms, since linking a non-canonical form to its stored canonical counterpart in the lexicon must require extra processing time. This so-called **canonicality advantage** has been tested in myriad studies using primarily phonological variables embedded in monomorphemic words (i.a. Andruski et al., 1994; LoCasto and Connine, 2002; Racine and Grosjean, 2000, 2005; Racine et al., 2014; Tucker and Warner, 2007; Gaskell and Marslen-Wilson, 1996; Ranbom and Connine, 2007; Pitt et al., 2011; Sumner and Samuel, 2005; Deelman and Connine, 2001). Some of these studies indeed find a processing advantage for canonical pronunciations over non-canonical ones. For example, Andruski et al. (1994) asked whether, in a semantic priming paradigm (e.g. using prime-target pairs like *king-queen*), semantic priming effects were larger when the word-initial consonant of the prime was pronounced with a more canonical long VOT, or a shorter noncanonical VOT. They found that semantic effects (compared to an unrelated baseline) were significantly larger when the prime had a canonical VOT than a noncanonical one. Similarly, Racine and Grosjean (2000, 2005) found that French words pronounced with a canonical schwa in the first syllable, gave bigger processing facilitation than words with a reduced schwa. Further, LoCasto and Connine (2002) used an auditory priming experiment to examine processing advantages of canonicality for word-medial schwa deletion in English words such as *camera*. They found that canonically pronounced target words (with a word-medial schwa) were processed quicker when preceded by a canonically pronounced word-medial schwa prime. However, and in additional support of a canonicality advantage, non-canonical (deleted word-medial schwa) primes did not facilitate non-canonical targets any better than canonical primes did. This means that non-canonical targets were primed equally well by a prime that had the same word-medial schwa pronunciation as by one that differed from it. This was interpreted as evidence that canonical pronunciations are easier to process than non-canonical ones, at least with respect to facilitating upcoming instances of the same phonological variable.

The canonicality advantage is, however, a hotly debated phenomenon. In direct contrast to the studies listed above, there are myriad studies that find no significant processing advantage for canonical over non-canonical word forms. Gaskell and Marslen-Wilson (1996) considered place assimilation: the process whereby a segment will change to be more similar to a neighbouring segment in articulatory features. For example, the final consonant of the word *wicked* can be pronounced as a labial stop when followed by a word that starts with a labial stop (e.g. in the phrase *wicked prank*). Gaskell and Marslen-Wilson (1996) found that both canonically pronounced words (non-assimilated) and non-canonically pronounced forms (place assimilated) yielded similar amounts of priming. Similarly, Gow (2001) employed form priming and rhyme priming to test whether this kind of feature mismatch disturbs word recognition when the words are presented in a sentence, and found that it does not, and that participants used assimilation to anticipate upcoming linguistic contexts. In a semantic priming paradigm, Deelman and Connine (2001) found that for primes with a word-final /t/, whereby the /t/ is either released or unreleased, facilitation for a semantically related target was unhindered by either variant. Sumner and Samuel (2005) found the same for primes whereby the /t/ was either released, glottalised, or replaced by a glottal stop, in contrast to primes whereby the /t/ was replaced by what they call an illegal variant (e.g. /s/). They also found that in a long-term form priming task, whereby priming effect was measured across two experimental blocks, the canonical variant /t/ was more effective than the noncanonical glottalised /t/ and glottal stop variants. They interpret the result as indicating that in short term semantic processing, surface variation does not play a role. However the long-term priming results suggest that the canonical form (released /t/) may be the stored representation of these forms. Other studies looking at voicing assimilation (Snoeren et al., 2008), nasal flapping (Pitt et al., 2011; Ranbom and Connine, 2007; Sumner, 2013), and other variables found a similar lack of immediate processing difference for canonical versus non-canonical forms.

Bürki et al. (2018) argue that the picture is further complicated because processing advantages for canonical forms can stem from different sources. They suggest that variant frequency and context-dependent listener expectations could account for the canonicality advantage. For instance, Pitt et al. (2011) found that response times to different variants of word-medial /t/ corresponded with the variant frequencies (see also Ranbom and Connine, 2007). Adding a layer of complexity, variant frequency can be context-dependent, and most controlled studies investigating pronunciation present stimuli in a context that favours canonical pronunciations (such as an experimental setting in which words are presented in isolation). Finally, Bürki et al. (2018) suggest that variant duration must be accounted for when modelling response times to pronunciation variants that differ in duration - most variables studied involve some form of reduction or deletion - not only because duration can impact RTs (Ranbom and Connine, 2007), but also because reduced forms can be harder to recognise as words (Ernestus et al., 2002).

Taken together, conflicting results and unaccounted for confounding factors mean that there is still no clarity on whether the mental lexicon stores canonical forms differently from non-canonical forms.

3.2 Integrating social and linguistic priming

It is not the case that socially meaningful variables have never been employed in experimental priming paradigms. There are, to my knowledge, two key examples of this. However, the goal in these studies was, crucially, to examine the way in which social demographics of the listeners impacted their processing of the different variants, rather than about the mental representation of the variants themselves.

The first of these studies by Sumner and Samuel (2009) studied how the perception of local variants was impacted by a listener's exposure to a certain regional dialects. They used a more traditional psycholinguistic priming paradigm to examine whether -er final words pronounced either with an r-ful (as in Mainstream American English) or r-less (as in New York City English) final syllable facilitated responses to a General American or New York City English target (e.g. *baker* pronounced as [bɛikɚ], or [bɛikə]). They found that participants with little exposure to the NYC dialect encountered less facilitation after NYC primes and to NYC targets than participants who had lived or still lived in New York City. They also found a difference between participants who had a little exposure to NYC English through having lived there briefly, versus a lot of exposure to NYC English (people who lived in NYC for a longer period of time). The former group only encountered short-term facilitation for NYC primes and targets, whereas the latter enjoyed facilitation for NYC targets over both short and longer timespans. They suggest that the cognitive representation or processing of different sociolinguistic variants can be affected by exposure to a certain dialect.

The second example by Sumner and Kataoka (2013) explored whether the processing of a local variant was affected by the speaker's regional accent. In a similar priming paradigm to the Sumner and Samuel (2009) study, they compared primes that in General American

English (GA) have a word-final rhotic (e.g. *baker* pronounced as [bɛikɚ], to their non-rhotic counterparts (i.e. *baker* as [bɛikə]), crucially pronounced by both a non-rhotic Southern Standard British English (SSBE) speaker and by a non-rhotic New York City English (NYC) speaker. They found that, for their General American participants, only GA and SSBE forms primed related targets equally well, and NYC non-rhotic primes gave no facilitation to related targets. Sumner et al. (2014) suggest that certain varieties may be more socially salient than others, and that highly idealised varieties (like SSBE) may give processing advantages over less socially idealised varieties (like NYC).

These studies are trying to probe how social information is integrated into spoken word recognition, and, in a sense, they are taking a top-down approach to the question. They vary the higher level social parameters in the experiment, and ask whether these social factors impact the processing of variants that have different social meanings. However, although interesting in its own right, this does not tell us much about the mental representation of the specific variants or variables that are used. These studies remain relatively agnostic about the identity of the variables they use, and the locus of the grammar at which they are situated. Thus although the results do tell us something about the processing of variants, we must keep in mind that differences in priming effects between variants could be caused by *representational* differences as well as (or perhaps instead of) *social* differences, that in these studies are undetectable.

There is a more basic set of questions (such as: do different variants prime each other?) that more directly probes how variables are represented. Understanding how variants are represented and related to each other will provide a backdrop for the above studies, and may inform the extent to which we can expect social manipulations to contribute to variant priming. This is the work I propose in this dissertation and it will support and contribute to our understanding of the representation of variation, and in turn provide a comprehensive baseline that could help explain results such as those discussed above.

3.3 Teasing apart aspects of shared representation of variable ING

As discussed in Chapter 2, priming can be used to tease apart how words are related in the mental lexicon. If two words are related semantically, like *king* and *queen*, then this will be evident through a processing facilitation compared to an unrelated baseline like *table* and *queen*. In this way, researchers have studied semantic and phonological relatedness (see section 2.3.2), and also probed morphological relatedness (section 2.3.4).

At the heart of this dissertation lies the question of how the sociolinguistic variable ING is mentally represented, and how -ing and -in' are related. This is complicated since ING exists as a suffix in complex words (like *thinking*) and as a variable part of monomorphemes (like *awning*). Although this is not the usual approach to probing aspects of shared representation, the way I approach this is by first determining the relevant ways in which -ing and -in' *could* be related, in as many of the word types as possible that they can be found. I first list different word types that -ing and -in' can be found in, and then construct an overview of relevant aspects of shared representation that differentiate those word types. This gives me both a backdrop from which to start teasing apart different aspects of representation, and also provides a framework for future research on exploring aspects of shared representation, especially for complex words where there are many possible interconnected relationships.

In this section I will elaborate on these potential relationships, and break down which aspects of shared representation I am going to isolate and probe in this dissertation.

3.3.1 The Master Table

Considering the ways in which -ing and -in' could be related is a more complex undertaking than it may seem at first glance. A key starting point is to realise that primed lexical decision experiments involve the presentation of whole words, which means that a prime and target pair can be related through their stem or through their suffix. The full table of relevant aspects of shared representation can be seen in Table 3.1. This table shows many of the ways in which primes listed on the left are related to the target *thinkin'*.

It is important to note here that the Master Table is by no means an exhaustive list of the potential aspects of shared representation. I deliberately only included aspects of shared representation that are relevant to the work in this dissertation *and* that are relatively uncontroversial. For example, the Master Table includes a column for **surface phonology** but not **underlying phonology**, because the fact that *jumping* and *thinking* share surface phonology is clear, but their underlying phonology has yet to be determined. In this dissertation I show how primed lexical decision can be used to give insight into the undetermined aspects of shared representation, but much future research will be needed to say with confidence what those relationships look like. Simply put, what this means is that the Master Table is unfinished (and perhaps will never be finished), but can be built upon through the systematic experimentation demonstrated in this dissertation.

Given unlimited time and resources, it would be most informative to test all of the prime-target combinations in the Master Table in an extensive set of systematically linked experiments. Through careful condition choice, and using a few thousand participants to ensure well-powered experiments, one could in principle tease apart relatively thoroughly how -ing and -in' are related to one another in the lexicon. Further, the same rigorous structure could be applied to other socially meaningful variables like agentive -er (as in *baker*), which would probe the universality of the relationships found for ING. However, that is a huge undertaking, and is a much larger project than I can accomplish in this dissertation alone.

I have therefore strategically selected prime-target pairings that will give us the baseline and framework from which, in future work, many more of the relationships can be systematically tested. In section 3.3.4 I will detail the specific pairings from this table that I will use in this dissertation, but I begin by demonstrating the relevant ways in which primes and targets in ING paradigms are related, before narrowing it down to a practical selection from which we can begin to test these relationships in a systematic and informative way.

Prime	Beginning of word				End of word			
Target = thinkin’	Complete root overlap	Phonological root overlap	Semantic root overlap	Free (pseudo) root	Verbal suffix	Variable ING	Surface phonology	Shared social meaning
thinkin’	✔	✔	✔	✔	✔	✔	✔	✔
thinking	✔	✔	✔	✔	✔	✔	✗	✗
drinkin’	✗	✔	✗	✔	✔	✔	✔	✔
drinking	✗	✔	✗	✔	✔	✔	✗	✗
musin’	✗	✗	✔	✔	✔	✔	✔	✔
musing	✗	✗	✔	✔	✔	✔	✗	✗
jumpin’	✗	✗	✗	✔	✔	✔	✔	✔
jumping	✗	✗	✗	✔	✔	✔	✗	✗
innin’	✗	✗	✗	✔	✗	✔	✔	✔
inning	✗	✗	✗	✔	✗	✔	✗	✗
awnin’	✗	✗	✗	✗	✗	✔	✔	✔
awning	✗	✗	✗	✗	✗	✔	✗	✗
chicken	✗	✗	✗	✔	✗	✗	✔	-
Reading	✗	✗	✗	✔	✗	✗	✗	-
dolphin	✗	✗	✗	✗	✗	✗	✔	-
Irving	✗	✗	✗	✗	✗	✗	✗	-
jiggle	✗	✗	✗	✗	✗	✗	✗	-

Table 3.1: Master Table showing relevant aspects of shared representation between the target *thinkin’* and different prime types

3.3.2 Shared representation for ING

I will start with the ways in which the variants of ING can be related. In Table 3.2 is an extract from the Master Table that shows prime-target pairs that for all important considerations do not have related roots. I therefore zoom in on relationships of interest at the end of the word[1]: where the ING is. The aspects of representation that variable word ends can share have not been diagnosed or well thought out in the same way that we have thought them out for stems. With this in mind, I propose here a basic set of aspects of shared representation (see Table 3.2).

Prime	End of the word			
Target = thinkin'	Verbal suffix	Variable ING	Surface Phonology	Shared social meaning
jumpin'	✔	✔	✔	✔
jumping	✔	✔	✗	✗
awnin'	✗	✔	✔	✔
awning	✗	✔	✗	✗
dolphin	✗	✗	✔	-
Irving	✗	✗	✗	-
jiggle	✗	✗	✗	-

Table 3.2: Aspects of shared representation for the end of primes to target *thinkin'*

Starting on the left of Table 3.2, the first column shows whether the listed prime and target *thinkin'* both have a verbal suffix. The end of the prime *jumpin'* shares the fact that it has a verbal suffix with the target *thinkin'*, as does *jumping*. However, the monomorphemes *awning* (or *awnin'* if pronounced with the -in' variant), *dolphin*, and the place name *Irving*, do not have such a verbal suffix. It is important to observe here that this column "verbal suffix" does not distinguish between possible semantic and/or morphosyntactic contributions of the suffix as they do not obviously dissociate in the examples I am using. Because it is less controversial that the meaning component of that suffix is shared across both

[1]In this dissertation I talk about nouns and verbs that have a variable ING such as *thinking* and *awning*, but also monomorphemic words that are not variable, like *dolphin*. Since only *thinking* has a suffix, I will refer to the -ing or -in' parts of primes that I use as the word end, for lack of a better term.

variants, I will sometimes refer to this aspect of shared representation as "shared progressive/gerundive semantics" [2]. The primes *jumping* and *jumpin'* share these semantics with the target *thinkin'*, whereas *awning* and *awnin'*, although variable, do not.

With that in mind, I must provide a note about the verbal stimuli used in this dissertation. All of the critical stimuli are progressive verbs, but they are *also* gerunds. The experimental paradigm used in this dissertation is an auditory paradigm that presents words in isolation with no sentential context. This means that there is no way for a listener to distinguish whether a word they have heard (e.g. *thinking*) is gerundive or progressive. Furthermore, since most, if not all, progressives can also be used as gerunds, there is in this paradigm no way to use a subset of words that is only a gerund or progressive. It is therefore important to keep in mind that the critical stimuli in this dissertation constitute verbal items and could in principle be processed as either gerundive or progressive.

Moving to the second column of Table 3.2, what *jumpin'/jumping* and *awnin'/awning* both share with *thinkin'* is the fact that they have the variable ING. As discussed in section 2.2, both verbal and monomorphemes are sensitive to sociostylistic constraints and involve making a choice between using the -ing variant or the -in' variant. There is, however, an important asymmetry in which words have the variable ING: most monomorphemes ending in [ɪŋ] are said to be variable, but monomorphemes ending in [ɪn] (such as *dolphin*) categorically are not. Houston (1985) reports one exception to the word-final [ɪŋ] class of monomorphemes, stating that place names such as *Irving* and *Flushing* occur invariantly with the velar [ɪŋ]. Taken together this means there there is a class of variable [ɪŋ]-final monomorphemes (like *awning*), a class of invariable [ɪn]-final monomorphemes (like *dolphin*), and a class of invariable monomorphemic [ɪŋ]-final place names (like *Irving*). This aspect of shared representation is the broadest of the four that I propose in Table 3.2, and may have different moving parts: having the variable ING involves making a choice between variants, but those variants also have their own social meaning and may be linked in some way. I

[2] Note here that what I am calling the "semantics" or "meaning" of the suffix is actually likely to be its syntactic representation. This, however, is still up for discussion, so for now I am using the term "semantics" for simplicity, but the situation is more complex. Although not relevant for the discussions in this dissertation, see Embick et al. (forthcoming) for more on this topic.

therefore anticipate the possibility of reconceptualising this aspect of shared representation as I learn more about how variants are related through the experiments in this dissertation.

The third column in Table 3.2, entitled 'Surface phonology' details whether the end of the prime word overlaps in its surface phonology with the target *thinkin'*. Put simply, *jumpin', awnin'*, and *dolphin* all share a surface [ɪn] with *thinkin'*, whereas *jumping, awning, Irving*, and *jiggle* do not. This is included since priming through string overlap could potentially contribute to priming effects found in this dissertation (see section 2.3.2 for a rhyme-prime background).

A very important thing to note here is that shared *surface* phonology does not necessarily mean shared *underlying* phonology. Just because two words share the same surface form, does not mean their entries in the mental lexicon share the same underlying form. It is possible that between the retrieval of their entry from the mental lexicon and their surface realisation, phonological processes such as a phonological rules or allophony effects caused the surface form to differ from the underlying one. So a word like *thinkin'* could in principle have the underlying phonology of -ing, but be changed via a phonological rule to -in' given the context. This is a hypothesis that I will explore in depth in this dissertation. For the moment, it is simply important to realise that surface and underlying phonology are not the same thing.

The final column in Table 3.2 refers to the social status of the prime-target pairs. This column combines the Variable ING and Surface Phonology columns to highlight shared social relationships or conditioning. The target *thinkin'* has a noncanonical variant at its end: -in'. Primes *jumpin'* and *awnin'* share this variant and, due to their sociolinguistic variability, share the canonicality (or more specifically noncanonicality), of the target. Primes *jumping* and *awning* have the canonical -ing variant, and therefore differ in social status from the target *thinkin'*. The primes *dolphin, Irving* and *jiggle* do not have a variable ending, and therefore do not have an ending that is more or less canonical. If we see a difference in the processing of the -ing versus the -in' variant, then we must take the noncanonicality of the -in' variant into account as a factor that could influence the way that it is processed. This hypothesis will be discussed further in light of the experimental results in this dissertation.

I stated above that I subsetted a critical set of primes from the Master Table to discuss here, but it would be remiss of me to not mention the remaining four primes that share no semantic or phonological root overlap with the target and are in the Master Table, but that are not included here in Table 3.2. These are *innin', inning, chicken,* and *Reading.* The former two primes parallel *awnin'* and *awning*, and the latter two parallel *dolphin* and place-name *Irving*, save for the critical difference that *awnin', awning, dolphin* and *Irving* cannot be aggressively decomposed into a pseudoroot and suffix, whereas *innin', inning, chicken* and *Reading* are in principle decomposable into the roots *inn, chick*, and past tense *read*. As discussed in section 2.3.5, theoretically a word such as *corner* could undergo early decomposition into *corn* and -er, despite this being a superfluous processing step. The psycholinguistic evidence on pseudo-decomposition in auditory priming paradigms is rather unclear, so to avoid pseudo-decomposition effects becoming a confound in my dissertation, I decided to make a distinction between monomorphemes that have a pseudoroot (like *inning*) and those that do not (like *awning*). More research into the effects of pseudo-decomposition in regular non-variable priming is needed to shed light on this situation. At present, I have eliminated it as a confound from my experiments, and will not pursue the topic further.

3.3.3 Shared representation for stems

Now let's return to the beginning of the prime and target words. I will again take as target the verb *thinkin'* with the noncanonical variant -in'. There are three representational aspects that the literature has deemed important when it comes to shared representation of stems: phonological overlap (in this work I use 'phonological overlap' to refer to vowel plus coda overlap), semantic overlap, and complete root overlap. Table 3.3 below shows how primes with different roots but the same suffix relate to the target *thinkin'*. Starting simply, the root in *thinkin'* shares full overlap with the root in *thinkin'*, since they are the same word. The root in *drinkin'* shares phonological but not semantic overlap with the root in *thinkin'*. The root in the infrequent word *musin'* shares semantic overlap with *thinkin'* but no phonological overlap. In theory, it is possible for a root to share both semantic and phonological overlap with another root, yet them not be the same word, but this would require two rhyming verbs with a synonymous meaning[3], of which there are only a few pairs in English: *wink-blink*, *crinkle-wrinkle*, and in American English *boil-broil* (Stockall and Marantz, 2006). I therefore exclude them from Table 3.3.

Prime	Beginning of the word		
Target = thinkin'	Complete overlap	Phonological overlap	Semantic overlap
thinkin'	✔	✔	✔
drinkin'	✗	✔	✗
musin'	✗	✗	✔
jumpin'	✗	✗	✗
jiggle	✗	✗	✗

Table 3.3: Aspects of shared representation for the beginning of primes to target *thinkin'*

In the context of a priming experiment, very basically we expect that the more aspects of shared representation between a prime and target, the larger the facilitation of the response to the target [4]. Thus if we were to test the four conditions in Table 3.3 we would expect the most facilitation from *thinkin'-thinkin'*, the least from *jumpin'-thinkin'*, and in between from the other two. Note here that we are using the same suffix variant across the conditions. The results from these experiments are insightful from two perspectives. First, they tell us whether any differences in priming effects between -ing and -in' are independent of stem-type, and can therefore be attributed to them as pieces in and of themselves. Second, they tell us whether the stem priming effects found for complex words with inflectional suffixes (e.g. by Wilder et al. (2019)), hold up when a noncanonical suffix variant is used. In Chapter 7 I use repeated stem, rhyming stem, and unrelated stem primes to test this.

[3]Note that this is the case because I have defined phonological overlap to refer to vowel plus coda overlap. Phonological overlap could also refer to onset overlap, in which case there are many word sets that share phonological and semantic overlap, such as phonaesthemes like *glow, glare, gloom, gleam, glimmer,* and *glint* (Baayen et al., 2011)

[4]Whether it is the case that facilitation from multiple shared aspects of representation adds up, or is combined in a more complex way (for example through multiplication or a more complex interaction) is not clear (Goodwin Davies, 2018; Gonnerman et al., 2007; Bacovcin et al., 2017)

3.3.4 Systematic and practical experimental approach

The number of ways in which a multimorphemic word such as *thinkin'* can be related to other words ending in -ing or -in' may seem overwhelming, and this is an important reason why sociolinguists (as discussed in section 2.1) often ask questions about the representation of social constraints on variables without considering the influence of phonological, semantic, and morphological factors. Unfortunately, it is not clear to me that one of these aspects can be tested without controlling for and understanding the others, and it is for this reason that I test these relations systematically in this dissertation.

Naturally, from a practical perspective, I cannot test the conditions in Table 3.1 in one go. Not only is there a limit to the number of critical items that can be included in an experiment (due to participant fatigue and the inclusion of sufficient real and nonword filler items), there is also a limited number of available words in the English language, meaning that testing some of the comparisons in the table is simply not possible for statistical power-related reasons. An example of this is the *awning* class of -ing final monomorphemes. There are 17 usable monomorphemes in this class of words, which is simply too few to use in a statistically well-powered experimental design. This is unfortunate, since contrasting *jumping-thinking* with *awning-thinking* helps to diagnose whether the progressive semantics of the variable ING causes target facilitation. If priming is found in *jumping-thinking* but not in *awning-thinking* then this could be attributed to the progressive semantics of the -ing suffix, since neither *jumping* nor *awning* share stem overlap with *thinking*, and they both share surface phonological overlap at the end of the word. With a little creativity, however, there are ways around this problem, for example we could run a small experiment with a large number of participants, responding to a very limited number of critical trials, but such a design is costly and requires careful preparation. This lies outside of the scope of the current dissertation, although it is a logical next step for future research branching off from this dissertation.

Where, then, is the best place to start with this investigation of the mental representation of ING? In this dissertation, I am going to test a subset of the prime-target pairs from the Master Table that aim to address the following three core research questions:

1. Can I reliably detect affix priming for both pronunciation variants of variable ING?

2. Can I detect which aspects of shared representation contribute to processing facilitation of the ING variants?

3. Can I detect differences in processing between -ing and -in'?

As I have mentioned a number of times, the simplest way to probe the representation of ING is to isolate it, such that priming facilitation can only come from a few limited aspects of shared representation. For this reason, I start this dissertation using primes and targets that have unrelated stems. Since one of the things I want to probe is the difference in representation between -ing and -in', I will start by using primes and targets that both have an ING suffix attached to a verbal stem. This leads me to start with prime-target pairs of the form *jumping-thinking*.

In a straightforward auditory affix-priming design, which we know can be used with inflectional affixes (Goodwin Davies and Embick, 2020), I can test whether -ing primes -ing, which is a direct contribution of affix priming with a novel inflectional affix in a well-powered design. Further,in the same design, I can test whether -in' primes -in', which is a novel contribution to this literature using noncanonical pronunciation variants.

Next, in the same paradigm, I can ask whether the variants cross-prime each other. This is an important question since it tells us something about whether -ing and -in' have related mental representations, and give me a baseline from which I can start to tease apart which kinds of relatedness facilitate their processing. If, in the basic affix priming paradigm, I see no priming at all in the cross-variant conditions (which is unlikely), then this would provide evidence for the representation of -ing and -in' as two completely independent pieces in the mind, or for the whole-word storage of verbs with both variants (i.e. we store both *thinking* and *thinkin'* in the mental lexicon). If I do see priming in these cross-variant conditions, then I must ask where that priming comes from. As has been extensively discussed in Chapter 2, and as shown in Table 3.4, it is unclear what the underlying morphological and

Prime-Target	Semantic	Morphological	Underlying Phonology	Surface phonology
jumping - thinking	✔	✔	✔	✔
jumpin' - thinkin'	✔	✔	✔	✔
jumpin' - thinking	✔	?	?	✗
jumping - thinkin'	✔	?	?	✗

Table 3.4: Shared representation for variants in ING-final prime-target pairs

phonological relationships between -ing and -in' are. As discussed in section 2.2.3, what a morphological relationship between -ing and -in' might look like is not clear. Perhaps there are two independent allomorphs for -ing and -in', in which case in the cross-variant conditions that is one less piece of shared representation than in the same-variant conditions, which should lead to less processing facilitation. Simultaneously, another option is that there is one underlying abstract morpheme (say, a piece for ING) that has -ing as the underlying phonological form, and that there is some phonological process is responsible for the derivation of -in'. In that case we would expect most priming for *jumpin'-thinkin'*, since they share semantics, an abstract morpheme, underlying phonology, and also the phonological process deriving -in', and equal priming for the remaining three conditions that share underlying semantics, morphology, and phonology.

Using carefully constructed within- and between-subjects designs, I explore these hypotheses in Experiments 1 and 2 (Chapters 4 and 5).

Next, a crucial consideration for any priming seen in the conditions listed in Table 3.4 is that there are two types of phonological relatedness that could contribute to processing facilitation: underlying and surface phonology. We know that surface overlap can, at least in the visual modality, cause processing facilitation. I therefore want to check whether surface phonology contributes to the priming that we see for *jumping-thinking* and *jumpin'-thinkin'* in Experiments 1 and 2. In Chapter 6, I therefore contrast processing facilitation from *jumpin'-thinkin'* with *dolphin-thinkin'*, because if there is any facilitation from surface string overlap, then this should be detectable in the *dolphin-thinkin'* condition, where surface phonology is isolated from semantic effects and from any facilitation due to the canonicality or variability of -in'.

The choice to use [ɪn] primes and targets here is not arbitrary. This is another example of a case where the limitations of the English language steer the choice of stimuli in order to ask this question using a well-powered experiment. In theory, as we can deduce from the Master Table, I could use *Irving-thinking* compared to *jumping-thinking* to test this surface phonology hypothesis. However, the place-name, invariable -ing final word class (once controlled for homophony: i.e. *Flushing* cannot be used due to its homophony with the verb *flushing*) is far too small to run a well-powered experiment. I am therefore restricted to the monomorphemic [ɪn] word class (e.g. *dolphin, chicken, mission, cousin*) for controlling for surface phonology effects. This word class is substantial and provides ample examples to reliably run this control experiment.

The abovementioned experiments (Chapters 4-6) establish a stable baseline for -ing and -in' affix priming. Once this baseline is in place, I can start to test other prime-target relations from the Master Table. I demonstrate this in Chapter 7 by asking whether the robust affix-priming pattern that is shown in Experiments 1-3 holds up across stem types with varying degrees of relatedness. Put simply, I ask whether the priming pattern seen for the conditions listed in Table 3.4 pertains when the prime and target share the same stem (e.g. *thinking-thinking*) or have stems that rhyme (e.g. *drinking-thinking*). These experiments test whether priming effects seen in Experiments 4-6 stand alone, or whether they can be influenced by aspects of shared representation between the prime and target stems.

To summarise, affix priming for -ing and -in' is established and replicated in Experiments 1-3, 5, and 6. In Experiments 3-6 I probe which aspects of shared representation contribute to the processing facilitation that is established in Experiments 1 and 2. Finally, the differences between the processing of -ing and -in' are made evident in Experiments. 1,2, and 4-6. In the general discussion in Chapter 8, I will discuss the implications of these six experiments for the abovementioned three core research questions.

3.4 Introducing noncanonical word pronunciations into a laboratory setting

So far, this chapter has outlined how we can ask questions about the mental representation of ING using an experimental approach. It is, however, important to acknowledge that introducing noncanonical pronunciations, such as -in', to this methodology is unusual and certainly not trivial. Although creating stimuli with noncanonical variants is relatively simple with a skilled speaker to do the recordings, there are challenges that arise with regard to the perception of words with noncanonical variants in isolation. This section outlines these challenges and discusses solutions I devised to adapt the primed lexical decision task for successful use with noncanonical stimuli like words with an -in' variant.

3.4.1 Naturally produced versus spliced stimuli

One of the benefits of the priming methodology is how it allows the researcher to isolate a particular linguistic feature in a highly controlled setting. However, there is such a thing as a setting that is too controlled.

The studies discussed in section 3.1 isolate a pronunciation variable and compare the processing of canonical to noncanonical variants. In order to isolate the variants, researchers often record a single word frame and using speech manipulation software will splice the canonical and noncanonical variants into the same (often carefully enunciated) word frame (e.g. Andruski et al. (1994) studied word-initial VOT length in words like *king*. They took the carefully enunciated soundfile for *king* with a canonical long VOT, and shortened the VOT using software to create the noncanonical short VOT version of *king*). The idea behind this is that researchers want to avoid phonetic differences between canonical and noncanonical stimuli that could impact the processing of the linguistic features of interest. Many of these studies found a processing advantage for canonical pronunciations over noncanonical ones, and have argued for a representational advantage for canonical forms. McGowan and Sumner (2014) argues however that the splicing of a noncanonical variant into a canonical wordframe creates a contextual mismatch between the word frame and the variant, which could cause a processing delay. In a replication of Andruski et al. (1994), who found a processing advantage for canonical long VOTs over noncanonical short VOTs in a semantic priming task, McGowan (2014) finds that the advantage for canonical forms disappears if the noncanonical variants are produced in a matching word frame. Sumner (2013) found the same by contrasting semantic priming effects to canonical word-medial /nt/ pronunciations, and noncanonical flapped variants in a careful wordframe and produced naturally. This suggests that in order to use priming to tap into spoken word recognition processes, it is important to use naturally produced stimuli as opposed to splicing variants into a single word frame. This does mean giving up some control over how coarticulation may affect RTs to stimuli, but since coarticulation facilitates perception in every day speech, this may actually not be a factor that we want to control out.

3.4.2 Variant duration as a confound

Using naturally spoken variants does add a confound to many studies comparing across pronunciation variants, which is that durational differences between stimuli can impact RTs. Many of the studies that use priming experiments to explore the canonicality advantage (a processing advantage for canonical over noncanonical pronunciation variants - discussed in section 3.1), use variables whereby one of the variants is a reduced form of the other. For example schwa deletion obviously means that no-schwa variants are shorter than words with a schwa (Racine and Grosjean, 2005). This is often controlled for by adding stimulus duration into the mixed-effects models used to analyse this data (Bürki et al., 2018).

The current dissertation actually diverges from much of the prior literature that uses noncanonical variants in priming paradigms because it uses a variable whereby one variant is not a reduction or deletion of the other. The variants -ing and -in' differ in their final phoneme: [ŋ] or [n]. Despite the lack of reduction of deletion in this case, it is still possible that the [ɪŋ] and [ɪn] variants differ in duration. To test this I pulled 10 stimulus pairs (disyllabic ING verbs for which my speaker had recorded both an -ing and an -in' version) from the critical stimuli used in the experiments in this dissertation. Using Praat, I measured the duration of the variants from the onset of the [ɪŋ] and [ɪn], and found an average -ing duration of 228ms and average -in' duration of 225ms. This is highly reassuring that (at least for my speaker) there is no great durational difference between the -ing and -in' stimuli in the experiments in this dissertation.

3.4.3 Variant conditioning by stem-final consonants

Another potential confound that must be accounted for is the reports of **regressive assimilation** for ING. This entails that the choice of ING variant can be conditioned by the preceding consonant, such that a stem-final velar stop significantly favours the -in' variant (e.g. in *speaking*) (Shuy et al., 1968; Cofer, 1972; Houston, 1985). This could have consequences for ING-final critical word pairs in a primed lexical decision experiment. For example, if the prime is *speaking* which favours -in' and the target is either *sending* which favours -ing or *licking* which favours -in', then the target choice could affect priming effects in a way that is complicated to unravel, or at a minimum will require additional testing to confirm.

That being said, there is some evidence that suggests that regressive assimilation may not be problematic for the experiments in this dissertation. Tagliamonte (2004) considered linguistic conditioning differences between ING-final nouns and verbs, and found that preceding phonological segment was a significant conditioning factor only for ING-final nouns, but not for progressive verbs. Nonetheless, in Pilot Experiment B (see Section 3.6), which was a test of the ING-final progressive verb stimuli used throughout this dissertation, I paired my stimuli according to stem-final consonant, and added stem-final consonant as a fixed effect to the linear mixed effects regression model to test for conditioning by preceding phonological segment, but it did not significantly affect participant response times. Since this is in line with Tagliamonte's (2004) finding for progressive verbs, it is further omitted as a control factor from the analyses in Chapters 4-7 in this dissertation.

3.4.4 Speaker characteristics

This research is not the first study to use primed lexical decision to examine phonological variation. It is, however, one of the first to use a fully auditory design to study *sociolinguistic* variation. The papers discussed in section 3.1 consider variables such as English place assimilation, or VOT duration, which are variables common to most, if not all, varieties of English. A key difference with sociolinguistic variables is that they are socially conditioned, and often differ in usage between socially differentiated groups of speakers, or at least, and adding an important layer of complexity to this issue, they are *thought* to differ in usage between different groups. As was discussed in section 2.2 of Chapter 2, ING is conditioned by among others, socioeconomic status, regional accent, and age.

These social conditioning factors on ING variant usage mean that listeners may form an expectation of how much -ing and -in' a speaker will use based on their social profile. For primed lexical decision tasks, this means that the researcher must bear in mind the fact that the speaker that they choose to record stimuli will likely give listeners an expectation of how much -ing or -in' they use. The way in which listener expectations affect lexical access when sociolinguistic variants are used is a fascinating topic of research that can be explored using the ING priming baselines detailed in this dissertation.

In order to establish a baseline, I chose to use a male upper-middle class speaker in his mid-twenties who is from Massachussetts (not the metropolitan Boston area). His accent is close to what has often been described as a "General American" accent, and is not distinguishable as from a specific region other than perhaps the general north-east of the USA. His accent should therefore not give listeners much explicit information about his ING variant usage, or at best they should expect him to use -ing more in formal contexts, and -in' more in informal contexts (see section 2.2.2.2 for ING conditioning by style). Additionally, the speaker is a linguist familiar with making recordings for linguistic research purposes, so easily produced naturalistic instances of both -ing and -in' versions of all of the ING-final words in this experiment. Altogether, this speaker was chosen for their relatively neutral accent when it comes to the social conditioning of ING usage.

3.4.5 Response accuracy to noncanonical stimuli

As this chapter discusses, in priming experiments like those in this dissertation participants hear words in isolation and respond whether they think that that word is real or not. This is by definition not a natural way of perceiving spoken language. However, more unnatural still is to hear a word in isolation in a laboratory setting that contains a noncanonical variant that is often associated with casual speech. Put simply, participants do not expect to hear a word like *thinkin'* in isolation and in a more formal experimental context. It is simply out of place, which may make it harder to process.

Previous studies that have used noncanonical variants have dealt with this in a variety of ways, the most common being the use of a paired lexical decision paradigm (described in section 2.3.1). Recall Sumner and Samuel (2005), discussed in section 3.1, who used the canonical released /t/ variant (e.g. in *flute* as [flut]), the noncanonical glottalised /t/ (e.g. [fluʔt̚]) and glottal stop (e.g. fluʔ]) variants, and an illegal feature mismatched variant (e.g. [flus] using /s/ instead of a legal variant of /t/). In their semantic priming paradigm, they use a paired lexical decision design in which participants only decide whether the second word of a pair is a real word of English or not. Since the /t/-final words are all primes, this means that participants never have to make an overt decision whether a word with a noncanonical variant is real or not. Unfortunately, since I would like to test bi-directional relationships between variants (i.e. does *thinkin'* prime *thinking*, but also, does *thinking* prime *thinkin'*?) I need to be able to use -in' final words as targets, so I need a design in which participants do respond to words with noncanonical variants. It is possible to use targets with noncanonical variants in a paired design as Sumner and Samuel did in their (2009) paper on word-final rhoticity (e.g. *fɪltɚ-bɛikə*). However, the prime always contained a word-final rhotic (either r-ful or r-less), explicitly cuing an upcoming rhotic in the target, and even with this cuing (which is problematic for reasons described in section 2.4.3), accuracy rates for words with noncanonical variants are much lower than for words with canonical variants.

This raises an interesting question: why are accuracy rates lower for noncanonical variants? As will be shown in Pilot Experiment A (see section 3.5), I encountered the same accuracy problem, although more extreme, in a continuous lexical decision paradigm. Lower accuracy rates in any priming paradigm means that participants are processing the word in question as a nonword, or are at least choosing the nonword key as their lexical decision. Participants assume a certain level of formality when doing experiments such as these, so a casually pronounced word in isolation may seem too out of place when the participant expects to hear citation forms of words. It is possible that this discrepancy between expectation and perceived pronunciation leads a participant to believe that what they heard was not a real word, instead of a real word just pronounced in a casual way. Nonetheless, listeners hear casual pronunciations of words on a daily basis, and in many cases canonical variants are not the most frequently used variants. This means that listeners hear the noncanonical variants much more often than they do the citation forms. It is therefore interesting that top-down expectation violation could affect the recognition of words pronounced with a noncanonical variant to such an extent that they are recognised as nonwords. This relationship between what participants will process as a nonword, and how that relates to noncanonical pronunciations is a potentially interesting topic of research that falls outside of the scope of this dissertation. Nonetheless, it is clear that I must use a well-designed methodology to ensure that when hearing words with noncanonical variants in isolation, participants can process and accept them as real words.

3.5 Pilot Experiment A

This pilot experiment set out to test two baseline hypotheses:

1. Can we get regular repetition priming (*thinking-thinking*) using new -ing stimuli?

2. Can we get cross-variant priming with a repeated stem (*thinkin'-thinking*)?

There were three conditions in this pilot experiment, as shown in Table 3.5. The unrelated control condition paired a disyllabic word with no word-final [ɪŋ] or [ɪn] sound with -ing final targets (e.g. *jiggle-thinking*). This pilot was set up to test-run the first recorded set of -ing and -in' stimuli, and therefore only two critical prime conditions were included. Both conditions had a repeated stem across prime and target. The difference between them was that in one condition the prime had a canonical variant (e.g. *thinking-thinking*) and in the other it had a noncanonical variant (e.g. *thinkin'-thinking*). Significant facilitation in both conditions due to the repeated stem (i.a. Forster and Davis, 1984; Wilder et al., 2019) was expected, and a further comparison of interest was whether there would be a similar or different priming effect for the cross-variant *thinkin'-thinking* condition, compared to the same-variant *thinking-thinking* condition.

Condition type	Example prime	Example target
Repeated stem + canonical suffix	*thinking*	
Repeated stem + noncanonical suffix	*thinkin'*	*thinking*
Unrelated control	*jiggle*	

Table 3.5: Prime and target design Pilot A

3.5.1 Stimuli

The stimuli for this experiment consist of 69 critical targets that are all disyllabic progressive verbs ending in -ing (see Table 3.5.1 in Appendix B). These targets were carefully chosen such that they are not homophonous in their progressive form, and also their stems do not have multiple meanings besides the verbal one intended in the target progressive. The primes are also all controlled for homophony. Words with medial /t/ or /d/ that could be flapped were excluded, as were words whereby the addition of a progressive suffix caused a phonological change to the stem. The unrelated stem primes were frequency matched to the targets using the CDlog10 frequency measure from SUBTLEX-US (Brysbaert and New, 2009).

The stimuli were all recorded by a male speaker of mainstream American English who is in his mid-twenties. He was asked to produce both -ing and -in' primes, and after checking that there were no large durational differences between the variants and whole primes (e.g. between *thinking* and *thinkin'*), for the sake of naturalness the unmanipulated soundfiles were used. All stimuli were recorded in a sound-attenuated booth using a high-quality microphone.

3.5.2 Procedure

Seventy-two participants from the University of Pennsylvania Psychology Subject Pool completed the experiment in the fall semester of 2020. Each participant completed an informed consent form, and the experimental protocol has IRB approval. Participants received course credit for their participation.

The experiment was run online using the PennController in Ibex, an online experimental software (Drummond, 2018; Zehr and Schwarz, 2018). Participants completed the experiment at home and were instructed to use headphones. Written instruction informed the participants that they would hear words of American English, and needed to determine whether what they heard was a real word or a nonsense word. They were instructed to press a left-hand key with their left index finger if the word was not real, and a right-hand key with their right index finger if the word was real. They then completed 40 practice trials (50% nonwords). These trials included 4 ING words (3 -ing, 1 -in'), and 4 words ending in -ment (3 with released /t/, 1 with a final glottal stop). Participants were then reminded to work quickly and accurately before starting the critical experimental trials.

Participants were randomly assigned to one of 3 lists. Each list contained all 69 targets, paired with 33 primes from each critical condition, as per a between-subjects design. Each list also contained a standard set of 198 filler pairs, totaling 534 items in total. The items were presented in three blocks (1/3 of the critical items per block), between which participants could take a short break. The experiment took participants around 20 minutes to complete. The inter-stimulus-interval (ISI) was 400-600ms, randomised to ensure participants could not just respond at regular rhythmic intervals. The ISI started at either the participants' response or the end of the soundfile, depending on which was later. Response time was measured from the beginning of the soundfile to the buttonpress.

3.5.3 Results and discussion

The results of this pilot experiment were unusable for modeling purposes. The simple reason for this is that participants had a mere 56% accuracy rate to primes containing an -in' variant (compared to a 93% accuracy rate for primes ending with -ing), as shown in Table 3.6. In a lexical decision experiment such as this, trials for which participants responded incorrectly to either prime or target are discarded before the data is trimmed and modeled. This would mean removing half of the -in' trials, which does not leave enough data to model and draw conclusions from. Inspection of the raw average reaction times for the *thinking-thinking* condition compared to the *jiggle-thinking* condition did show around 200ms facilitation, which is a large repetition priming effect. However, since this cannot be statistically examined, the more important result of this pilot is the chance level accuracy rates of participants to words ending with -in'.

Prime condition	Prime Accuracy	Target Accuracy
thinking	93	98
thinkin'	56	96
jiggle	89	94

Table 3.6: Accuracy scores by priming condition in Pilot A

Interestingly, as can be seen from the density plot in Figure 3.1 which shows how speakers clustered according to their accuracy score on the primes ending in -in', we seem to be dealing with a bimodal distribution. A subset of the participants recognise -in' final words as real words the majority of the time, albeit not quite as well as they do -ing final words. However, a smaller yet not insubstantial group of participants recognise primes with an -in' variant as real words less than 30% of the time. This dichotomy is not easy to explain. Clearly, it is possible that the violation of participants' expectation of hearing citation form words in a formal experimental setting is too great, and means that they cannot parse a noncanonical pronunciation of a word as being a real word. This is fascinating since listeners hear noncanonical pronunciations of words all day, every day, so the overriding of the frequency of exposure by expectation violation is very intriguing. Another option is that because participants hear disyllabic nonwords with late disambiguation points in the experiment, they may parse the -in' final primes as nonwords with late disambiguation points. In other words, the task may be too hard. However, neither of these explanations explains why we see participants clustering into two groups. This bimodal pattern is highly intriguing and forms a potentially fruitful research topic.

For my current purposes, however, I needed to change the experimental design such that participants would process noncanonical pronunciations as being existing words of spoken American English. There were a number of options: using a paired design, as discussed in section 3.4, and using either explicit or implicit training and instructions.

3.6 Pilot Experiment B

Seventeen participants from the University of Pennsylvania subject pool participated in Pilot B. This experiment is identical in stimuli and design to Pilot A. The only change was in the instructions and practice items, preceding the actual experiment.

3.6.1 Procedural differences with Pilot Experiment 1

As in Pilot A, participants completed a consent form. Then, written instruction informed the participants that they would hear words of **spoken** American English, and needed to determine whether what they heard was a real word or a nonsense word. The difference with the instructions in Pilot A was the addition of the word 'spoken' to the information that they would hear words of American English. Further, a line was added that informed participants that they may hear words spoken in a casual way, but that these still constitute real words of spoken American English. Next, they were given 8 clips of words such as *basement* with the word-final /t/ both present and glottalised, to give them an idea of what it means to hear words pronounced in a casual way. Like in Pilot A, they then completed 40 practice trials, although now with less nonwords (35%), and more noncanonical variants: these trials included 10 ING words (3 -ing, 7 -in'), and 10 words ending in -ment (4 with released /t/, 6 with a final glottal stop).

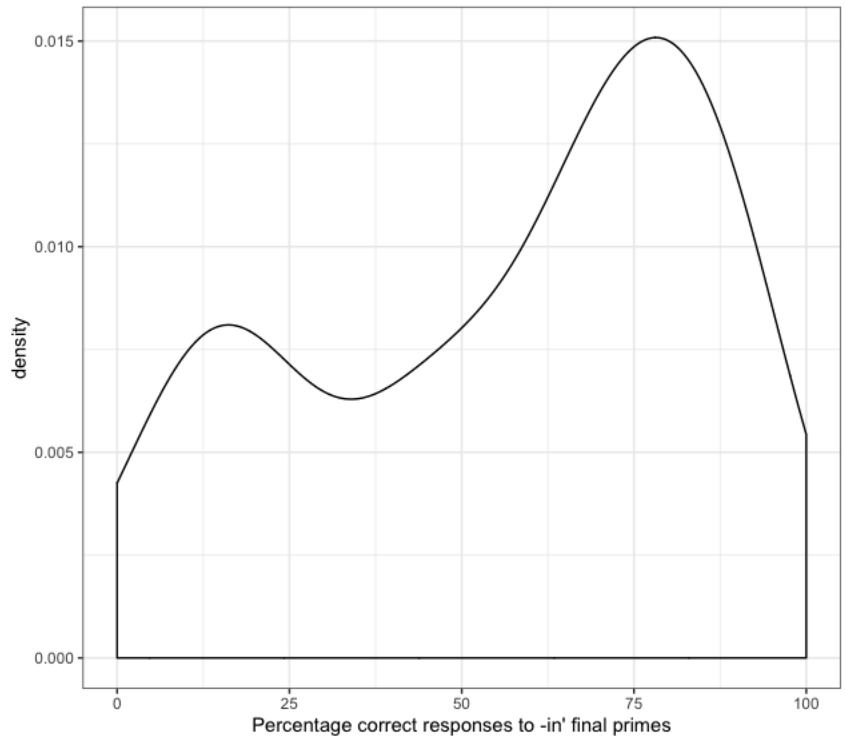

Figure 3.1: Pilot A: density plot of rate of correct responses to -in' with no explicit instruction

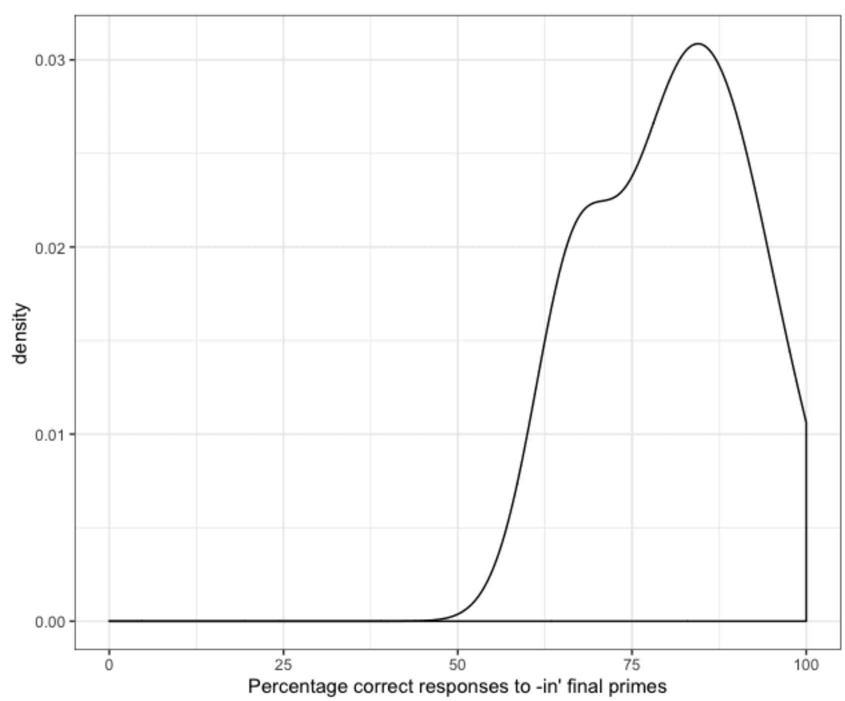

Figure 3.2: Pilot B: density plot of rate of correct responses to -in' with explicit instruction and noncanonical practice trials

3.6.2 Results and discussion

As can be seen in Figure 3.2, the accuracy rates to primes with word-final -in' are much improved as a result of this explicit instruction to treat casually pronounced words as real words of spoken American English. The average accuracy rate is 82%, which, although still lower than for the primes ending in -ing, is a lot higher than in Pilot A, and well above chance level. It seems that the explicit information that a participant would hear casually pronounced words, paired with additional practice items with noncanonical variants successfully lowered expectations of formality or at least allowed participants to process -in' primes as real words.

The explicit permission to process words with noncanonical variants (or that are pronounced in a non-citation form) as real words clearly led to a substantial improvement in accuracy rates to noncanonical ending primes. This method can therefore be used for my purposes of teasing apart aspects of shared representation in an auditory priming paradigm. However, it is important to note that it is interesting that explicit highlighting of the fact that noncanonical pronunciations are still real words influenced a process that we think is an automatic bottom-up cognitive process. We do not usually think of lexical access as a process that can be easily influenced by top-down conscious mechanisms, so there remain questions around this accuracy issue that warrant exploring in the near future. For now, I will proceed with this explicit instruction procedure, but it is worth highlighting that a novel puzzle ripe for exploration has emerged from these pilots.

Chapter 4

Affix priming of -ing and -in'

Section 3.3 in Chapter 3 of this dissertation discusses how experimental priming can be used as a tool to tap into aspects of shared representation in cases that involve sociolinguistic variation. For a case like variable ING, whereby the sociolinguistic variable is found in a suffix , disentangling aspects of shared representation is complicated by the fact that words that have a suffix consist of multiple discernable parts. Setting aside the fact that different models of the lexicon deal with this in different ways, a complex word like *thinking* gives us the semantics of pondering or ruminating on an idea or concept, as well as progressive verbal semantics, and the first part (or stem) and second part (or suffix) of the word have their own phonology. It is for this reason that the Master Table of aspects of shared representation in Table 3.1 separates the beginning and end of words when listing possible aspects of shared representation.

Crucially, the current dissertation aims to examine the representation of the variable suffix ING, which means that we are primarily interested in the aspects of shared representation that are unrelated to the first part of words containing an ING. We know from identity priming studies (Forster and Davis, 1984; Scarborough et al., 1977) and from morphological priming studies looking at word stems in complex words (Wilder et al., 2019; Kouider and Dupoux, 2009; Rastle et al., 2004; Marslen-Wilson et al., 1994) that stem repetition elicits a priming effect when complex words are used as prime-target pairs in lexical decision experiments. For example, Wilder et al. (2019) finds using an auditory continuous primed lexical decision paradigm that *frogs* primes *frog* and vice versa. Although interesting, and a topic that I will revisit experimentally in Chapter 7 of this dissertation, this evidence of stem-priming effects means that when contrasting a prime-target pair like *thinking-thinkin'* to *thinking-thinking*, priming effects caused by shared representation of the suffix could be hard to disentangle from stem priming effects such as those found by Wilder et al. (2019) and Kouider and Dupoux (2009), among others. For this reason, the experiments set out here in Chapters 3, 4, and 5 of this dissertation isolate aspects of shared relatedness to the end of the prime-target word pairs. Put simply, all critical prime-target word pairs in these experiments have unrelated verbal stems (e.g. *jumping-thinking* or *jumpin'-thinking*).

As shown in the excerpt of the Master Table, shown in Table 4.1, there are multiple aspects of shared representation to tease apart. But before we can even begin to tackle this by using carefully selected prime-target pairs, we must establish three very basic facts about variable ING. First, whether we actually get a suffix priming effect at all using the canonical -ing suffix: affix priming has only been attempted once using -ing (Emmorey, 1989), but this study and others in this literature often suffer from being severely underpowered and showing mixed results, so establishing that *jumping* reliably primes *thinking* is a critical baseline for this dissertation. Second, direct affix priming using unrelated stems and noncanonical variants has also not been done before, so parallel to establishing that -ing primes -ing, we must establish that -in' primes -in'.

Prime	End of the word			
Target = thinkin'	Progressive semantics	Sociolinguistic variable ING	Phonological [ɪŋ] or [ɪn]	Phonological overlap
jumpin'	✔	✔	✔	✔
jumping	✔	✔	✔	✗
jiggle	✗	✗	✗	✗

Table 4.1: Aspects of shared representation for the end of primes to target *thinkin'*

4.1 Experiment 1

The above can be condensed into three critical research questions that are tested in Experiment 1:

1. Does -ing prime -ing?

2. Does -in' prime -in'?

3. Does -ing prime -in' and vice versa?

The hypotheses for these research questions come from quite different lines of research. The first of these questions addresses a fundamental question underlying affix priming studies; does an affix in a prime word facilitate the processing of that same affix in a target word, even when the stems are unrelated? This question has been addressed for example by Goodwin Davies and Embick (2020), who ask whether the English inflectional plural morpheme -s shows affix priming in a continuous auditory lexical decision paradigm like the one used in this dissertation. The authors ask whether a prime like *crimes* facilitates the processing of a target like *trees*, whereby both end with the plural morpheme -s (and whereby they share the same pronunciation /z/). They find that plural primes facilitate the processing of plural targets by 18.3ms, compared to singular primes (i.e. contrasting *crimes-trees* to *crime-trees*). From this result we can predict that in a similar experimental design, we should expect to see significant priming for -ing-ing prime-target pairs compared to an unrelated baseline.

Although this has not been directly tested in the affix priming literature, if we hypothesise that -ing primes -ing, then by extension we would expect that the alternate pronunciation variant of -ing, namely -in', should prime itself as well. Some experimental evidence supporting this hypothesis comes from Sumner and Samuel (2009) who find that (for listeners from New York City, where non-rhoticity is common), primes ending in an orthographic -er pronounced as a non-rhotic schwa gave a ∼60ms priming effect to targets ending with an -er pronounced as a schwa, but that started differently (e.g. *filter-baker*). Since some of the words in this study are morphologically complex and have an -er suffix (such as the agentive *baker*), but others do not (e.g. *filter* or *soccer*), these results do not completely parallel what I am asking in this study about variable ING. Nonetheless, they do show priming of a non-canonical word-final pronunciation across different words, which means we can hypothesise a similar, potentially more robust priming effect for -in'-in' pairs, since they share both morphological complexity, phonological identity, and progressive semantics, whereas the discussed -er stimuli share only phonological identity.

Further experimental evidence supporting this hypothesis comes from the canonicality advantage literature discussed in Section 3.1. To recap the most relevant result, LoCasto and Connine (2002) find that non-canonical primes with a deleted schwa prime non-canonical targets with a deleted schwa in word-pairs that share a stem (e.g. *believe-believe* whereby in both prime and target the schwa is deleted from the first syllable). An important note here is that a) schwa-deletion is not a socially salient variable, b) the variable occurs word-medially in morphologically simplex words, and c) this is repetition priming. Nonetheless, this result does give some credence to the hypothesis that non-canonical variants will prime themselves.

The canonicality advantage priming literature, and in particular the LoCasto and Connine (2002) study, is more suited to inform the third of my research questions. It asks whether the variants will cross-prime each other. LoCasto and Connine (2002) find (for two-syllable words) an asymmetry in how canonical and non-canonical targets are facilitated. They find that for canonical targets, same-variant primes prime better than cross-variant primes. By contrast, for non-canonical targets, they find that same- and cross-variant primes give similar sized priming effects. They argue that this is evidence for a processing boost for canonical variants, and that this processing boost is making up or reducing the processing disadvantage that should be caused by simple phonological difference for cross-variant conditions compared to same-variant conditions.

This gives us two reasonable hypotheses for research question three. First, we can predict, by all of our reasoning about shared aspects of representation, that phonological overlap for same-variant conditions should facilitate processing compared to cross-variant conditions where there is no phonological repetition. This would result in -ing priming -ing better than -in' does, and -in' priming -in' better than -ing does. By contrast, if we follow the canonicality advantage hypothesis, we could predict that for -in' targets, this phonological facilitation will be evened out by a processing advantage for -ing primes, which would result in both -ing and -in' giving similar processing facilitation to noncanonical -in' targets, and for -ing targets, -ing gives a much larger priming effect than -in' does (larger also than -in'-in' priming).

4.2 Method

4.2.1 Participants

The participants for Experiment 1 were 67 native North American English speakers studying at the University of Pennsylvania. All were recruited through the university's Psychology subject pool, and were awarded course credit for their participation. Participants were randomly assigned to one of 5 lists. Each list contained all 60 targets, paired with 12 primes from each critical condition, as per a within-subjects design.

4.2.2 Materials and design

The critical stimuli in this experiment consist of 60 of the 63 prime-target pairs tested in Pilot Experiments A and B (see Section 3.4.5). The specific critical stimuli in this experiment are listed in Appendix C. All primes and targets are disyllabic. The targets consist of 60 progressive verbs. In Experiment 1, half of the targets have a word-final -ing (e.g. *thinking*), and half a word-final -in' (e.g. *thinkin'*) (counterbalanced in a Latin-square design). The primes are either progressive verbs with an -ing (e.g. *working*), progressive verbs with an -in' (e.g. *workin'*), or an unrelated disyllabic simplex verb (e.g. *jiggle*). This results in two target types: -ing targets and -in' targets, and three prime types: -ing primes, -in' primes, and control primes which serve as the phonologically, morphologically, and semantically unrelated baseline. None of the progressive prime-target pairs shared phonological or semantic overlap of their stems. See Table 4.2. Prime-target pairs are matched for stem frequency to avoid pairs with a high frequency prime but low frequency target or vice versa. Frequency for primes and targets was extracted from the SUBTLEX-

US (Brysbaert and New, 2009) corpus and was included as a predictor in the regression model.

A total of 198 filler pairs (see Appendix A) were used to a) distract away from the critical variable ING by ensuring that only 23% of the pairs were critical items, and by using real words with no ING pronounced in casual and more formal ways (e.g. *basement* pronounced with a word-final glottal stop, and *swimmer* pronounced non-rhotically), b) ensure that participants encountered strings resembling the variants of ING in nonwords as well as real words (e.g. in nonwords like *runnink* or *watchint*), and c) to ensure that 50% of the trials in the experiment were nonwords. The nonwords in this experiment included disyllabic nonwords with late disambiguation points (e.g. RABBISK) to ensure that participants had to listen to the end of each word (where the ING variable is located when it occurs) before they could decide if the word was a real word of spoken North American English or a nonword.

Prime type	Example prime	Example -ing target	Example -in' target
-ing	*jumping*		
-in'	*jumpin'*	*thinking*	*thinkin'*
Unrelated	*jiggle*		

Table 4.2: Conditions and example critical items for Experiment 1. -ing and -in' targets were paired with each of the three prime types, creating six critical conditions.

4.2.3 Apparatus

The stimuli were recorded by an adult male native speaker of North American English from Massachussetts/New Jersey (not from Boston) who is a PhD student in Linguistics. They were recorded in a sound-attenuated booth using a high-quality Blue Snowball iCE microphone. Soundfiles were segmented using Praat (Boersma and Weenink, 2002) and normalised to a peak amplitude of 70 dB SPL. The task was implemented using the PennController for IbexFarm, an online platform for running online experiments (Zehr and Schwarz, 2018). Participants completed the experiment on their personal computers using headphones.

4.2.4 Procedure

The experiment was preceded by a consent form. Participants were then informed that they would hear real and nonsense words of **spoken American English**, and that they would have to determine whether what they heard was a real word or not. This was further elaborated on by informing participants that some of the words they would hear may be pronounced in a casual way, but that casually pronounced words are still real words of spoken American English, as per the instruction protocol tested in Pilot Experiment B (Section 3.6). Participants were presented with soundclip examples of words pronounced with an -in' and words pronounced with a word-final glottaled /t/. This elaboration was motivated by pilot work that showed that the formality of doing a research experiment meant that with no instruction on the acceptability of casual pronunciations, participants are likely to report these as nonwords. To conclude the setup before the start of the experiment, participants completed 40 practice trials, including ING and -ment final words pronounced in formal and casual ways, and were given written feedback on each practice trial (e.g. *"Correct, because you can say 'She was callin' her mother.' "* or *"Incorrect, because you can say 'The basemen' flooded in the storm.' "*.

The task was a continuous primed lexical decision task. Participants responded 'Word' and 'Nonword' through button presses on their keyboard and were instructed to use their index fingers on two hands to press the keys. This experiment consisted of six lists, with the three prime types matched with each of the two target types in a Latin Square design, which meant that each participant saw each target only once. An inter-stimulus interval (ISI) of 400-600ms was used, and this was measured from the end of the prime soundfile or the participant's response to the prime (whichever was later) to the onset of the target. The stimuli were spread across three blocks, with randomised stimulus presentation within the blocks. After each block, participants had the option to take a break before continuing the experiment. In total, the experiment took participants around 25 minutes to complete.

4.2.5 Modelling

Responses in the experiment were coded for accuracy (was a word correctly identified as a real or nonword?) and for response time (RT; measured in milliseconds from the onset of the prime or target soundfile). Participants with an overall accuracy of lower than 80% were excluded from the dataset resulting in an exclusion of 10 participants from Experiment 1. Next, all trials to which either the prime or target received an incorrect response were discarded. We combined minimal a priori data trimming with post-fitting model criticism, as is recommended by Baayen (2010). All primes and targets with RTs shorter than 250ms and longer than 2000ms were excluded (45 data points). The RT data were log-transformed and any remaining outliers for specific individuals or items, as determined by Shapiro-Wilk's tests for normality that showed non-normal distributions, were removed (166 data points). The a priori trimming resulted in the removal of 6.8% of the total number of critical correct observations, leaving 2895 observations for the linear mixed effects regression analysis.

Log-transformed RTs were analysed using linear mixed-effects models, using the lme4 package in the R environment (Bates et al., 2015). Initially, a maximal random-effects structure was fitted. However, as this model was overfit for the data it was pared down: we determined that the optimal random-effects structure that fit the data consisted of random intercepts for Participant and Target, so random slopes were removed from the model. The following main effects were included in the model: PrimeType (Unrelated/ing/in), TargetType (ing/in), TrialNumber, logPrimeFrequency, logTargetFrequency, and PrimeRT. PrimeType and TargetType are treatment coded. Following (Baayen and Milin, 2010), model criticism was performed in order to identify overly influential outliers. Data points with absolute standardised residuals greater than 2.5 standard deviations were removed from the dataset (55 data points), after which the model was refitted. The below results are those of the final post-criticism models. Significant p-values are reported at p<0.05, and were obtained using the lmerTest package (Kuznetsova et al., 2016). Critical comparisons between the levels were performed using the emmeans package in the R environment, which adjusts the p-values using the Tukey method to account for multiple comparisons.

4.2.6 A note on accuracy

The analyses in these experiments only use trials in which participants respond correctly to both prime and target. All incorrect trials are discarded. However, the use of non-standard variants in an experimental setting, and outcome of Pilot Experiment A, warrant taking a look at how accurately participants respond to -in' words in comparison to -ing and other words pronounced in a standard way in Experiment 1. We extracted accuracy scores to the three different prime types: unrelated disyllabic verbs (e.g. *jiggle*), -ing verbs (e.g. *jumping*), and -in' verbs (e.g. *jumpin'*). The unrelated and -ing verbs are responded to with 92% and 95% accuracy respectively. However, only 79% of -in' verbs are responded to correctly. An experimental setting generally leads to an expectation of more formal/standard pronunciations, and this specific experimental setup adds to this expectation because words are presented in isolation, not in sentential context. It is extremely rare to hear a non-standard pronunciation when words are produced in isolation, and this expectation violation surfaces in the accuracy scores to -in' final words. Despite the lower accuracy for -in' words, there is enough data left to continue with the analysis.

4.3 Results

In Table 4.3 you can find raw mean reaction times per condition and the priming effects in ms.

	ing target		in' target	
	RT in ms(SD)	Priming effect	RT in ms(SD)	Priming effect
Unrelated prime	992 (116)	NA	1022 (121)	NA
ing prime	948 (111)	44	971 (114)	51
in' prime	956 (113)	36	938 (111)	84

Table 4.3: Experiment 1: mean response times and priming effects to targets (in ms) per prime and target type. Standard deviations are shown in parentheses.

Priming effects for the critical conditions are shown in Figure 4.1. Starting with the -ing targets, analysis of the log-transformed reaction time data showed significant priming effects of 44ms for -ing primes (β = -0.05, p <0.001) and 36ms for -in' primes (β = -0.04, p <0.001), compared to the unrelated baseline condition. There was no significant difference between these two priming effects (β = 0.008, p = 0.55). For -in' targets, the log-transformed reaction time analysis yielded significant facilitation of 51ms for -ing primes (β = -0.05, p <0.001), and 84ms for -in primes (β = -0.09, p <0.001) compared to the unrelated baseline. By contrast to the -ing target condition, these two priming effects do differ significantly from each other (β = -0.03, p <0.001). There was no significant difference between the unrelated baselines for -ing versus -in' targets (β = 0.03, p <0.09).

As expected for a lexical decision task, both logPrimeFrequency (β = 0.007, p <0.05) and logTargetFrequency (β = -0.03, p <0.01) were significant in the model, along with PrimeRT (β = 0.0005, p <0.001), indicating that when a participant responds slower to a prime, they also respond slower to its target. Interestingly, TrialNumber (β = 0.003, p = 0.75) was not a significant predictor, indicating that participants did not slow down as the experiment progressed.

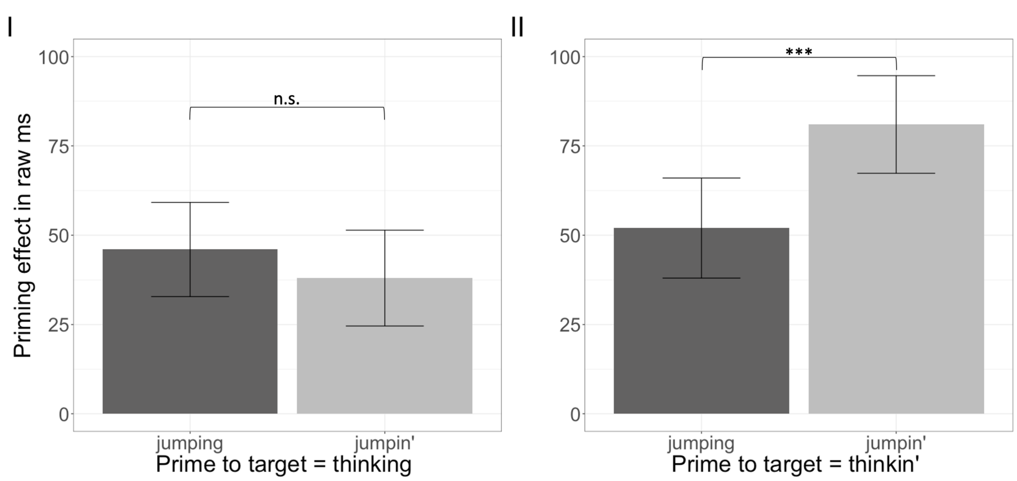

Figure 4.1: Experiment 1 results: priming effects to target *thinking* in I, and to target *thinkin'* in II, in raw ms, comparing ING prime conditions to unrelated baseline prime condition (e.g. *jiggle-thinking*).

4.4 Discussion

Experiment 1 investigated affix priming using the two pronunciation variants of ING in a continuous auditory lexical decision paradigm. I asked simply whether, when primes and targets have unrelated stems, -ing primes -ing, -in' primes -in', and whether the variants cross-prime each other.

In Figure 4.1 we can see significant priming in all of the critical conditions pairing and crossing ING variants compared to the unrelated baseline (*jiggle-think[ing/in']*). Before we even consider the differences in priming magnitude between the conditions, we must acknowledge that this finding is in itself meaningful for the affix priming literature in its own right. It parallels the result found by Goodwin Davies and Embick (2020) for English plural affixes, and is responsive to their call for this result to be replicated using other affixes. In their discussion, Goodwin Davies and Embick (2020) mention that the magnitude of their priming effects differ significantly from those found in studies that used repeated stems (e.g. *thinking-thinking*), and that this could result from representational differences. They suggest that it therefore may be fruitful to consider priming effects as a percentage speedup across the duration of the stem/affix. They compare priming effects from their affix priming study to a stem priming study by Wilder et al. (2019) and find that the effect sizes are comparable if percentage speedup over the duration of the stem/affix is used [1]: 15% facilitation across the duration of the English plural affix versus 11% and 15% speedup across the duration of the stems in Wilder et al. (2019)'s plural-singluar stem priming study (e.g. *frogs-frog*). In Experiment 1, the duration of the -ing suffix is on average 228 ms and the mean duration of the -in' suffix is 225 ms. The percentage speedup for -ing-ing priming is 22%, which is in the same ballpark albeit slightly larger than the facilitation found in Goodwin Davies and Embick (2020) and Wilder et al. (2019). This lends support for the idea that what I am measuring in Experiment 1 is morphological priming as has been found in prior psycholinguistic studies.

Considering the research questions for this experiment, then, it is evident that we find

[1] This is calculated by dividing the mean priming effect by the mean duration of the suffix.

robust -ing-ing priming. This contributes to the auditory affix priming literature on inflectional affixes. Further, we also find strong -in'-in' priming. In a sense, this result is more important since until now, straightforward affix priming using noncanonical variants has not been done. It tells us that the canonical -ing and noncanonical -in' are processed in similar ways in primed lexical decision tasks. This is good as it supports the idea that we can use this methodology to test and contrast the processing of canonical versus noncanonical variants in a highly controlled way. Lastly, and in support of that statement, we see cross-variant priming in both the -ing-in' and -in'-ing directions. This tells us that the pronunciation variants have related representations, and are at the very minimum not two completely independent unrelated pieces. Therefore, as far as the simple question of "Do the variants prime themselves and each other?" goes, the answer is a resounding they do. What is however unexpected and more interesting, is the pattern of priming seen across the the conditions.

Figure 4.1 shows an asymmetrical pattern of priming effects across the different target types. We see in the left panel that for -ing targets, there is no significant difference between the observed priming effects between -ing and -in' primes. However, in the right panel, for the -in' targets, there is a significantly larger priming effect for same-variant primes compared to cross-variant primes. From this point on I will call this pattern the **ing/in' asymmetry**, and I will call the significantly larger facilitation in the -in'-in' condition over the other conditions the **-in' boost**. This asymmetry can be looked at from two interconnected perspectives.

Considering the literature discussed in Section 2.3.2 on more shared representation causing larger priming effects, we hypothesised that same-variant conditions would yield comparatively larger priming effects than cross-variant conditions, due to more representational overlap. Experiment 1 does support this hypothesis, but *only* for the -in' final targets. If we only consider this condition, then the result of Experiment 1 aligns with hypotheses about shared representation. However, the fact that we do *not* see an -ing-ing boost (henceforth **-ing boost**) suggests that perhaps the same-variant processing advantage here is caused by something besides more representational overlap; if that were the sole cause, then we would expect it not to matter whether the targets ended in -ing or -in', we would expect the same pattern across target types. The difference in same- versus cross-variant priming with -in' targets therefore at this stage has a source that has yet to be determined.

By contrast, under a hypothesis that the lexicon has a single progressive/gerundive suffix stored that is underspecified for phonological form, one could argue that we should expect to find equivalent priming across same- and cross-variant conditions (i.e. we would just detect suffix priming of the underlying ING in all conditions). Experiment 1 supports this line of thinking, but *only* from the results for -ing targets. However, even if underlying suffix priming is causing priming in the -ing-ing condition, the -in' boost means that there must be an additional source of priming causing the -in' boost that remains to be determined.

Under these perspectives, both the finding of no difference between the priming effects to -ing targets, *and* the significant difference between the priming effects to -in' targets can be seen as the unusual result that needs further investigation. What we can say for certain is that purely semantically and phonologically, the same- and cross-variant conditions parallel each other across target types. This means that if only semantic and phonological forces were at play here, we would expect a symmetrical result across the target types.

Note here, before I turn to explanations of the -in' boost, that the ing/in' asymmetry *directly* opposes the finding by LoCasto and Connine (2002) and thereby directly contradicts the canonicality advantage hypothesis. LoCasto and Connine (2002) found a same-variant boost to their canonical targets, and found no difference between same- and cross-variant primes to noncanonical targets. The current finding of exactly the opposite pattern, using a variable for which we have strong reasons for thinking that -ing is more canonical than -in' (see section 2.2), lends further evidence to the researchers who question the validity of the canonicality advantage hypothesis.

As I see it there are two potential explanations for the -in' boost. The first is representational, the second is social. First, I must consider the possibility that -ing and -in' are represented slightly differently. If underlyingly the ING variable takes -ing as its phonological form and the -in' form is derived phonologically, then the -in'-in' pairs share the additional application of a phonological rule deriving -in' from -ing. The -ing-ing, and cross-variant pairs do not share the application of this rule. Under this hypothesis, -in'-in' pairs therefore share something extra, and more shared representation can be hypothesised to lead to more processing facilitation. In other words, the -in-in boost may arise via priming of the application of a phonological rule.

Second, a crucial factor that differs between -ing and -in' is the social meaning of the variants. I therefore must also consider whether the -in' boost seen in Experiment 1 is the result of social information affecting the spoken word recognition process. As was discussed in Section 2.2, we think, from decades of sociolinguistic research, that of the two variants of ING, -ing is associated with standard language contexts, education, higher socioeconomic status, etc. By contrast, -in' is associated with casual speech, and is saliently incongruent with the social context of an academic experiment. Experiment 1, clearly, asks participants to process words presented in isolation, in an experimental setting. Despite the explicit instructions warning participants of casually pronounced words in the experiment, it is possible that the processing of words ending with -in' (especially two presented back to back) could violate participants' expectations for an experimental setting. It seems that unexpectedness can facilitate subsequent processing of shared aspects of representation. We know from lexical repetition priming that low frequency words that may be thought of as unexpected show stronger repetition priming than high frequency words (Scarborough et al., 1977; Forster and Davis, 1984), and a similar phenomenon is seen in syntactic priming studies for unexpected verb/word-order combinations (Bernolet and Hartsuiker, 2010). In the context of Experiment 1, we can hypothesise that the unexpectedness of -in' given the context may be causing the -in' boost.

To unpack the unexpectedness hypothesis in more detail, we can identify at least three potential catalysts for such an unexpectedness driven boost:

1. Expectations created by the experimental context

2. Expectations created by the -ing/-in' proportion that the listener expects to hear from

the speaker

3. Expectations created by the -ing/-in' proportion that the listener expects based on their own speech or language experience

The simplest reason for -in' being unexpected is simply that it is a variant used exclusively in conversational contexts, and almost never as a citation form. However much you inform a participant that they will hear casually pronounced words, when noncanonical variants are used in isolation, particularly two of them in quick succession, they will always sound out of place. This is a reality that will continue to pose a challenge for the experimental study of sociolinguistic variation.

The second reason is that participants may perceive -in' as unexpected regards whether there is a mismatch between what participants expect our model talker to sound like (e.g. will he be a heavy -ing or a heavy -in' user, or more balanced?) and the proportion of -ing and -in' words used in the experiment. As a white, educated, upper-middle class speaker of a dialect of American English that is perceived as fairly standard, in principle we would expect him, in casual contexts, to be a more prolific user of -ing than of -in' (see section 2.2). In Experiment 1, there is an equal number of -ing and -in' stimuli, by virtue of the use of both target types and both prime types, which should be at the high end of social expectations of our speaker's -in' use based purely on his accent.

Finally, it is possible that by virtue of being a user of ING variation, and being exposed to certain proportions of -ing and -in' in our own speech and that in the world around us (for example in the social environment in which we grow up), listeners have an -ing/-in' proportion that they expect or that is most natural for them to hear. For example we could hypothesise that a speaker of Appalachian English, who uses and is used to hearing a high proportion of -in', may be less surprised to hear -in' words in an experiment, and may not experience as strong an unexpectedness boost as someone from the northeast who is not accustomed to prolific -in' use.

In order to understand whether the -in' boost reflects a representational or social difference between -ing and -in' processing, I need to find out more about its properties.

For example, I want to probe is the temporal properties of the -in' boost. Morphological priming studies tell us that morphological priming is a robust processing facilitation that persists across intervening items between primes and targets (Wilder et al., 2019). However, phonological and semantic effects are much more short-lived. The representational account suggests that application of a shared phonological rule between -in'-in' primes and targets could be responsible for the -in' boost. If this is the case, then the introduction of an intervening item between the primes and targets should attenuate the -in' boost as we would not expect phonological effects to persist across an intervener due to their temporal properties. In Chapter 5 I probe this by inserting an intervening item between primes and targets.

Another example, is that I want to know whether the -in' boost is sensitive to the proportion of -ing and -in' words in the experiments. If the -in' boost is caused by an underlying representational property, as I hypothesised above, then it should not be sensitive to how many -in' or -ing words there are in the experiment: the same -in' boost should show up every time there is an -in'-in' pair, regardless of how many there are in total in the experiment. The experiments reported in Chapters 5-7 happen to use different ing-ing proportions, which will allow me to explore this possibility.

Chapter 5

Temporal properties of the ing/in' asymmetry

In Chapter 4, Experiment 1 crossed canonical and non-canonical ING primes and targets. The key result showed that to -ing targets, canonical and noncanonical primes give equivalent processing facilitation, whereas for -in' targets, same-variant primes (i.e. *jumpin'-thinkin'*) give a larger priming effect than cross-variant primes (i.e. *jumping-thinkin'*. I introduced this result as the **ing/in' asymmetry**, and called the larger priming effect for -in'-in' pairs over the other conditions the **-in' boost** (see Figure 4.1).

5.1 Experiment 2

In this chapter I present Experiment 2, which serves two purposes. As discussed in the previous chapter, the first purpose is explore the temporal properties of the -in' boost. In Experiment 2, I ask whether the -in' boost is attenuated or retained when there is an intervening item (e.g. *jumpin'-truck-thinkin'*). In the discussion of Experiment 1, I laid out how there are two potential explanations for the -in' boost: a representational and an unexpectedness explanation. I suggested that the -in' boost must be comprised of more than straightforward affix priming, although the exact nature of the -in' boost has yet to be determined. One way to tease apart different contributing factors is by exploring the temporal properties of the -in' boost. Priming studies on complex words have shown that sources of processing facilitation differ in their durability. In short, morphological priming is fairly persistent, whereas priming from phonological or semantic sources is short-lived

(Wilder et al., 2019). These studies using intervening items between primes and targets to test how long a priming effect can persist.

The use of intervening items in priming studies is relatively novel, yet there are certain reliable outcomes of this practice that are relevant for Experiment 2. Among others (Creemers et al., 2020; Marslen-Wilson and Tyler, 1998; Bacovcin et al., 2019), there are two key research papers that use interveners in fully auditory primed lexical decision paradigms with inflected words: Kouider and Dupoux (2009) and Wilder et al. (2019). Kouider and Dupoux (2009) use this method to ask whether there are differences in priming effects between French gender-based adjectival variants (masculine: ∅, feminine: -e) when repeated (e.g. *froid-froid*) and crossed (e.g. *froid-froide*). They contrasted an immediate priming condition with long lag conditions that had between 18 and 144 intervening items between primes and targets. Wilder et al. (2019) did the same but used the English singular/plural ending -s in a repeated (e.g. *frog-frog*) and crossed (e.g. *frogs-frog*). They compared an immediate distance to one and five intervening items.

Both of these studies find that stem priming both in repeated and cross-variant conditions is robust across short and long-lags. At an immediate distance they find an advantage in the repeated stem conditions, whereas at longer lags they find that the difference decreases and the priming effects converge. They also both find priming effects for phonological and semantic control conditions but *only* at an immediate distance. The papers suggest that episodic traces and the activation of surface properties decay quickly, and that only the activation of a more abstract underlying representation persists over longer lags. Although the underlying nature of morphologically complex words is not at issue in the current dissertation, there are two important inferences to draw from this research. First, priming morphological pieces can be detected using auditory lexical decision tasks over very long lags, which lends support to the idea that we will be able to detect priming of the ING suffix over 1 intervening item. Second, phonological and semantic priming does not persist over intervening items. This means that any phonological or semantic properties of the ING suffix that is inducing priming should be reduced when we insert an intervening item (see also Monsell and Hirsh, 1998).

Further support for the idea that episodic surface information is reduced over intervening items comes from Wilder (2018), who does repetition priming using different speakers (i.e. the prime and target are spoken by different model talkers). He finds that at an immediate distance, repetition priming is stronger for same-speaker prime-target pairs than for different-speaker pairs. However, at longer lags, this difference disappears and the priming effects converge. Combining these studies lends credence to the idea that the -in' boost, whether caused by phonological similarity (since it is the same-variant condition) or by a listener expectation violation (akin to a talker switch), could be attenuated by the insertion of an intervener.

The choice to use a single intervening item, rather than many, as was done in Kouider and Dupoux (2009) and Wilder et al. (2019) is motivated by a similar auditory primed lexical decision experiment by Creemers et al. (2020), who found that for semantically transparent and opaque Dutch prefixed verbs (e.g. target = *bieden* 'to offer', transparent prime = *aanbieden* 'to offer', opaque prime = *verbieden* 'to forbid'), all priming effects, both morphological and phonological, disappeared with five intervening items. The key difference between their study and the two discussed above is that Creemers et al. (2020) used polysyllabic words, whereas the prior studies used monosyllables. Creemers et al. (2020) suggest that perhaps with longer words, decay is faster, and that therefore a single intervener would have been enough to detect morphological priming but still see the decay of phonological and semantic effects. Since the words in this study are all disyllabic by virtue of being a (monosyllabic) stem+ING, I chose to use a single intervener for this reason.

In sum, the use of an intervener can shed light on the potential sources of facilitation that are causing the -in' boost in Experiment 1. One possible outcome is that the -in' boost is attenuated when an intervener is used, resulting in equivalent priming across all four -ing/-in' prime-target combinations. If this happens, I can argue that the -in' boost could have been caused by the combination of suffix priming from the ING suffix (equivalent to the priming seen in the -ing-ing, -ing-in', and -in'-ing conditions of Experiment 1), plus a phonological or other short-lived processing boost. Or, I can argue that the -in' boost stems from the unexpectedness of processing multiple non-canonical variants, especially when they are presented sequentially (as -in'-in' prime-target pairs are in these kinds of experiments). If the sequential presentation is a key factor here, then introducing an intervening item could eliminate the -in' boost. These two explanations will need to be further disentangled in future experiments. Another possible outcome is that the processing facilitation in all of the prime-target conditions is eliminated, which would suggest that the priming across the board was caused by semantic or phonological effects. Finally, the -in' boost could be retained across an intervener, and the results with and without an intervener could look the same, which would suggest that the -in' boost is caused by a source that causes temporally robust priming.

A secondary goal for Experiment 2 is to replicate the ing/in' asymmetry from Experiment 1, but in a single-targets experimental design. The use of a single-targets design here is motivated by the fact that introducing an intervener doubles the number of conditions of interest in a single experiment, which greatly decreases the number of observations in each condition, which in turn decreases statistical power. By switching from a mixed-targets to a single-targets design, I alleviate this problem. Simultaneously, this switch allows me to attempt to replicate the results from Experiment 1 in a different experimental design, but crucially, with a different -ing/-in' proportion from Experiment 1. As discussed in section 4.4, if the -in' boost is caused by the social incongruence of -in' words in an experimental context, then manipulating how many of these there are could modulate the size of the boost. Experiment 2 has two subexperiments, Exp2a which has exclusively -ing targets and Exp2b which has exclusively -in' targets. The former therefore has a high -ing proportion[1] and the latter a high -in' proportion. This kind of modulation could therefore be detected in the Experiment 2.

Concretely, I expect to a) attenuate the -in' boost in the 1-intervener condition of Experiment 2, and b) replicate Experiment 1 in the 0-intervener condition of Experiment

[1] Exp2a has 20 -ing primes + 60 -ing targets, but only 20 -in' primes and 0 -in' targets. Exp2b has 20 -in' primes + 60 -in' targets, but only 20 -ing primes and 0 -ing targets.

2.

5.2 Method

Experiment 2 uses the same stimuli, conditions, procedure, and analysis as Experiment 1. There are two crucial differences between the experiments: a) In Experiment 1 all critical primes and targets are presented sequentially, in Experiment 2 half of the critical primes and targets are separated by a monosyllabic nominal intervener (e.g. *truck*. For a full list see Appendix D.), and half are presented sequentially. b) Experiment 1 uses both -ing and -in' final targets in a within-participant design, whereas Experiment 2 uses -ing targets with one group of participants(Exp2a) and -in' targets with another group(Exp2b), in a between-subjects design (See Tables 5.1 and 5.2).

Prime type	Example prime	Example target
-ing	*jumping*	
-in'	*jumpin'*	*thinking*
Unrelated	*jiggle*	

Table 5.1: Conditions and example critical items for Exp2a. -ing targets were paired with each of the three prime types, at a with 0 and 1 interveners, creating six critical conditions.

Prime type	Example prime	Example target
-ing	*jumping*	
-in'	*jumpin'*	*thinkin'*
Unrelated	*jiggle*	

Table 5.2: Conditions and example critical items for Exp2b. -in' targets were paired with each of the three prime types, at a with 0 and 1 interveners, creating six critical conditions.

5.2.1 Participants

For Experiment 2, 99 participants were recruited to Exp2a with -ing targets, and 175 [2] were recruited to do Exp2b with -in' targets.

Participants were randomly assigned to one of 6 lists. Each list contained all 60 targets, paired with 10 primes from each critical condition, counterbalanced across number of interveners and prime type.

5.2.2 Analysis

When modelling the data from Exp2a and Exp2b, the same trimming method was employed as for Experiment 1. This resulted in the exclusion of 22 participants from Exp2a, and 58 participants from Exp2b for having accuracy scores lower than 80%. Following this, datapoints with extremely long or short RTs (Exp2a: 88 data points, Exp2b: 96 data points), and outliers based on by-participant and by-item normality tests (Exp2a: 127 data points, Exp2b: 144 data points) were removed. In Exp2a, 3.4% of the data was removed leaving 3566 observations for analysis, and in Exp2b 2.8% of the data was removed leaving 5069 observations. Finally, model criticism cut the last outliers from the dataset (Exp2a: 95 data points, Exp2b: 126 data points). The model included an interaction between PrimeType and TargetType, and further fixed effects for TrialN, PrimeFrequency, TargetFrequency, and PrimeRT. Random intercepts were included for Participant and Target. The critical comparisons were performed using the emmeans package.

5.3 Results

Table 5.3 and 5.4 show the raw reaction times and priming effects to all of the conditions in Experiment 2.

[2] When using university students as subjects, the time in the semester in which an experiment is run influences the quality of the respondents. Exp2b was run at the end of the semester, which resulted in 33% of the participants being removed for having an overall accuracy score of lower than 80%. Contrast this with Experiment 1, run at the start of the semester where only 15% of participants were excluded for having an accuracy of lower than 80%. The timing in the semester in which each experiment was run is the justification for the increase in number of recruited participants from Exp1 through Exp2a, to Exp2b.

	0-intervener		1-intervener	
	RT in ms(SD)	Priming effect	RT in ms(SD)	Priming effect
Unrelated prime	1015 (150)	NA	1022 (152)	NA
ing prime	972 (148)	43	993 (149)	29
in' prime	984 (143)	31	989 (147)	33

Table 5.3: Exp2a: mean response times and priming effects to -ing targets (in ms) per prime and intervener condition. Standard deviations are shown in parentheses.

	0-intervener		1-intervener	
	RT in ms(SD)	Priming effect	RT in ms(SD)	Priming effect
Unrelated prime	1041 (164)	NA	1034 (164)	NA
ing prime	1011 (158)	30	1011 (159)	23
in' prime	982 (155)	59	1003 (159)	31

Table 5.4: Exp2b: mean response times and priming effects to -in' targets (in ms) per prime and intervener condition. Standard deviations are shown in parentheses.

In Figure 5.1 and 5.2 priming effects to the critical conditions are shown. Exp2a used only targets ending with -ing, and compared baseline, -ing, and -in' primes without an intervening item, and with one intervener. The 0-intervener conditions replicated the -ing target conditions of Experiment 1. At 0-intervener, analysis of the log-transformed reaction time data showed significant priming effects of 43ms for -ing primes (β = -0.04, p<0.001) and 31ms for -in' primes (β = -0.03, p<0.001) to -ing targets. Furthermore, the one-intervener conditions show the same priming effects as in the 0-intervener condition with 29ms of priming for -ing (β = -0.03, p<0.001) and 33ms of priming for -in' (β = -0.03, p<0.001) primes. In both the 0-intervener condition (β = -0.01, p = 0.20) and one-intervener condition (β = -0.003, p = 0.88) there was no significant difference between the priming effects from -ing and -in' primes.

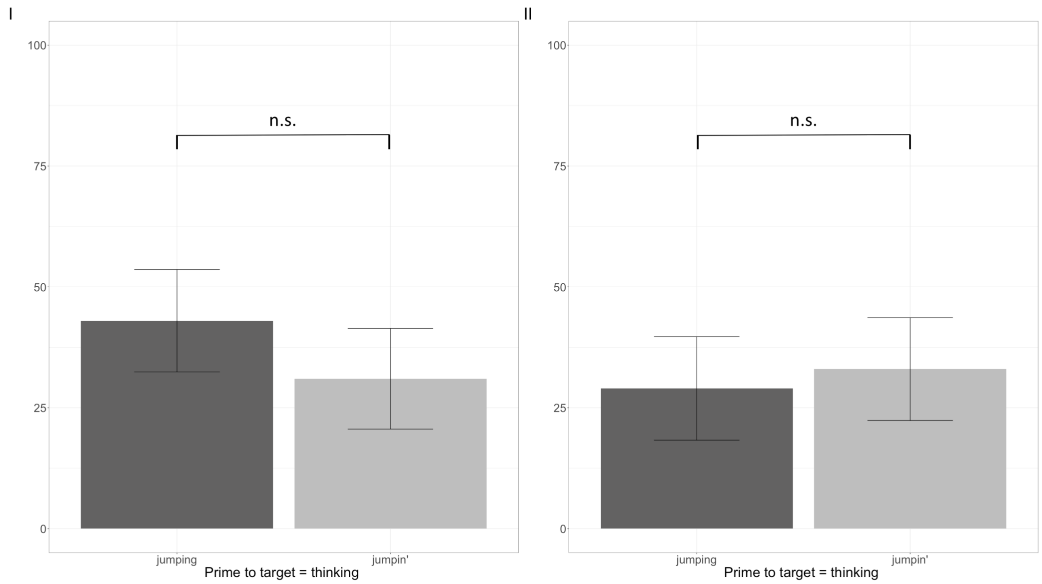

Figure 5.1: Exp2a: Priming effects in ms for -ing and -in' primes to -ing targets in the 0-intervener(I) and 1-intervener(II) conditions.

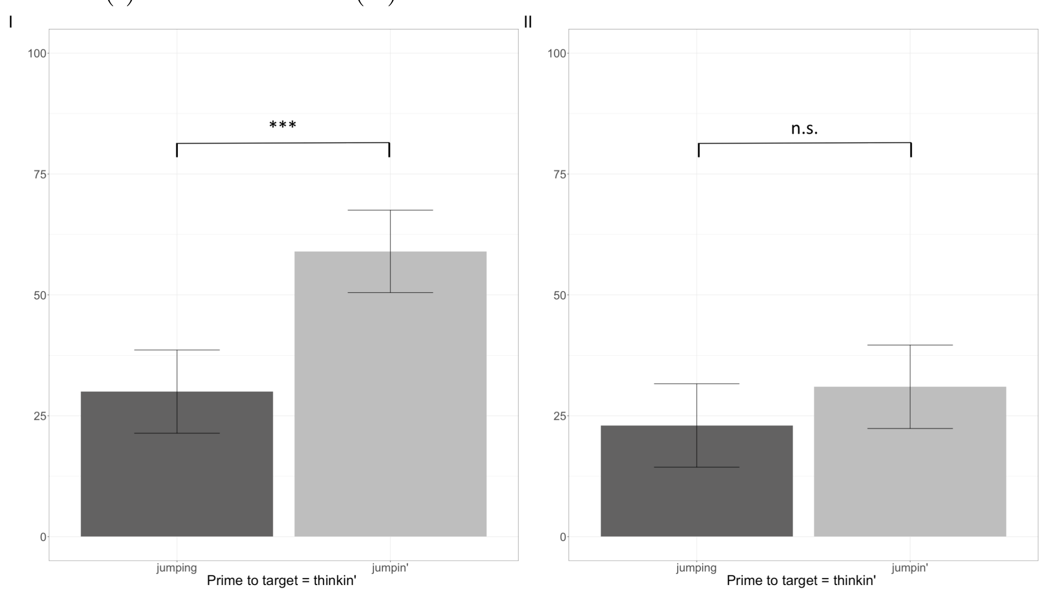

Figure 5.2: Exp2b: Priming effects in ms for -ing and -in' primes to -in' targets in the 0-intervener(I) and 1-intervener(II) conditions.

Exp2b used only targets ending with -in', and the same set of statistical tests as were run on Exp2a were used. The 0-intervener condition replicated Experiment 1, showing the same asymmetry between -ing and -in' primes to -in' targets. In the 0-intervener condition, we see significant 30ms of priming for -ing primes (β = -0.03, p<0.001) and 59ms for -in' primes (β = -0.06, p<0.001), and the 59ms of priming from -in' primes is significantly larger than the 30ms from -ing primes (β = -0.03, p<0.001). However, the one-intervener condition shows a different picture. We still see significant priming of 23ms for -ing (β = -0.02, p<0.001) and 31ms for -in' (β = -0.03, p<0.001) primes, but now, there is no asymmetry between the prime types (β = -0.007, p = 0.48). This pattern is parallel with the 0-intervener and one-intervener conditions in Exp2a. The one-intervener condition eradicates the asymmetrical -in' boost, and leaves stable priming effects across the prime types. This finding is crucial to understanding the asymmetrical pattern found in Experiment 1.

5.4 Discussion

The primary goal of Experiment 2 was to explore the temporal properties of the -in' boost through the use of an intervening item between the primes and targets. The secondary goal was to replicate the ing/in' asymmetry from Experiment 1 with a different ing/in' proportion in the experiment. To put the results from the intervener conditions against a stable backdrop, in this discussion I will first discuss the replication of Experiment 1 in the 0-intervener condition, before turning to what the 1-intervener conditions tell us about the properties of the -in' boost.

5.4.1 0-intervener condition

Experiment 2 replicates the ing/in' asymmetry seen in Experiment 1, but in a **between-subjects** design. This supports the notion that the asymmetry is not the product of design-specific issues or list-effects. In the left-hand panel of Figure 5.1 we can see the priming effects from same- and cross-variant primes to -ing targets in Exp2a. The priming effects are of a similar magnitude to those found in Experiment 1, and show the same lack of significant difference between the prime types. In the left-hand panel of Figure 5.2 we see the, again, similar sized priming effects on the left to -ing primes and right to -in' primes, to the -in' targets used in Exp2b. Crucially, here we see the prominent -in' boost that we encountered in Experiment 1.

This result is not only important because it shows that the ing/in' asymmetry is robust and replicable across multiple groups of participants, and in different experimental design configurations (a finding which in itself lends empirical credibility to both the methodology and results in this dissertation), but it also gives us insight into what factors may (or in this case may not) influence the processing of sociolinguistic variants. More specifically, this result shows that the proportion of -ing and -in' tokens in the experiment does not affect the ing/in' asymmetry. In Experiment 1, there were 50 critical -ing words (across all primes and targets) and 50 critical -in' words. This balanced proportion of -ing and -in' tokens is congruent with my model talker's accent and should, by itself (i.e. context notwithstanding), not bias a speaker towards hearing more of one variant than the other. Experiment 2, by contrast, was split into two subexperiments that only used one target type. As such, Exp2a had 80 -ing words and 20 -in' words, and Exp2b had the reverse; 20 -ing words and 80 -in' words.

In Exp2a, there is a bias towards hearing more words with the canonical variant -ing. From a social context perspective, this is more in line with what listeners will be expecting from an experimental context. One could extrapolate from this that having more -ing words in the experiment should make hearing a noncanonical -in' word even more unexpected than it is in Experiment 1. No consequences of this materialise in Exp2a, however. The priming effects remain comparable and in the same pattern to those in Experiment 1.

In Exp2b, participants hear many more -in' words than they hear -ing words. It can be argued that this should familiarise listeners more with hearing noncanonical variants in the experiment, making -in' not as surprising or unexpected as in Experiment 1. This proportion-effect could in principle be solely responsible for the -in' boost, and if so, the -in' boost could be attenuated in the 0-intervener condition of Exp2b. This however is not what we see. In contrast, the additional exposure to more -in' words in the experiment does nothing to diminish the -in' boost.

In both subexperiments of Experiment 2 we can think of ways in which changing the proportion of -ing/-in' words could influence listener's expectations of what they are going to hear, and thereby influence their response times. The finding of no change between Experiments 1 and 2, in that light, is surprising, since I expected the incongruence of the -in' variant given the experimental context to change based on the -ing/-in' proportion. At a minimum, this shows that unexpectedness cannot simply be operationalised by calculating how unexpected something will be over the statistics of the experiment, as is often posited in the syntactic priming surprisal literature (Jaeger and Snider, 2007; Rácz, 2013; Jaeger and Snider, 2013). I am not ready to dismiss the unexpectedness hypothesis for the -in' boost before manipulating speaker and listener characteristics, which is a future line of research, but for now, the lack of sensitivity of the -in' boost to -ing/-in' proportions is indicative of no expectation violation involvement.

There is one potential technical reason that we may not see a change in the -in boost as a result of changes to -ing/-in' proportion. White, Tamminga, and Embick (under review) used an auditory primed lexical decision task to measure simple semantic priming effects (e.g. *doctor* - *nurse*). In this work, I manipulated two key experimental parameters: the **inter-stimulus interval** (ISI) and the proportion of semantically related pairs in the experiment (also called the **relatedness proportion** or RP). Across a series of experiments crossing low-high ISIs (0ms, 200ms, and 800ms) with low-high RPs (25%, 50%, and 75%), I found that although participants noticed the semantically related pairs in the experiment - over 80% of participants mentioned in their post-experimental questionnaire that they thought the experiment was about word pairs with related meanings - response times *only* fluctuated (the change was not significant although I suspect that in a higher powered design the difference may have been statistically detected) at a high RP (75% related pairs) when the ISI used was also high (800ms). In experiments with smaller ISIs, participants' response times were insensitive to the RP manipulations. We suggested that in auditory primed lexical decision paradigms, listeners may need a substantial amount of time between primes and targets before their expectations about the experiment start to influence their response times. This is in spite of their conscious recognition of the pattern linking primes and targets in the experiment. The experimental setup in this dissertation uses a 500ms ISI, substantially smaller than the long 800ms ISI that I found to be responsible for a response time change in my semantic priming work. This must be kept in mind when interpreting the -in' boost: the insensitivity of the -in' boost to -ing/-in' proportion changes at this ISI does not necessarily mean that expectation violation is not a factor, it is still possible that these effects do play a role but only when listeners are given more processing time. This is a hypothesis that can be explored in future experiments.

5.4.2 1-intervener condition

The 1-intervener condition of Experiment 2 eliminates the -in' boost compared to Experiment 1 and the 0-intervener condition. As the right-hand panels of Figures 5.1 and 5.2 show, there is no significant difference in priming effects from -ing and -in' primes to either -ing or -in' targets. The -in' boost is eliminated in this condition. This result tells us that the -in' boost is short-lived and therefore decays fast.

The elimination of the -in' boost is reminiscent of the convergence of repetition and morphological priming effects in the studies discussed in Section 5.1. Those studies suggested that over long lags, activation of the abstract underlying representation of the stem (in those studies they were doing stem rather than affix priming) was the only remaining source of priming, and episodic effects such as surface form effects had decayed. In Experiment 2, where we are priming the suffix not the stem, we could use a similar reasoning and suggest that after an intervener, the underlying suffix is the sole source of priming that remains, which is why we see no significant differences between same- and cross-variant priming conditions in any -ing/-in' prime-target pairings. The underlying ING suffix gives $\sim$ 30-50ms of priming, regardless of its eventual surface form. This reasoning has important implications for our understanding of the locus of ING variation. In brief, the lack of long-lasting sensitivity of the priming effects to the specific variants suggests that there is a single underlying ING suffix and that the phonological surface form is determined later in processing. This will be discussed further in Chapter 6.

Of note now, though, is the fact that although this reasoning explains the diminishing of the -in' boost, it does not explain the exact cause of the -in' boost. The short-lived nature of the -in' boost however leaves two plausible hypotheses. First, as discussed in Chapter 4, it is possible that there is an underlying representational difference between -ing and -in'. Following the above reasoning, it could be that there is an underlying ING suffix and that that is causing the long-lasting priming effects in all four conditions. It may be the case that this underlying ING suffix has -ing as its phonological form, but that this could change to -in' through phonological derivation. In this case, the application of this phonological rule could be primed in an -in'-in' prime-target pair, causing the -in' boost.

An important note here is that this suggests that the priming comes from a **phonological process** and not from **surface phonology**. An obvious difference between the same-variant condition and the cross-variant condition in Exp2b is the shared surface phonology of the suffix in the same-variant condition. We know from among others Kouider and Dupoux (2009) and Wilder et al. (2019) that priming effects caused by shared surface phonology diminish over interveners; a very similar pattern to what we see happening in Exp2b with the elimination of the -in' boost. Whether this is the case for both surface phonology and other phonological processes is not clear. Since I have not yet run a phonological control condition with ING stimuli, I cannot tease a phonological process explanation from a phonological surface explanation at present. That being said, the lack of an -ing-ing boost does make the surface phonology explanation much less plausible. If shared phonological surface form in the same-variant condition is causing the -in' boost, then I would expect a symmetrical -ing boost in Exp2a and in Experiment 1. In Chapter 6 I will run an experiment that tests the contribution of surface phonology to the priming patterns found in this dissertation.

Second, it is still possible that the -in' boost reflects the contextual unexpectedness of -in'. Little is known about the temporal properties of unexpectedness effects (i.e. whether they persist over intervening items), which means that I cannot rule out the idea that the unexpectedness of an -in' prime is boosting priming effects from its shared representation with an -in' target.

Chapter 6

The contribution of surface phonology

6.1 Experiment 3

In Chapter 5 I showed how when placing an intervening item between two -in' words in the -in'-in' condition, the in' boost seen in Experiment 1 and in Experiment 2 in the 0-intervener condition is eliminated. I suggested two potential explanations for the -in' boost, based on its short decay profile: a listener expectation violation account, or a representation-based account. The latter of these suggests that the stable priming seen in the 1-intervener condition of Experiment 2 is caused by the underlying ING suffix, and that the -in' boost seen when no intervener is used reflects a shared phonological process that changes an underlying -ing to -in'. In the discussion of Experiment 2 (see section 5.4), I noted that at this stage I cannot rule out that, instead of the application of such a phonological process, the -in' boost reflects the shared phonological surface form in the same-variant condition (i.e. the shared [ɪn] between *jumpin'-thinkin'*) compared to the cross-variant (i.e. *jumping-thinkin'*) condition. Shared phonological surface form has been shown to facilitate spoken word processing in prior work (Kouider and Dupoux, 2009; Wilder et al., 2019; Slowiaczek et al., 2000; Bacovcin et al., 2017; Monsell and Hirsh, 1998), so this is a realistic hypothesis here. Experiment 3 teases these apart by testing whether shared surface form contributes to the priming effects seen in this dissertation.

There are two pieces of evidence that heed caution against a phonological surface form account. The first is a lack of -ing boost in Experiments 1 and 2. If surface form causes processing facilitation for -in'-in' pairs we would expect the same for -ing-ing pairs. The second comes from the fact that the abovementioned studies that find phonological surface form priming use monosyllabic words. In her study of polysyllabic Dutch verbs, Creemers et al. (2020) finds no phonological surface form priming at all in her phonological control condition (e.g. *bespieden-bieden*) compared to her unrelated baseline condition (e.g. *opjagen-bieden*). Since I use polysyllabic words whereby the shared phonological form is the rhyme of the last syllable, my work aligns more with that of Creemers et al. (2020), so I do not expect the -in' boost to be caused by priming of the phonological surface form. Nonetheless, to rule this out, Experiment 3 uses exclusively -in' targets, and compares two critical prime types to an unrelated baseline (e.g. *jiggle-thinkin'*). The first prime type is the -in' verbs that we have seen in both Experiments 1 and 2 (i.e. *jumpin'-thinkin'*). The second prime type is a phonological surface form control, whereby the primes are simplex nouns that end with [ɪn] (e.g. *dolphin-thinkin'*). The nouns in this condition crucially, like in the -in' condition, only overlap with the targets in the last syllable-rhyme of the word.

Note here that in principle, I should be able to use either [ɪn] or [ɪŋ] or ideally both to rule out the contribution of surface phonology to processing facilitation seen in Experiments 1 and 2. However, in practice, this is a case in which the limitations of the English language precludes the use of [ɪŋ] for this purpose. The set of words that has an invariable [ɪŋ] consists exclusively of placenames, and, once excluding homophononous words (such as *Flushing*), is too small to run a well-powered experiment. By contrast, the set of [ɪn]-final words is much larger, and provides more than enough usable words for the purpose of testing the effects of surface phonology. It is for that reason that Experiment 3 uses [ɪ] rather than [ɪŋ] as a test case.

6.2 Method

Experiment 3 uses the same targets, -in' primes, and unrelated primes as Experiments 1 and 2. It also uses the same procedure, and analysis (see section 4.2). The main difference in Experiment 3 is the addition of a phonological condition (see Table 6.1). For a full list of the stimuli used in Experiment 3, see Appendix E.

Prime type	Example prime	Example target
-in'	*jumpin'*	
Phonological	*dolphin*	*thinkin'*
Unrelated	*jiggle*	

Table 6.1: Conditions and example critical items for Exp2b. -in' targets were paired with each of the three prime types, at a with 0 and 1 interveners, creating six critical conditions.

6.2.1 Participants

98 participants were recruited to Experiment 3. They were again recruited from the University of Pennsylvania's subject pool. Participants were randomly assigned to one of 3 lists. Each list contained all 60 targets, paired with 20 primes from each critical condition, as per a within-subjects design.

6.2.2 Analysis

The same trimming method was employed for Experiment 3 as for Experiments 1 and 2. The trimming procedure resulted in the exclusion of 23 participants for having accuracy scores lower than 80%. Following this, datapoints with extremely long or short RTs (67 data points), and outliers based on by-participant and by-item normality tests (146 data points) were removed. 4.2% of the data was removed leaving 3338 observations for analysis. Finally, model criticism cut the last outliers from the dataset (70 data points). Fixed effects in the model were once again PrimeType, TrialN, PrimeFrequency, TargetFrequency, and PrimeRT. Random intercepts were included for Participant and Target. The critical comparisons were performed using the emmeans package.

6.3 Results

Table 6.2 shows the raw reaction times and priming effects to the conditions in Experiment 3.

	Raw RT in ms (SD)	Priming effect in ms
Unrelated prime	1084 (145)	NA
phonological prime	1087 (145)	-3
in' prime	1018 (137)	66

Table 6.2: Experiment 3: mean response times and priming effects to -in' targets (in ms) per prime type. Standard deviations are shown in parentheses.

Experiment 3 used exclusively -in' targets, and compared a phonological condition (i.e. *dolphin-thinkin'*) and the same-variant -in' condition we have already seen in Exp2b and Experiment 1 (i.e. *jumpin'-thinkin'*) to an unrelated baseline (i.e. *jiggle-thinkin'*). The results are shown in Table 6.2 and Figure 6.1. As we have seen twice before in Experiment 1 and 2, the -in' prime condition gives a significant priming effect of, in this experiment, 66ms (β = -0.06, p<0.001). By contrast, the phonological condition gives no facilitation at all as evidenced by the insignificant 3ms inhibition (β = -0.003, p = 0.82).

Of the remaining predictors, TrialN (β = -0.004, p = 0.49) and PrimeFrequency (β = 0.005, p = 0.06) did not come out as significant. TargetFrequency (β = -0.03, p<0.05) and PrimeRT (β = 0.03, p<0.001) contributed to the model, as expected.

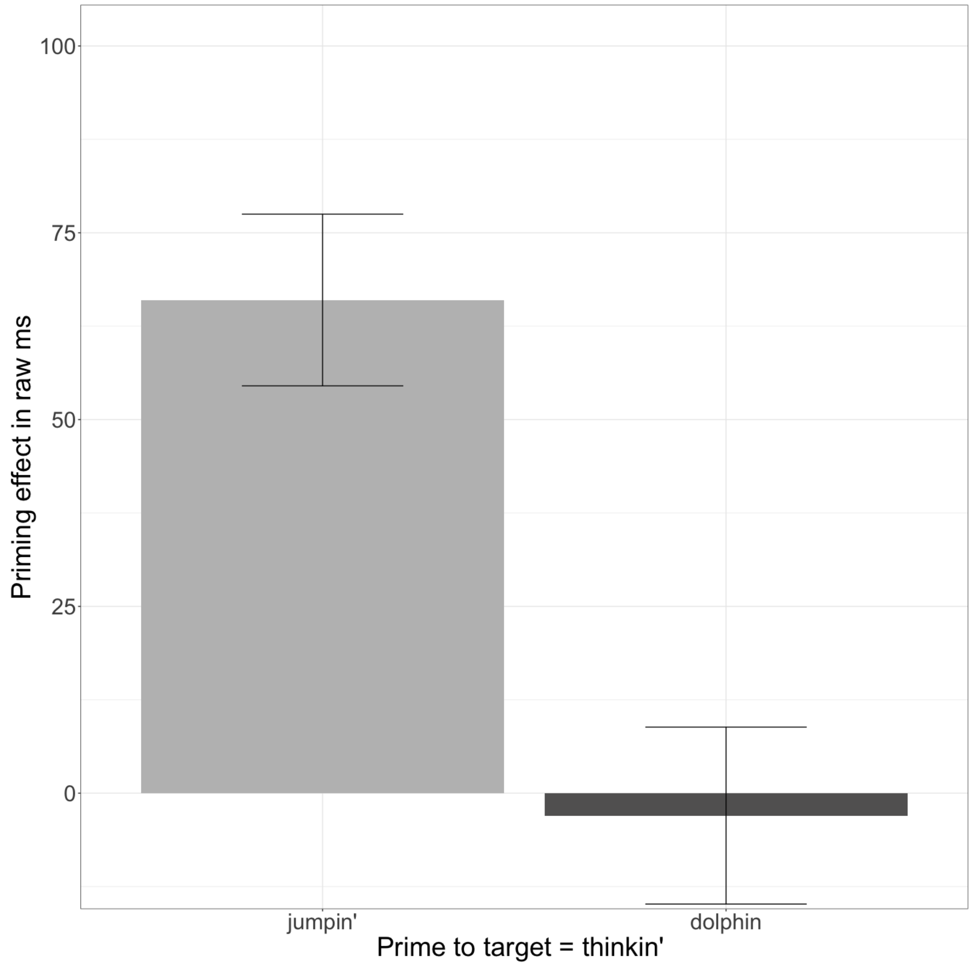

Figure 6.1: Exp3: Priming effects in ms for -in’ and phonological primes to -in’ targets.

6.4 Discussion

The goal for Experiment 3 was fairly straightforward: can the shared phonological surface form in the word-final rhyme of a polysyllabic word facilitate processing such that we need to take shared surface form into account as a contributor to the ING priming seen in Experiments 1 and 2? More specifically, is it possible that the -in’ boost (in part) reflects shared surface phonology in the -in’-in’ condition when compared to the -ing-in’ condition?

The results from Experiment 3 show no priming at all for prime-target pairs such as *dolphin-thinkin’* that share only a word-final [ɪn] but no other semantic or morphological properties. Participant response times in this condition are equivalent to those in the unrelated baseline condition *jiggle-thinkin'*. This is in line with the prediction drawn from Creemers et al. (2020) and from Experiments 1 and 2 that the -in' boost is not being caused by surface form overlap in the same-variant -in'-in' condition compared to the cross-variant -ing-in' condition. On this basis, I can rule out a surface form explanation for the -in' boost. Crucially, this result does not preclude an explanation where an underlying -ing is changed via application of a phonological rule to -in'. This is still a plausible explanation for the -in' boost, and will be discussed further in the General Discussion in Chapter 8.

A final observation of note in Experiment 3 is the third replication of facilitated processing for -in'-in' prime-target pairs, in yet another -ing/-in' proportion. Experiment 3 has no critical -ing primes at all, meaning that all critical items with a variable ING are -in' words. Despite this, the magnitude of the -in'-in' priming effect is of the same order of magnitude as previously found facilitation for this condition. This is further evidence supporting the idea that the the -in' boost is insensitive to the proportion of -ing and -in' words in the experiments.

Chapter 7

The contribution of different stem-types

So far, the experiments in this dissertation have probed the processing of -ing and -in' using prime-target pairs with unrelated stems. This has produced several replications of the ing/in' asymmetry under different -ing/-in' proportions and in both within- and between-subjects designs. In this chapter, I add a layer of complexity to the paradigms to ask how robust the ing/in' asymmetry is when primes and targets share more representation than just the underlying ING suffix. Section 7.1 details Experiment 4 uses the same design and setup as Experiment 1: a within-subjects design using both -ing and -in' targets in a balanced -ing/-in' ratio, but the primes in this experiment have the same stem as their respective targets. Section 7.2 expands this into Experiment 5 which is modeled on Experiment 2, and therefore uses a between-subjects design that tests -ing targets in subexperiment Exp5a and -in' targets in subexperiment Exp5b. Experiment 5 uses prime-target pairs that have unrelated stems and repeated stems, allowing for a direct comparison between the stem types. It also includes a rhyming stem condition (e.g. *drinking-thinking*), which, compared to unrelated and repetition, is of intermediate stem-relatedness. Lastly, section 7.3 shows Experiment 6, which was done to test how well the undergraduate participants used in the first five experiments in this dissertation reflect the general population. In design, Experiment 6 is identical to Exp5b, but it uses the online participant recruitment tool Prolific Academic to recruit a more diverse set of participants.

7.1 Experiment 4: repeated stems, mixed targets

Repetition priming studies, in which a prime and target overlap completely in semantic, phonological, and morphological aspects (although not necessarily in phonetics (c.f. Wilder, 2018)), show robust facilitatory processing effects both in auditory and visual modalities and across different languages (Wilder et al., 2019; Forster and Davis, 1984; Scarborough et al., 1977; Kouider and Dupoux, 2009). Similarly, stem priming of inflected and derived words has been observed cross-linguistically across different modalities (Kouider and Dupoux, 2009; Wilder et al., 2019; Marslen-Wilson, 1984; Rastle et al., 2004; Crepaldi et al., 2010; Stanners et al., 1979; Creemers et al., 2020). As there seems to be a discrepancy between results obtained from visual paradigms compared to auditory paradigms (Wilder et al., 2019), and the work in this dissertation pertains solely to spoken word recognition, I will focus on the results from auditory studies.

Section 5.1 already details the results from the key papers in this literature, but to summarise the most relevant points for Experiment 4: when no intervener is used, repetition priming gives larger facilitation than stem priming (also sometimes called morphological priming) (Wilder et al., 2019; Kouider and Dupoux, 2009; Creemers et al., 2020). Normally, this is attributed to representational overlap or to the strength of activation as a result of that overlap.

In this dissertation I am focusing on the mental representation of the ING suffix variants, and I have found evidence that they share aspects of their representation and in fact show a stable facilitation pattern for variant pairings (if an asymmetrical one) across experimental setups. In order to focus on the suffix variants, I have until now used prime-target pairs that have unrelated stems. The question, however, arises whether the priming pattern that I have shown and replicated for the ING variants when stems are unrelated holds up when there is additional facilitation involved from shared representation between the prime and target stems. Tamminga (2016) finds a significant interaction of variant choice priming and lexical repetition, which means that in production, persistence is stronger when two subsequent words have the same stem than when they have a different stem. Although I am not suggesting that production and perception work in the same way, this does motivate investigating whether affix priming effects in perception also interact with stem-type, and if so, in what way. I would expect based on the abovementioned literature that *thinking* primes *thinking* better than *jumping* primes *thinking*, since more overlap is assumed to mean more facilitation. However, what about *thinking-thinking* compared to *thinkin'-thinking*? This comparison is akin to what in Wilder et al. (2019) and Kouider and Dupoux (2009) would refer to as comparing a repetition to a morphological condition, although there are some critical differences: a) in those studies the inflectional variants alternate with -∅, b) they use mostly monosyllabic stimuli, whereas mine are all disyllabic c) their variants differ in semantic meaning, mine differ in social meaning. Starting with the first two of these three, in these studies word pairs such as *frog-frog* are compared to *frogs-frog* which means there are durational differences between the primes and targets plus there is an imbalance in how much phonological information there is to process compared to the ING pairs where the primes and targets do not differ in duration, and in all combinations have an overt surface form. The third difference is the most crucial. In the morphological condition in Kouider and Dupoux (2009) the primes and targets differ in grammatical gender, and in Wilder et al. (2019) they differ in plurality. In the variable ING experiments the primes and targets differ in social meaning, or canonicality. It is well-acknowledged that semantics are a crucial part of the mental representations of words and pieces of words (like suffixes). It is partially on this basis that we expect more priming from the repetition than the morphological conditions. When it comes to *social* meaning, by contrast, we have yet to pinpoint how it manifests in the representation of words. On the basis of the prior studies, we could hypothesise that *thinking-thinking* should give a larger priming effect than *thinkin'-thinking*, and vice versa *thinkin'-thinkin'* should give stronger priming than *thinking-thinkin'*. We know however that with unrelated stems, that is not the priming pattern across variant types, and I have argued that the -in' boost must be caused by the noncanonicality of the -in' variant. There is no strong reason to think that by adding an equivalent layer of shared representation across all four variant crossing conditions (i.e. by changing the stem from unrelated to repeated) that this noncanonicality processing effect will be attenuated or affected in any way. The overall facilitation in each condition will likely increase, as a function of the additional shared representation of the stem, but I expect that the ing/in' asymmetry will remain detectable in Experiment 4.

7.1.1 Method

Experiment 4 uses the same targets, and unrelated primes as Experiment 1, and shares the same mixed-target within-subjects design. It also uses the same procedure, and analysis (see section 4.2). The main difference in Experiment 4 is the use of -ing and -in' primes whereby the stem is the same as the stem in the target, leading to conditions such as *thinking-thinking*, and *thinkin'-thinking*, etc. See the critical conditions in Table 7.1. Crucially, in the same-variant conditions in Experiment 4 (which are full repetition conditions since the primes and targets share stems) a different soundfile is used for the prime and target. My model talker produced each stimulus word multiple times, and different recordings were therefore used to avoid episodic memory effects caused by identical phonetic profiles between primes and targets which have been shown to boost processing (Wilder, 2018).

Prime type	Example prime	Example -ing target	Example -in' target
-ing	*thinking*		
-in'	*thinkin'*	*thinking*	*thinkin'*
Unrelated	*jiggle*		

Table 7.1: Experiment 4 conditions and example critical items. Each of the two target types was paired with each of the three prime types, creating six critical conditions.

7.1.1.1 Participants

71 participants were recruited to Experiment 4. They were again recruited from the University of Pennsylvania's subject pool.

7.1.1.2 Analysis

The same trimming method was employed for Experiment 4 as for the previous experiments in this dissertation. The trimming procedure resulted in the exclusion of 10 participants for having accuracy scores lower than 80%. Following this, datapoints with extremely long or short RTs (28 data points), and outliers based on by-participant and by-item normality tests (168 data points) were removed. 5.4% of the data was removed leaving 2972 observations for analysis. Finally, model criticism cut the last outliers from the dataset (61 data points). The model included an interaction between PrimeType and TargetType, and further fixed effects for TrialN, PrimeFrequency, TargetFrequency, and PrimeRT. Random intercepts were included for Participant and Target. The critical comparisons were performed using the emmeans package.

7.1.2 Results

In Table 7.2 you can find raw mean reaction times per condition and the priming effects in ms.

	ing target		in' target	
	RT in ms(SD)	Priming effect	RT in ms(SD)	Priming effect
Unrelated prime	1021 (130)	NA	1069 (131)	NA
ing prime	881 (130)	140	908 (131)	161
in' prime	868 (131)	153	859 (132)	210

Table 7.2: Experiment 4: mean response times and priming effects to targets (in ms) per prime and target type. Standard deviations are shown in parentheses.

Figure 7.1 shows the priming effects for the critical conditions in Experiment 4. Starting with the -ing targets, analysis of the log-transformed reaction time data showed significant priming effects of 140ms for -ing primes (β = -0.15, p<0.001) and 153ms for -in' primes (β = -0.16, p<0.001), compared to the unrelated baseline condition. There was no significant difference between these two priming effects (β = -0.01, p = 0.49). For -in' targets, the log-transformed reaction time analysis yielded significant facilitation of 161ms for -ing primes (β = -0.17, p<0.001), and 210ms for -in primes (β = -0.22, p<0.001) compared to the unrelated baseline. By contrast to the -ing target condition, these two priming effects do differ significantly from each other (β = -0.05, p<0.001).

logPrimeFrequency ($\beta = 0.002$, $p = 0.6$) and logTargetFrequency (β = -0.02, p<0.05) were significant in the model, along with PrimeRT (β = -0.04, p<0.001), indicating that when a participant responds slower to a prime, they also respond slower to its target. Interestingly, TrialNumber ($\beta = 0.0003$, $p = 0.97$) was not a significant predictor, indicating that participants did not slow down as the experiment progressed.

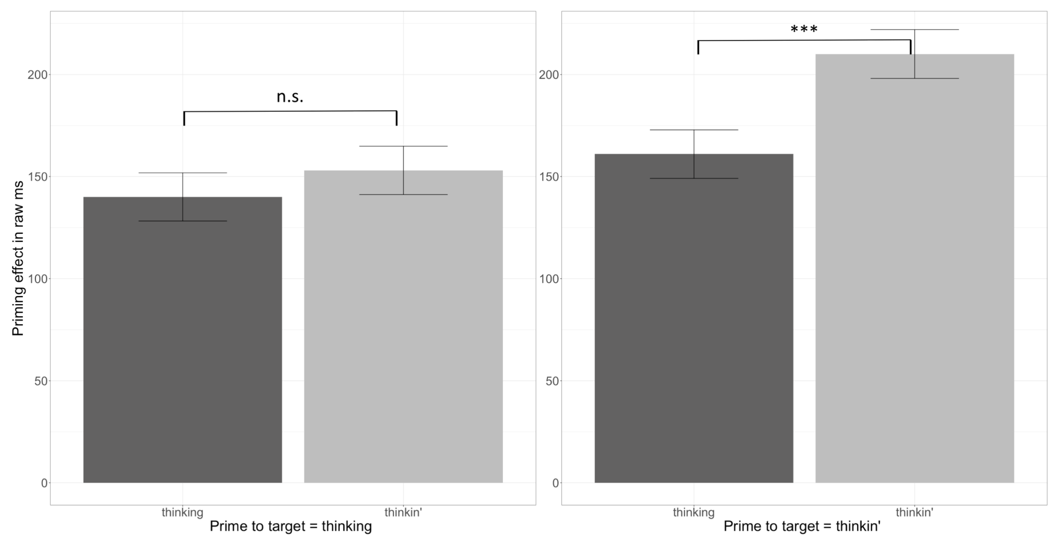

Figure 7.1: Experiment 4 results: priming effects to target *thinking* (left), and to target *thinkin'* (right), in raw ms, comparing ING prime conditions to unrelated baseline prime condition (e.g. *jiggle-thinking*).

7.1.3 Discussion

The goal of Experiment 4 was to test the stability of the ing/in' asymmetry by using a different stem type. In this experiment, instead of using primes that had a stem completely unrelated to the targets (like *jumping-thinking* as in Experiments 1, 2, and 3), the primes had the same stem as the targets (e.g. *thinking-thinking*). As in Experiment 1, targets either had the -ing or -in' variant, and were crossed with primes that also had either the -ing or -in' variant.

Two key observations should be made when looking at Figure 7.1. First, the ing/in' asymmetry remains intact, even with this new stem type: when the target is *thinking*, both -ing and -in' primes facilitate the upcoming target equally well compared to the unrelated baseline. However, when the target is *thinkin'*, the same-variant condition gives a larger facilitation than the cross-variant condition. It is remarkable how stable this asymmetry is, and lends further support for the idea that this asymmetry reflects the processing of the ING suffix, and is insensitive to the stem of the word it is found in. Like in Experiment 1, the proportion of -ing and -in' words in Experiment 4 is balanced, which gives us a replication of the ing/in' asymmetry and -in' boost at that variant proportion.

Second, despite replicating the ing/in' asymmetry, it must be noted that the priming effects in Experiment 4 are substantially larger in magnitude than in any of the previous experiments. They are three to four times larger than those observed when primes and targets with unrelated stems are used. This is not unexpected, since if the prime and target share a stem, then the prior activation of that stem during the processing of the prime, will facilitate the processing of a subsequent target with the same stem (i.a. Wilder et al., 2019; Kouider and Dupoux, 2009; Forster and Davis, 1984; Scarborough et al., 1977; Marslen-Wilson et al., 1994). Put simply, *thinkin'* and *thinking* have a much more overlapping mental representation than *jumpin'* and *thinking* do, so we would expect the target of the prior pair to be facilitated more strongly, and indeed it is. That being said, it is important to note that despite the large increase in size of priming effect, the ing/in' asymmetry is unaffected.

This result, compared to the parallel design of Experiment 1 raises the question of what priming effects consist of. The fact that the ing/in' asymmetry is retained means we must consider whether the priming effects seen in Experiment 4, are a straightforward linear summation of stem-priming facilitation plus suffix-priming facilitation. Stem-repetition priming using inflected verbs with unrelated endings (e.g. *jumping-jumped*) would be necessary to dig deeper into this question, and further exploring how priming effects are composed when words share multiple aspects of mental representation that are not necessarily socially meaningful, lies outside the scope of this dissertation project.

7.2 Experiment 5: expanded stem-type manipulation

At this stage, we have seen that the ing/in' asymmetry is insensitive both to manipulations to the proportion of -ing and in' tokens in the experiment, and to the relationship between the prime and target stems. In Experiment 5 I push this stability further by crossing these factors and asking, in a between-subjects design like the one we used in Experiment 2, and using three different stem relationships (repetition, rhyming stem, and unrelated), is the ing/in' asymmetry still intact.

Since Experiment 5 is a between-subjects design, it consists of two complimentary subexperiments: Exp5a uses exclusively -ing targets, and Exp5b uses exclusively -in' targets. Both of the subexperiments use the same seven priming conditions. These conditions can be seen in Table 7.3. The seven prime conditions can be broken down into three complementary sets and a control condition. The control condition, like in all previous chapters, has an unrelated disyllabic verb as prime, that has no ING and no phonological or semantic overlap with the target (e.g. *jiggle* - *thinking* [1]). This condition serves as the baseline to which any facilitation in the other six conditions is compared. These six remaining prime conditions cluster into three types: a repeated stem condition (e.g. *thinking* - *thinking*), a rhyming stem condition (*drinking* - *thinking*), and an unrelated stem condition (*working* - *thinking*). For each of these three types the prime occurs with the canonical suffix variant -ing and with the noncanonical variant -in'. This gives the six critical conditions seen in Table 7.3. For simplicity, for the rest of this section I will for clarity often call each condition by its example prime-target pair seen in the table.

The *thinking-thinking* condition has the maximal amount of shared overlap between the prime and the target. They have the same stem which means phonological and semantic overlap, plus, on top of that they share the same variant -ing. They do not share

[1] For clarity in the upcoming examples I will use *thinking* as the example target, but all of this can be extended to Exp5b by replacing this target with *thinkin'*.

Condition type	Example prime	Example target
Repeated stem + canonical suffix	*thinking*	
Repeated stem + noncanonical suffix	*thinkin'*	
Rhyming stem + canonical suffix	*drinking*	
Rhyming stem + noncanonical suffix	*drinkin'*	*thinking*
Unrelated stem + canonical variant	*working*	
Unrelated stem + noncanonical variant	*workin'*	
Unrelated control	*jiggle*	

Table 7.3: Prime and target design Exp5a. (For Exp5b, replace target with *thinkin'*).

exact phonetic overlap as two separate soundfiles, both recorded by the same speaker, were used here. This was done to avoid episodic memory effects in which hearing an identical phonetic pattern can induce an additional processing boost (Wilder, 2018). The *thinkin'-thinking* condition parallels this condition, and combining insights from Experiments 1-4, I expect that there will be no significant difference between these conditions, as per the -ing component of the ing/in' asymmetry.

The *working-thinking* condition and *workin'-thinking* conditions are the most familiar conditions as we have seen them multiple times, most relevantly in Experiment 2. Like the repeated stem conditions, I expect no significant priming difference between these two conditions. I do however expect the priming effects in this condition to be significantly lower than those in the *thinking-thinking* and *thinkin'-thinking* conditions, due to the lack of shared overlap of the stem.

The *drinking-thinking* and *drinkin'-thinking* conditions are interesting since there is phonological overlap between the stems of the prime and target (*drink* and *think*). Rhyme prime where both the prime and target are multimorphemic has not yet been tried in an auditory paradigm, so the outcome of these conditions is hard to predict. That being said, based on the shared representation assumption, it could be hypothesised that we will see no difference between the conditions (upholding the ing/in' asymmetry), and will see priming effects that are not as strong as the repeated stem conditions, but are stronger than the unrelated stem conditions. The word *drink* does not share as much overlap with *think* as *think* itself does - it misses semantic overlap and phonological onset overlap - but it shares more overlap with *think* (they share phonology of the rhyme) than *work* does. This condition will confirm whether the ing/in' asymmetry indeed holds up across stem types with different amounts of relatedness, in particular, relatedness between full overlap and no overlap. When considering Exp5b, I predict a similar pattern of overall priming effects: repeated stem will be the largest, then rhyming stem, then unrelated stem. However, in this experiment, because we are using -in' targets, I expect to see the -in' boost surface across all stem-type condition pairs. In other words, I expect *thinkin'-thinkin'* to have greater facilitation than *thinking-thinkin'*, and expect a similar pattern for *drinkin'-thinkin'* compared to *drinking-thinkin'*, and for *workin'-thinkin'* compared to *working-thinkin'*. Overall, I do not expect the stem-type to interact with the presence of absence of the ing/in' asymmetry. Any difference in priming pattern between the stem-types would be an unusual result.

7.2.1 Method

The sixty-three critical pairs used in Pilot Experiments A and B were used in this experiment. A full list of the stimuli for this experiment can be found in Appendix F. The rhyming stem primes were selected using the CMU pronouncing Dictionary (Weide, 1998). Both rhyming stem and unrelated stem primes were approximately matched to the target in CDlog frequency as extracted from the SUBTLEX database (Drummond, 2018).

Recording of the stimuli was done by the same speaker as for the previous experiments using the same equipment.

7.2.1.1 Participants and procedure

The procedure for this experiment was identical to Experiment 2. 142 participants participated in Exp5a, and 75 participated in Exp5b. Participants were randomly assigned to one of 7 lists. Each list contained all 63 targets, paired with 9 primes from each critical condition, counterbalanced across the lists.

7.2.1.2 Modeling

The data from Exp5a and Exp5b were modeled and analysed in the same way as the previous experiments. Participants whose accuracy was less than 80% were excluded from the datasets (Exp5a: 8 participants. Exp5b: 13 participants). The critical trials were extracted from the data, and inaccurate responses to either the prime or target were removed. The data were trimmed by response time following procedures laid out in Baayen and Milin (2010). This involves minimal a priori data trimming (examining RTs by participant and by target and trimming off outliers that fall outside of a normal distribution), and post-fitting model criticism. All targets with RTs smaller than 200ms and larger than 2500ms were removed, which led to an exclusion of 116 datapoints from Exp5a, and 54 datapoints from Exp5b. The data were log-transformed, and a by participant and by item removal of outliers as determined by Shapiro-Wilk's tests for normality led to an exclusion of 354 datapoints from Exp5a, and 850 from Exp5b.

A linear mixed-effects model was fit to the log-transformed response times to the targets using the lme4 package (Bates et al., 2015) in R (R Core Team, 2015). Prime condition was treatment coded with the *jiggle-thinking* baseline as the reference level. Random effects for Participant and Target were included. The following fixed-effects were included in the model: Condition, Trial Number, Target Frequency, Prime Frequency, and Prime RT were included in the model. Prime Frequency, Target Frequency, Prime RT, and Trial Number are all z-scored.

After the fitting of the first model, model criticism was done to identify outliers that were overly influential (Baayen and Milin, 2010). Data points with absolute standardised residuals exceeding 2.5 standard deviations were excluded (Exp5a: 183 datapoints. Exp5b: 105 datapoints), and the model was refitted to the remaining 6936 observations in Exp5a, and 3959 observations in Exp5b. The results of the models are discussed below, and with significant p-values reported at $p<0.05$, as determined using the lmerTest package (Kuznetsova et al., 2016).

7.2.2 Results

The results for Exp5a are shown in Table 7.4 and in Figure 7.2. In Table 7.4, the raw reaction times to targets (i.e. *thinking*) per priming condition are shown, with priming effects in raw ms (calculated by subtracting RT per critical condition from the RT in the control condition *jiggle-thinking*). Do note, however, that all modeling was done on log-transformed RTs.

Prime condition	RT in ms(SD)	Priming Effect
thinking	911(133)	95
thinkin'	905(128)	101
drinking	904(129)	102
drinkin'	917(124)	89
working	961(135)	45
workin'	967(131)	39
jiggle	1006(143)	NA

Table 7.4: Mean RTs to targets (i.e. *thinking*) and priming effects (in ms) by priming condition in Exp5a. Note: all the priming effects are significant to p<0.001

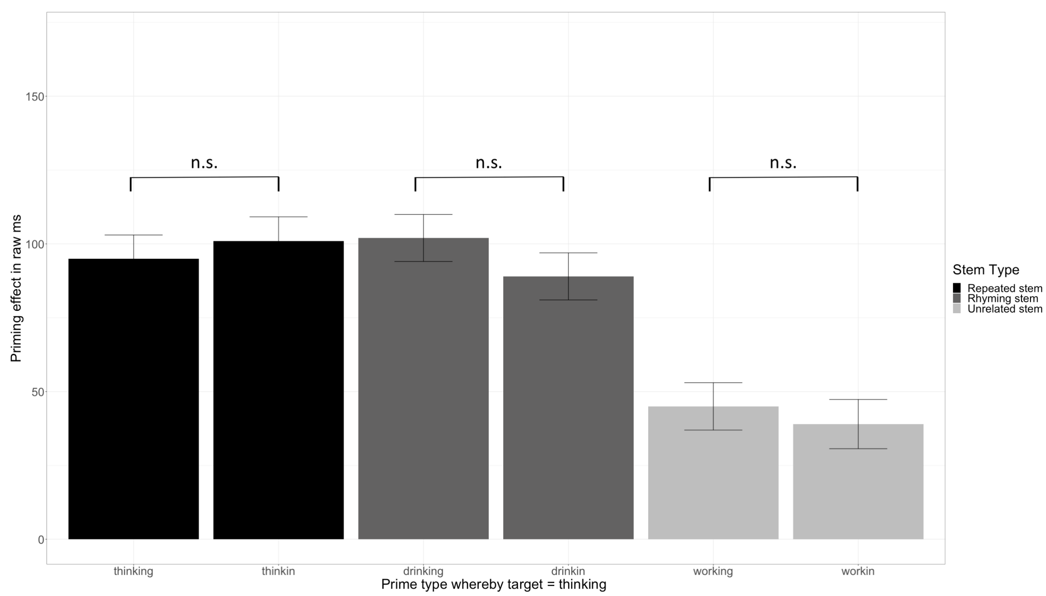

Figure 7.2: Priming effects in ms per priming condition to target *thinking*

Analysis of the log-transformed RTs shows significant facilitation for all six priming conditions, compared to the reference level. The *thinking-thinking* condition (β = -0.09, p <0.001), the *thinkin'-thinking* condition (β = -0.10, p <0.001), the *drinking-thinking* condition (β = -0.11, p <0.001), and the *drinkin'-drinking* condition (β = -0.09, p <0.001)) showed the largest priming effects. Nonetheless, also the unrelated stem conditions *working-thinking* (β = -0.05, p <0.001) and *workin'-thinking* (β = -0.04, p <0.001) I find significant facilitation compared to the baseline (i.e. *jiggle-thinking*). Further, as expected for this kind of experimental paradigm, I find a significant effect of the log-transformed Target Frequency (β = -0.03, p <0.01) and log-transformed Prime Frequency (β = 0.01, p <0.001), which indicates that participants respond faster to higher frequency targets, and slower after a high frequency prime. Similarly, I find an effect of TrialN (β = -0.02, p <0.001), showing that participants improved their response speed as the experiment progressed. There was also a significant effect of PrimeRT (β = 0.04, p <0.001), meaning that when a participant had a slow response to a prime, their response to the target was generally also slower.

Further planned comparisons were performed using the emmeans package. This was done in order to make a comparison between the -ing and -in' conditions within each stem-type. In the repeated stem conditions there was no significant difference between *thinking-thinking* and *thinkin'-thinking* (β = -0.006, p = 0.91). Similarly, in the unrelated stem set there was no significant difference between *working-thinking* and *workin'-thinking* (β = 0.007, p = 0.89). Further, in the rhyming stem set there is also no difference between *drinking-thinking* and *drinkin'-thinking* (β = 0.01, p = 0.13). One important note here is that before correcting for multiple comparisons this rhyming stem comparison does come out as significant. However, since multiple comparisons are necessary here, p-values are corrected accordingly using the tukey method. Finally, there is no significant difference between the priming effects in any of the repeated and rhyming stem conditions: *thinking* condition compared to *drinking* condition (β = -0.06, p = 0.78), *thinking* compared to *drinkin'* (β = -0.05, p = 1), *thinkin'* compared to *drinking* (β = -0.001, p = 0.87), and *thinkin'* compared to *drinkin'* (β = -0.01, p = 0.25).

The results for Exp5b can be found in Table 7.5 and Figure 7.3.

Prime condition	RT in ms(SD)	Priming Effect
thinking	954(133)	65
thinkin'	919(128)	100
drinking	925(129)	94
drinkin'	883(124)	136
working	970(135)	49
workin'	929(131)	90
jiggle	1019(143)	NA

Table 7.5: Mean RTs to targets (i.e. *thinkin'*) and priming effects (in ms) by priming condition in Experiment 1. Note: all the priming effects are significant to p<0.001

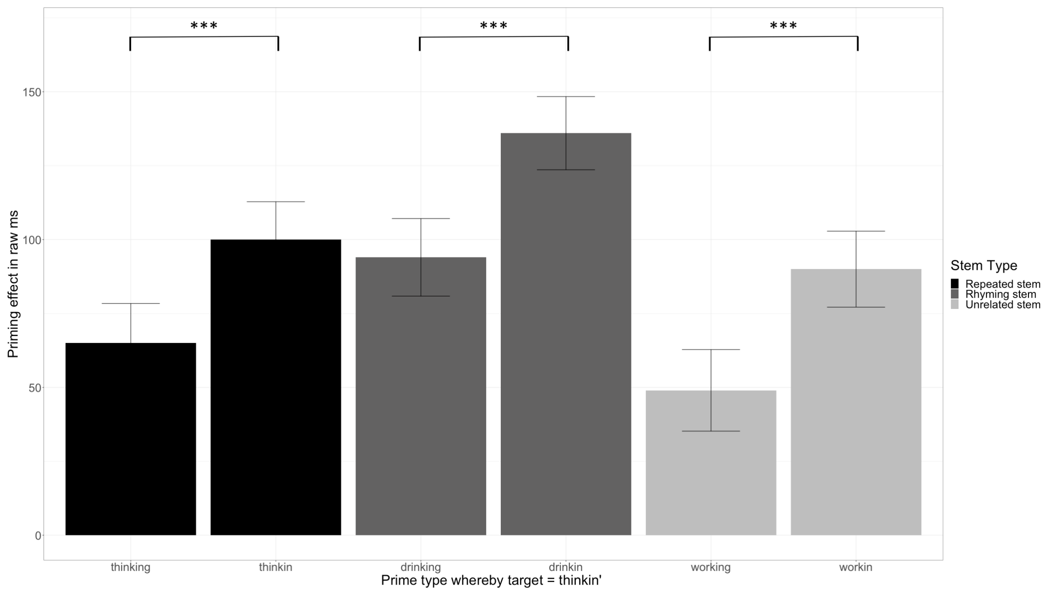

Figure 7.3: Priming effects in ms per priming condition to target *thinkin'*

Like in Exp5a, analysis of the log-transformed RTs shows significant priming in all six priming conditions, compared to the baseline. In the repeated stems conditions, we see 65ms of priming for *thinking-thinkin'* (β = -0.07, p <0.001) and 100ms of priming for the *thinkin'-thinkin'* condition (β = -0.10, p <0.001). In the rhyming stem conditions, there is 94ms of facilitation for *drinking-thinkin'* (β = -0.10, p <0.001), and 136ms of priming for *drinkin'-thinkin'* (β = -0.14, p <0.001). Finally, in the unrelated stems condition, which we have seen many times before in the other experiments in this dissertation, *working-thinkin'* gives 49ms of priming (β = -0.05, p <0.001), and *workin'-thinkin'* gives 90ms of priming (β = -0.09, p <0.001). In this experiment, only Target Frequency (β = -0.02, p <0.05) and PrimeRT (β = 0.04, p <0.001) are significant other predictors. Trial Number (β = -0.01, p = 0.16) and Prime Frequency (β = -0.006, p = 0.07) were not significant.

The same planned comparisons as were done in Exp5a were performed on the data using the emmeans package. There is a significant difference between the same- and cross-variant conditions in all three stem types. For the repeated stems, the priming for *thinkin'-thinkin'* is significantly larger than that for *thinking-thinkin'* (β = -0.04, p <0.001). The same is shown for *drinkin'-thinkin'* compared to *drinking-thinkin'* (β = -0.05, p <0.001). Finally, we see the now familiar -in' boost when comparing *workin'-thinkin'* to *working-thinkin'* (β = -0.04, p <0.001).

Of note is the significantly larger priming effect in the *drinkin'-thinkin'* condition compared to the *thinkin'-thinkin'* condition (β = -0.04, p <0.001), and the *drinking-thinkin'* compared to *thinking-thinkin'* condition (β = -0.03, p <0.01).

7.2.3 Discussion

The goal of Experiment 5 was to test the insensitivity of the ing/in' asymmetry to changes in stem type, and to further confirm its insensitivity to the proportion of -ing and -in' tokens in the expermental setup. As can be seen from Figure 7.2, when the target is *thinking*, there is no significant difference between the same- and cross-variant conditions within each stem-type. By contrast, as Figure 7.3 shows for Exp5b, when the target is *thinkin'*, there is significantly more priming for the same-variant condition than the cross-variant condition within each stem type. This is the fourth replication of the ing/in' asymmetry, and of the -in' boost.

The core research question for this experiment was testing the ing/in' asymmetry with different stem types, and on that front the results are clear and easy to explain. That being said, I must pay some attention to an unexpected outcome in this experiment: the magnitude of facilitation in the rhyming stem condition. It is worth noting here that to my knowledge, there has been no previous auditory priming study that uses complex primes and targets that have rhyming stems and also both have a suffix, so it was hard to predict what would happen in this rhyming stem condition. In Exp5a, the priming effects in both rhyming stem conditions do not differ significantly from each other. In Ex5b, facilitation in the rhyming stem conditions is significantly larger than their repeated stem counterparts. This is a highly unusual and unexpected outcome. Under all prior assumptions about how priming like this works, we would expect that repetition priming should be larger than rhyming stem priming. The more shared overlap, the larger the facilitation should be. Since *think* shares both phonology and semantics with *think*, but *drink* only share phonology (and only partially at that) and no semantics, it is very surprising to see equal (in Exp5a) and more (in Exp5b) facilitation in the rhyming stem conditions, in which there is no semantic overlap. I have no satisfactory explanation for this finding. In a future collaboration with a phonologist and morphologist I hope to be able to probe this relationship further, but at present it is an exciting line of research that must be pursued outside of this dissertation.

7.3 Experiment 6

This final experiment addresses one of the most contentious issues in social science research: the use of undergraduate college students as participants in behavioural studies (i.a. Dickinson et al., 2012; Peterson and Merunka, 2014; Lupton, 2019). In fields from psychology to advertising to political science, an overwhelming number of studies use university subject pools to recruit participants. This type of participant recruitment is called **convenience sampling** and, as the name suggests, involves recruiting participants who are easily accessible over a random sample of participants from the entire population of interest. There are several reasons why researchers opt for convenience sampling, the primary two being that access to these students is easy, and more attractively, it is usually free. Students often get course credit for their participation in research studies being done at their home university. This means that researchers can run hundreds of participants in their studies without financial burden. Furthermore, there are some who argue that students benefit pedagogically from participating in research studies and that it enhances their learning of related content matter (Rosell et al., 2005).

The biggest concern regarding the use of college student subject pools is the generalisability of results obtained from these participants to the population of interest (Peterson and Merunka, 2014; Dickinson et al., 2012; Lupton, 2019). Some researchers have expressed concerns about the use of such a narrow participant group for what we know about human behaviour (Gallander Wintre et al., 2001). College students are young, well-educated, have good cognitive skills, and less set behaviour, attitudes, and relationships than older adults. The fact that a lot of what we know about human behaviour is based on studies of this population is mildly concerning (Sears, 1986). Other researchers have argued that if the research emphasis is on basic psychological processes that are independent of the characteristics of the sample, then using college undergraduates as participants is appropriate (Kardes, 1996; Lucas, 2003). This is an unresolved debate, but as Peterson and Merunka (2014) points out, one key way to approach this issue is to test whether results are reproducible with other samples.

Spoken word recognition could be classified as one of the basic psychological processes that Kardes (1996) and Lucas (2003) refer to. That being said, the fact that the ING variants are socially meaningful, and that we know that speakers can use contextual and social information in their use of ING means that we expect that social demographics play a role in this research. The undergraduate subject pool at the University of Pennsylvania is clearly not representative of the population of native speakers of North American English. Therefore, in order to check whether the use of a college student subject pool is appropriate in this type of research, I ran Experiment 6; a direct replication of Exp5b, but with a different participant group, recruited through an online participant platform.

An important concern to raise here is that online platforms for participant recruitment are by no means the perfect solution to this problem. In fact, it has been argued that since undergraduate students are often motivated by an interest in psychology or behavioral research, they are keen to do well in studies that they participate in. By contrast, participants recruited through online participant platforms are anonymous, studies are done for financial reward, and participants complete the studies without researcher supervision in unknown locations, there is less incentive to pay attention and perform for these participants (Chandler et al., 2014). A study testing how well participants from an undergraduate subject pool and from the online participant platform Mechanical Turk actually found that participants from Mechanical Turk paid more attention during the experiments than college students did, as evidenced through instructional manipulation checks throughout the course of the experiments (Hauser and Schwarz, 2016). It will be of interest whether there are large differences in performance between the participants of Exp5b and Experiment 6, in particular with regard to the -in' boost, which I have discussed could be an attention-related expectation violation effect.

7.3.1 Method

7.3.1.1 Participants and procedure

The procedure was identical to Exp5b. However, the participant recruitment was significantly different. In this experiment, 107 participants were recruited through the online participant recruitment platform Prolific Academic (www.prolific.co)[2020]. All participants were native North American English speakers, both born and currently residing in the United States or Canada. The participants in this experiment had an average age of 29.4, and ranged from 18 years of age to 57 years, which is a broader age range and a higher mean age than the undergraduate participants from the subject pool have. Participants were randomly assigned to one of 7 lists. Each list contained all 63 targets, paired with 9 primes from each critical condition, counterbalanced across the lists.

7.3.1.2 Modeling

The data from experiment 6 were analysed in the same way as the previous experiments. The trimming procedure resulted in the exclusion of 8 participants for having accuracy scores lower than 80%. Following this, datapoints with extremely long or short RTs (116 data points), and outliers based on by-participant and by-item normality tests (1334 data points) were removed. In total, 12% of the data was removed leaving 4824 observations for analysis. Finally, model criticism cut the last outliers from the dataset (205 data points). The model included PrimeType as the critical predictor, and further fixed effects for TrialN, PrimeFrequency, TargetFrequency, and PrimeRT. Random intercepts were included for Participant and Target.

7.3.2 Results

The results for Experiment 6 can be seen in Table 7.6 and Figure 7.4. Analysis of the log-transformed RTs shows, like in Experiment 5b, significant priming in all six priming conditions. There is 66ms of significant facilitation in the *thinking-thinkin'* condition (β = -0.06, p<0.001) and 110ms in the *thinkin'-thinkin'* condition (β = -0.11, p<0.001). In the rhyming conditions I find 100ms of priming for *drinking-thinkin'* (β = -0.10, p<0.001) and 141ms of facilitation for *drinkin'-thinkin'* (β = -0.14, p<0.001). In the unrelated stems condition, there is a 59ms priming effect for *working-thinkin'* (β = -0.06, p<0.001) and a 96ms priming effect for *workin'-thinkin'* (β = -0.10, p<0.001).

In line with Exp5, the following planned comparisons were done using the emmeans package. The results pattern is identical to that found in Exp5b. There is significantly more priming for *thinkin'-thinkin'* compared to *thinking-thinkin'* (β = -0.05, p<0.001). There is also more facilitation in the *drinkin'-thinkin'* condition over the *drinking-thinkin'* condition (β = -0.04, p<0.001). Finally, there is more facilitation for the *workin'-thinkin'* condition over (β = -0.04, p<0.001).

Prime condition	RT in ms(SD)	Priming Effect
thinking	979(144)	66
thinkin'	935(137)	110
drinking	945(139)	100
drinkin'	904(133)	141
working	986(145)	59
workin'	949(141)	96
jiggle	1045(155)	NA

Table 7.6: Mean RTs to targets (i.e. *thinkin'*) and priming effects (in ms) by priming condition in Experiment 1. Note: all the priming effects are significant to p<0.001

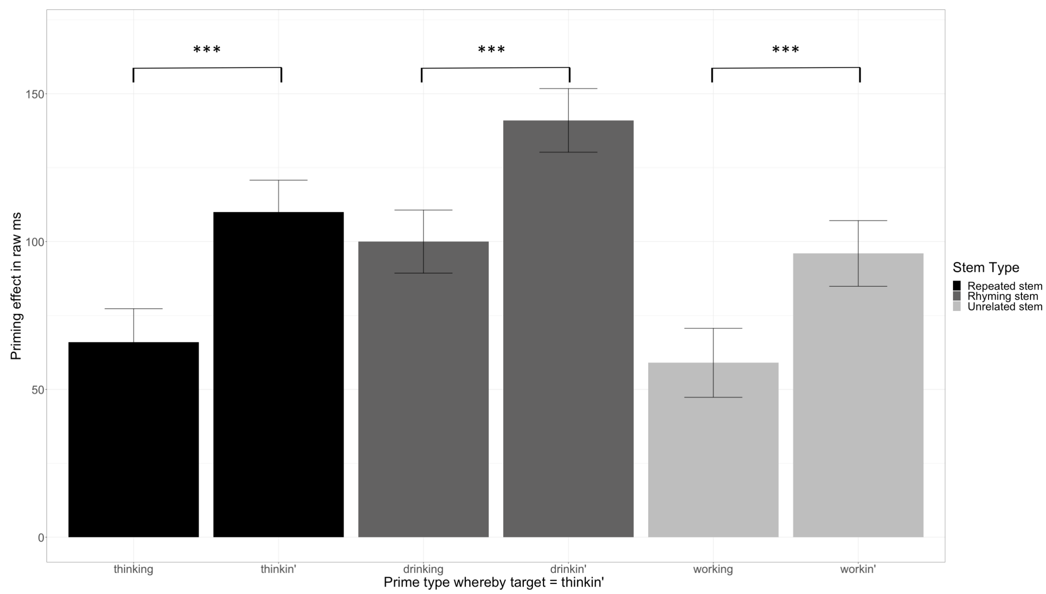

Figure 7.4: Priming effects in ms per priming condition to target *thinking*

7.3.3 Discussion

The results from Experiment 6 are almost identical to those from Exp5b. In all three stem type conditions, the -in' primes give a larger facilitation than the -ing primes, and if we compare Table 7.5 to Table 7.6, we can see that the priming effects are remarkably similar in magnitude. This is very encouraging evidence that the use of undergraduate students as subjects is not a confound for this line of research. The process under investigation in this research seems to be insensitive to the differences in demographics between college students and the sample of the population recruited through Prolific Academic.

This experiment is the final replication of the in' boost in this dissertation. Once again, the in' boost is insensitive to the relatedness between the prime and target stems. Furthermore, Experiment 6 replicates the boost of the rhyming stem condition over the repeated stem condition. The replication of this pattern from Exp5b with a novel population supports the idea that there is something unusual about disyllabic or multimorphemic words with rhyming stems that we have yet to research and understand. Experiments 5 and 6 together form a strong motivation for the pursuit of this enigmatic phenomenon.

Chapter 8

General Discussion

This dissertation explores the processing and mental representation of variable ING.

The starting point for this dissertation was the observation that although decades of variationist sociolinguistic research on naturalistic speech data has given us a comprehensive understanding of the use of -ing and -in', and of the way in which the variants are sociostylistically conditioned, the research methods used in this literature make it hard to resolve questions about the way in which socially meaningful variation is processed and mentally represented. To illustrate this: the fact that -ing/-in' usage has been found to differ between verbal words (such as progressive/gerundive *thinking*) and nominal words (such as *awning*), has led to a debate about whether variable ING is phonological or morphological. What it might mean exactly for a variable to be phonological or morphological is not well defined, and the messiness and lack of control in naturalistic speech data make it hard to probe such underlying properties of a variable in a way that will be informative of this discussion.

I therefore set out to explore these questions in a new way, by adopting a highly-controllable tool from psycholinguistic research on the mental lexicon: primed lexical decision experiments. Specifically, I proposed that, what in sociolinguistics is referred to as "locus of variation" questions, can actually be thought of as questions about the mental representation of variables. Primed lexical decision experiments are used by psycholinguists to probe mental representation questions, such as do shared aspects of representation between two words lead to processing facilitation? Using this tool, researchers have shown that semantic, phonological, and morphological aspects of representation contribute to processing facilitation in different ways. For example, a prime word like *king* will facilitate the processing of a semantically related word like *queen*, although this facilitation is temporally relatively short-lived. Also, a word like *teacher* will facilitate the word *teach*, because they share the same stem, and this facilitation is temporally more robust, in that it persists across intervening words.

To be concrete, in this dissertation I integrate our sociolinguistic knowledge of variable ING with our psycholinguistic knowledge of how to probe aspects of shared representation to ask the novel question: how are the socially meaningful variants -ing and -in' mentally represented, and which aspects of shared representation influence how they are processed? In Chapter 3 I laid out many of the ways in which words that contain an [ɪŋ] or an [ɪn] are related. Since -ing and -in' are found in both monomorphemic words and in verbs with an -ing or -in' suffix, there are in fact a very large number of ways in which ING-final words can be related to one another. For example, *jumping* and *thinking* have completely unrelated stems, but share progressive/gerundive interpretations, share surface phonology, and share the standardness of their ING pronunciation variants. By contrast, *awning* and *thinking* do share the latter two of those types of relatedness, but do not share any progressive/gerundive representation. In an ideal scenario, I would systematically contrast as many of the ways as possible in which words ending in [ɪŋ] or an [ɪn] are and could potentially be related, but that would be far too large an undertaking for a single dissertation. Instead, in this dissertation I use carefully constructed experiments to establish a baseline understanding of how ING is mentally represented. I ask three core research questions:

1. Can I reliably detect affix priming for both pronunciation variants of variable ING?
2. Can I detect which aspects of shared representation contribute to processing facilitation of the ING variants?
3. Can I detect differences in processing between -ing and -in'?

In the following subsections I recap my results on each of these questions in turn, discussing both their theoretical implications and prospects for further research.

8.1 Affix priming for -ing and -in'

Experiments 1 and 2 ask whether, in words that end with a verbal (progressive/gerundive) -ing or -in', the -ing at the end of a word like *jumping* will facilitate the processing of a word like *thinking*, because they both share the -ing suffix. This kind of primed lexical decision experiment, whereby primes and targets have an overlapping affix but no overlapping stem, is called affix priming. It isolates facilitation effects to the affix, such that any processing facilitation of the target must reflect aspects of shared representation of the affix, and cannot be attributed to shared representation between the prime and target stems. For spoken word recognition, the reliable detection of affix priming, particularly for inflectional affixes, is relatively novel (e.g. Goodwin Davies and Embick, 2020). With Experiments 1 and 2 I wanted to a) add to this field with a demonstration that affix priming can be obtained for the standard -ing suffix, and b) provide a novel contribution by showing robust affix priming for the noncanonical pronunciation variant of ING, i.e. -in'.

In both Experiments 1 and 2 I find robust and reliable affix priming for -ing-ing and also for -in'-in' prime-target pairs. This is exciting because affix priming on inflectional affixes is an understudied topic. Most prior work on affix priming was done in the visual modality, and the results are fairly mixed (i.a. Duñabeitia et al., 2008; Marslen-Wilson et al., 1996; Giraudo and Grainger, 2003). Most of these studies find reliable processing facilitation for derivational affixes (e.g. *blackness-shortness*) but not for inflectional affixes like -ing[1] (Emmorey, 1989). This claim is disputed in a much more recent inflectional affix priming paper by Goodwin Davies and Embick (2020) on the English plural suffix -s, who find robust inflectional affix priming. Goodwin Davies and Embick (2020) call for more rigorously designed affix priming studies on different inflectional affixes to support this literature and show that inflectional affix priming can be detected reliably.

The work in this dissertation not only parallels the Goodwin Davies and Embick (2020)

[1]Where -ing falls on the derivational versus inflectional suffix divide is actually slightly complicated. In principle, one could argue that *build-building* looks more derivational than inflectional. That being said, the function of -ing that I am focusing on in this dissertation is at the most inflectional end of the range of -ing functions.

finding that inflectional affixes can prime each other even when the prime-target stems are unrelated, but also shows that the result is robust and replicable across numerous related experiments, that all differ slightly in design. More interestingly, Experiments 1 and 2 show that affix priming is not a characteristic that only pertains to standardly pronounced words. Using a carefully constructed set of instructions, we can reliably detect affix priming across noncanonical pronunciation variants of affixes: in this case from -in' to -in'. Affix priming using socially meaningful noncanonical variants has not been done before, and to find strong -in'-in' affix priming across five experiments (an -in'-in' affix priming condition is included in all experiments in this dissertation except Experiment 4) is very exciting. It shows that we can use primed lexical decision tasks to explore the mental representation of noncanonical pronunciations in morphologically complex words. This opens a new avenue of research that focuses on disentangling the layers of of representation of socially meaningful variants, which can complement the experimental literature on how variants influence lexical access (e.g. Sumner and Kataoka, 2013).

Besides the finding of same-variant -ing-ing and -in'-in' affix priming, Experiments 1 and 2 also find robust cross-variant priming; -ing facilitates the processing of -in' and vice versa. This cross-variant priming is just as replicable as same-variant priming and is found in all experiments in which it was a condition in this dissertation (all experiments except Experiment 3). This finding is of theoretical relevance as it tells us that -ing and -in' are related to one another, and that it is unlikely that they are stored completely independently. This was at the outset an unlikely hypothesis, but the finding of cross-variant priming is evidence that there is at least some aspect of shared representation between them. Since at this stage, the words in which -ing and -in' are embedded all share progressive/gerundive meanings, these experiments do not give insight into exactly how -ing and -in' are related, but what the finding of cross-variant priming tells us is at least that we must posit some relatedness between them. In section 8.3.2 I will discuss the differences between same- and cross-variant priming in detail, and will give potential options for those shared aspects of representation.

One of the goals of affix priming researchers is to contribute to the discussion on whether inflectional affixes are represented as isolable morphological units or whether they emerge from semantic and phonological features of whole-word representations. Goodwin Davies and Embick (2020) explain that for English plurals, under the whole-word storage approaches that deny the existence of discrete morphological units, a word like *crimes* would be represented with its stem and a plural feature together as one unit (i.e. as [CRIME +PL]). By contrast, in theories that use morphemes, the stem and plural suffix would be separate pieces (i.e. as [CRIME]+[+PL]). Goodwin Davies and Embick (2020) suggest that primed lexical decision experiments could be used to tease apart the contribution of semantic interpretation, morpho-syntactics, phonological realisation, and syntactic structure to affix priming of the kind *crimes-trees*. For example, by contrasting words with the same phonological realisation of the suffix (i.e. *crimes-trees* which both have a /z/ plural realisation) to those with different realisations (like *cats-trees* or *oxen-trees*) could disentangle phonological from morphological representations.

Although not the goal of the current dissertation, the affix priming results for -ing and -in' provide an interesting option for this line of research since, by contrast to different phonological realisations of inflectional affixes like the English plural morpheme (i.e. /s/, /z/, etc.), -ing and -in' are used with the same stems. So, where the plural of *crime* (whether thought of as [CRIME +PL] or [CRIME]+[+PL]) has just a single phonological realisation (i.e. *crime*+/z/), the progressive form of *think* (so either as [THINK +PROGRESSIVE] or as [THINK]+[+PROGRESSIVE]) has two possible phonological realisations (i.e. *think*+[ɪŋ] or *think*+[ɪn]). This characteristic of variable ING is highly attractive since it allows the researcher to use an even more highly controlled design in which priming effects are not influenced by potential aspects of shared representation pertaining to the individual stems of words. Sociolinguistic variables like ING could therefore be a useful tool for researchers of morphological structure, especially since the experiments in this dissertation show such robust and replicable affix priming results.

8.2 Aspects of shared representation that facilitate ING processing

In Chapter 3 of the dissertation I presented a Master Table that lays out many of the ways in which words that end with an [ɪŋ] or an [ɪn] are related. I suggested that using primed lexical decision experiments I could test these relationships and tease them apart, and that this would give insight into the aspects of shared representation that play a role in the processing of ING variation.

A concrete example of this was tested in Experiment 3. One of the core results from Experiments 1 and 2 was large affix priming for -in'-in' (e.g. *jumpin'-thinkin'*) prime-target pairs compared to -ing-in' pairs (e.g. *jumping-thinkin'*). In Table 8.1 is an extract of relevant relationships from the Master Table. As can be seen from Table 8.1, there are two aspects of representation that differ between *jumpin'-thinkin'* and *jumping-thinkin'*: shared surface phonology and shared social meaning. It would be helpful to know if either of these aspects of representation contribute to the priming boost seen for -in'-in' over -ing-in' pairs in Experiments 1 and 2. In Chapter 5 I suggested that I can test whether surface phonology is a contributor by asking whether a word that shares only surface phonology with the target *thinkin'*, like *dolphin*, gives any processing facilitation (see Table 8.1). If the shared surface phonology between *dolphin* and *thinkin'* gives a priming effect over the unrelated baseline (i.e. *jiggle-thinkin'*), then I can assume that surface phonology may be contributing to the large same-variant priming effect seen in Experiments 1 and 2.

Prime	End of the word			
Target = thinkin'	Verbal suffix	Variable ING	Surface Phonology	Shared social meaning
jumpin'	✔	✔	✔	✔
jumping	✔	✔	✗	✗
dolphin	✗	✗	✔	-
jiggle	✗	✗	✗	-

Table 8.1: Aspects of shared representation for the end of primes to target *thinkin'*

Experiment 3 showed that *dolphin* in no way facilitates the processing of *thinkin'*: it gives the same processing time as the unrelated baseline *jiggle-thinkin'*. This tells us that surface phonological overlap of the end of the word is not an aspect of shared representation that facilitates processing, at least not in these complex words. Referring back to the Table in 8.1, I can then posit that the boost for same-variant priming for -in'-in' pairs is not likely to reflect surface phonological overlap. This means that I can move on to entertaining shared social meaning as a possible cause for the effect.

Another meaningful example of disentangling contributions of aspects of shared representation to processing facilitation is demonstrated in Experiments 4 and 5. In these experiments, instead of using affix priming with unrelated stems (i.e. *jumping-thinking*), I introduce two conditions whereby the stems are in fact related to each other in some way: repeated stems (i.e. *thinking-thinking*) and rhyming stems (i.e. *drinking-thinking*). In these experiments I ask whether aspects of shared representation between stems in complex words ending in -ing or -in' affect the affix priming facilitation seen in Experiments 1 and 2. The results of Experiments 4 and 5 show that, although the additional shared representation between the repeated and rhyming stem primes and targets definitely increases priming effects overall, the pattern of priming between -ing-ing, -ing-in', -in'-ing, and -in'-in' remains stable. The boost for -in'-in' pairs that I discussed above remained intact, even with these added aspects of shared representation.

An observation to note here is that in Experiments 4 and 5, the magnitude of the same-variant boost remains relatively stable across the different stem types. For both repeated and rhyming stems, the processing facilitation is greater than for the unrelated stem conditions. However, the same- to cross-variant difference in priming effects is stable (see Figure 7.3). This finding speaks to the question of how priming effects are composed when there are multiple contributing aspects of shared representation. There are a number of options (Goodwin Davies, 2018; Bacovcin et al., 2017; Gonnerman et al., 2007). The most straightforward option is that priming effects are caused by a simple additive process. For example, each aspect of shared representation facilitates the processing of a subsequent target by Xms, and when multiple aspects are involved, those facilitations simply add up to the eventual priming effect. It is also possible that there is a simple or more complex interaction between the processing facilitation caused by different aspects of shared representation. The data in the experiments in this dissertation perhaps do not lend evidence against a simple additive analysis of this. That being said, they were not designed to analyse magnitude effects, but it could be a fruitful avenue for future research on how shared aspects of representation contribute to processing facilitation.

The Master Table that I composed has proven to be a useful tool for structuring a set of experiments that teases apart the contributions of different aspects of shared representation to the processing of ING. However, it is important to note that the aspects that I listed in that table are not exhaustive; I only included aspects of shared representation that a) are relevant to this dissertation, and b) are relatively uncontroversial. As an example of the latter point, I did not include "underlying phonology" or "morphology" in the table because, especially for the -ing and -in' suffixes, we do not know what those aspects of representation actually look like. It is evident from the extensive discussions in sociolinguistics on the phonological versus morphological status of variable ING that what it means exactly for the variable to be one or the other of these is not clearly defined (see Section 2.2.3). Besides this, the relationship between semantic, phonological, and morphological representation is complicated and in itself still very much up for debate (see Embick et al.(forthcoming) for an overview of this discussion). In section 8.1 I highlighted how affix priming researchers want to use affix priming to tease apart these representations.

To demonstrate this complexity, Goodwin Davies and Embick (2020) suggest that two words that share semantics do not necessarily share morphology, and vice versa. For example, a word like *scissors* seems to have a plural -s, but does not have a plural interpretation, and by contrast, a word like *furniture* does not have a plural marker, but does have a plural interpretation. Contrasting priming effects from *scissors-trees* and *furniture-trees* with *crimes-trees*, could therefore give insight into whether the presence or absence of a plural -s or plural interpretation contribute to the processing facilitation for *crimes-trees*, which in turn tells us something about how semantic and morphological representations may work.

Relating this to variable ING, we simply do not know whether to interpret -ing and -in' as independent morphological pieces, or to posit that they have a single underlying morpheme, or whether they are emergent from the phonology and semantics, and it will take many more primed lexical decision experiments to pass judgement on this with any confidence. The above dissociation between semantics and morphology means that for ING although *jumping* and *thinkin'* share a progressive/gerundive meaning, it remains possible that -ing and -in' are distinct morphological pieces. Simultaneously, although *awning* and *thinking* do not share a progressive/gerundive interpretation, it remains possible that they both are derived from an underlying variable ING morpheme that does not care about the semantics.

In this dissertation I deliberately do not distinguish between morphological, semantic, and syntactic representation. However, in the future, I hope that experiments like these that follow a similarly structured teasing apart of aspects of shared representation can shed light on these different kinds of representation, and that then, the table can be expanded to include what we learn about these representational questions.

8.3 Differences between the processing of -ing and -in'

The most interesting result from this dissertation is the finding that -ing targets are facilitated differently from -in' targets by primes with -ing or -in' variants. More concretely; -ing targets are facilitated equally by -ing and -in' primes, whereas -in' targets are facilitated more by -in' primes than by -ing primes. I call this asymmetrical pattern the **ing/in' asymmetry**, and the boost for -in'-in' over the other conditions the **-in' boost**. Crucially, this asymmetrical pattern tells us that there is something different about the representation of -ing versus the representation of -in'. In section 8.3.1, I will recap what the experiments in this dissertation tell us about the properties of the ing/in' asymmetry. In section 8.3.2 I will suggest two potential explanations for the asymmetry, and in section 8.3.3, I will discuss ways to probe those explanations in future work using the framework and method from this dissertation.

8.3.1 Properties of the ing/in' asymmetry

The first property of note is that the ing/in' asymmetry is robust and replicable. The asymmetry is first seen in Experiment 1 (see Chapter 4), which uses prime-target pairs that have unrelated stems (such as *jumping-thinking*) in a mixed-targets design (targets end with both -ing and -in' in this experiment). It is then subsequently found in Experiment 2, which also uses prime-target pairs with unrelated stems, but has two sub-experiments that each use a single target type (-ing or -in') in a between-subjects design. Then, it is found in Experiment 4 with repeated stem prime-target pairs (e.g. *thinking-thinking*) in a within-subjects design parallel to Experiment 1. Finally, it is found in the between-subjects design of Experiment 5, which uses single targets in two subexperiments, but has repeated stem, rhyming stem, and unrelated stem conditions. In this experiment, the ing/in' asymmetry is found across all three stem types. To demonstrate this numerically, Table 8.2 shows the ing/in' asymmetry in each experiment as the difference between the same-variant and cross-variant conditions per target type (in other words, as the difference between -ing-ing and -in'-ing, and as the difference between -in'-in' and -ing-in'). As Table 8.2 shows, there is a consistent priming boost for same-variant -in-in' pairs, but not for same-variant -ing-ing pairs.

	Experiment 1	Experiment 2	Experiment 4	Experiment 5
-ing targets	8ms	12ms	13ms	6ms/-13ms/6ms
-in' targets	33ms***	29ms***	49ms***	35ms***/42ms***/41ms***

Table 8.2: Difference in priming effect (***=p<0.001) between -ing and -in' primes within target types across experiments with no interveners. For Experiment 5: repeated stem/rhyming stem/unrelated stem.

It is worth noting that, with unrelated stems, the ing/in' asymmetry is found three times, in different experimental setups each time. With repeated stems the asymmetry is found twice, again in different experimental designs. This shows that the asymmetry is replicable. Perhaps more importantly, it is an extremely robust phenomenon in numerous ways. First, the asymmetry is unaffected by changes in experimental design: it is found both in within-subjects and between-subjects designs. Extending this to a second factor, it is independent of stem-type. This is especially important for considerations of how to analyse -ing and -in', as it tells us that processing facilitation as caused by the presence of a preceding -ing or -in' is not affected by other aspects of shared relatedness in other parts of the word that may also cause facilitation. The facilitation caused by the -ing or -in' seems in that sense to be independent and does not interact with facilitation caused by other things. Some may take this finding as early evidence for an analysis in which morphemes exist and stems and suffixes are independent units with their own properties and features (see section 2.3.2). However, it is in principle still possible that for example a progressive/gerundive feature in a whole-word storage approach could induce a processing facilitation independent of the stem features that it occurs together with. The results in this dissertation were not meant to provide input on this debate, but they certainly show that by laying out a framework of aspects of shared representation, primed lexical decision experiments using a variable like ING can in principle be used to inform this discussion.

The third way in which the ing/in' asymmetry is robust is across different proportions of -ing and -in' items in the experiments. In the within-subject experiments (1 and 4), there were an equal number of -ing and -in' words. Since the speaker of my stimuli is a white, well-educated, upper-middle class man from the north-east of the United States, in casual speech, it is likely that he uses -in' between 10% and 50% of the time (see section 2.2). The ratio of -in' to -ing words in the experimental stimuli do not introduce a bias towards hearing one variant more than the other. In the introduction of Experiment 2 (see section 5.1), I discuss the possibility that the -in' boost may be influenced by the unexpectedness of -in'; the unexpectedness of an -in' prime could enhance the facilitation effect of shared aspects of representation with the target. If this is the case, then I would expect the unexpectedness of -in' to be modulated by the number of -in' words in the experiment. If there are more -in' words, then perhaps this will make the -in' less unexpected. This is tested in the between-subjects designs (Experiments 2 and 5), which use single targets (-ing or -in'), and which therefore have one subexperiment that is relatively -ing heavy, and one experiment that is relatively -in' heavy. Even in these experiments, in which participants heard many more of one of the variants than the other, the ing/in' asymmetry remained intact. In fact, in Experiment 3, an experiment with exclusively -in' targets, and *also* exclusively [ɪn]-final primes, the magnitude of *jumpin'-thinkin'* priming is comparable to that condition in Experiments 1, 2, 4, 5, and 6. Note that there was no -in' "boost" in Experiment 3 since there was no *jumping-thinkin'* condition to compare *jumpin-thinkin'* to. That being said, Experiment 3 suggests that either the unexpectedness explanation is inaccurate, or that manipulating the proportion of -in' words within the experiment does not obviously modulate the overall unexpectedness of -in from the listeners' perspective.

Another important property of the ing/in' asymmetry that we learned from Experiment 2 is that the -in' boost is temporally short-lived. Experiment 2 used affix priming (i.e. *jumping-thinking*, etc.), but for half of the prime-target pairs introduced an intervening item. This technique is used by psycholinguists to tease apart aspects of shared semantics and phonology from shared morphology; the former two give short-lived processing facilitation that does not last across intervening items, whereas the latter gives more robust priming that persists even with intervening items (Creemers et al., 2020). The introduction of an intervening item to the -ing-ing, -in'-ing, and -ing-in' conditions did not affect their processing facilitation. This in itself is an important result as it suggests that the priming facilitation seen in these conditions patterns with morphological priming in the intervener literature. More relevantly, when an intervening item is introduced between an -in' prime and -in' target (e.g. *jumpin'* - *truck* - *thinkin'*), the -in' boost, and therefore ing/in' asymmetry is eliminated. More so than that, the -in' boost is attenuated such that, with one intervener, there is an equivalent amount of processing facilitation across all four -ing-ing, -in'-ing, -ing-in', and -in'-in' conditions. This is remarkable, and can most simply be interpreted as follows. The priming effects seen for -ing-ing, -in'-ing, and -ing-in' reflect a shared aspect of representation that is long-lived, perhaps morphological. The -in'-in' priming effect seen without an intervener comprises at least two parts. One part reflects the same aspect of shared representation that causes long-lived processing facilitation in the other three conditions. The remaining part reflects an aspect of shared representation that causes short-lived priming, such as semantics, phonology, or perhaps something episodic (see section 2.3.2).

8.3.2 Explaining the -in' boost

Now that I have established what we know about the ing/in' asymmetry from the experiments in this dissertation, I turn to potential explanations for in particular the -in' boost, and to what this might mean for the mental representation of variable ING. As I see it, there are two potential explanations for the -in' boost: a representation-based and an unexpectedness-based account.

8.3.2.1 A representation-based account

The representation-based account suggests that the cause of the -in' boost lies in a difference in representation between -ing and -in'. More specifically, the fact that I only find a processing boost in the same-variant -in'-in' condition but not in the same-variant -ing-ing condition suggests that there is an additional aspect of shared representation between the -in' prime and -in' target, compared to the representation shared in the -ing-ing, -in'-ing, and -ing-in' conditions. When discussing the implications of Experiment 2 that has intervening items above in section 8.3.1, I suggested that the -in' boost could be comprised of a temporally strong aspect of shared representation, plus a more short-lived component. One option then, is that -ing and -in' come from the same underlying suffix. This would cause the long-lived part of the processing facilitation. Next, let's suppose that underlyingly this suffix is phonologically -ing, but can be changed to -in' under certain circumstances through the application of a phonological process or rule. Then, in the -in'-in' condition, the prime and target share both an underlying suffix (like the other conditions), but also the application of a phonological process changing -ing to -in'. The -in'-in' condition is the only condition in which both prime and target share this process, and it is the only condition where a same-variant boost is seen.

This analysis is attractive for a number of reasons. First, it explains why we see a same-variant -in'-in' boost but not an -ing-ing boost. Second, processing facilitation from phonological properties has been shown to be temporally weak, in the sense that it rarely persists over intervening items (Creemers et al., 2020). This aligns with the results from Experiment 2 that show that the -in' boost does not persist over intervening items. Third, if the -in' boost is caused by a representational difference, then there is no reason to think that it would be modulated by the number of -ing and -in' words in the experiments, and indeed, I show that the -in' boost is retained across several different -ing/-in' proportions. Fourth, and similarly, there is no reason to think that the application of a phonological rule to a suffix that is underlyingly -ing should be affected by the stem-type, or at least, by the kinds of shared aspects of representation between stems that I tested in Experiments 4-6 [2].

All in all, then, I have found no evidence against the representation-based analysis of the -in' boost, across any of my experiments. In fact, it quite tidily explains the properties of the ing/in' asymmetry. An interesting parallel test-case that has not been done but could support the representation-based account comes from the affix priming literature discussed earlier in this chapter. Goodwin Davies and Embick (2020) used the English plural suffix /z/ to see whether *crimes* would facilitate *trees* through affix priming. In their study, they limited themselves to using the /z/ form of the plural suffix. However, it is well-understood that although underlyingly the suffix is /z/, when it is preceded by a voiceless stop, the /z/ changes to /z/, as in *cats*. This occurs through the application of the phonological rule shown below.

$$/z/ \rightarrow /s/ \; / \; [\text{-voice}] \; \underline{\hspace{2em}}$$

Taken together, the English plural suffix is thought to be /z/ underlyingly, but can be changed to /s/ via a phonological rule. This is an obligatory analogue to to the

[2] It is, however, possible that preceding phonological context is important for the phonological process, which needs further testing. It has, however, been suggested in the sociolinguistic literature on variable ING that regressive assimilation such that a preceding alveolar prefers -in' and a preceding velar prefers -ing (Campbell-Kibler, 2006; Houston, 1985; Cofer, 1972; Roberts and Labov, 1995).

representation-based analysis of ING, in which I suggested that the suffix may be underlyingly -ing but that can be changed to -in' via a phonological rule. It would therefore be fruitful to contrast the ING case with an experiment on English plurals that, like in Experiment 1 of this dissertation, contrasts *crimes-trees*, *cats-trees*, *crimes-boats*, and *cats-boats* (or /z/-/z/, /s/-/z/, /z/-/s/, and /s/-/s/). If the application of a phonological rule can facilitate the processing of a subsequent variant, then we would expect to see an /s/-/s/ boost in this experiment, over stable affix priming in the remaining three conditions. This setup could lend support for the representation-based account for the -in' boost.

Finally, sociolinguists will notice that the representation-based account attributes the -in' boost to a phonological analysis of ING (see section 2.2.3). One advantage of the phonological account is that it can unify ING across different contexts. This means that, if the representation-based account is correct, and if indeed ING is "the same" phonological variable across contexts, then I would expect that *jumpin'* should prime a word like *awnin'* that has an -in' that is derived from -ing via the shared phonological rule, but that it should not prime *awning* since the phonological rule is (to my knowledge) the only shared aspect of representation between *jumpin'* and *awnin'*. This type of result would be strong evidence in favour of the representation-based account. That being said, it is also possible the the application of the phonological rule is specific to the suffix context in which case more careful teasing apart of semantics, syntax, and morphology would be necessary to find evidence for the representation-based account.

8.3.2.2 An unexpectedness account

Although the relatedness-based account explains the -in' boost well, I cannot pass by the fact that one of the core differences between -in' and -ing is that they have different social meaning and conditioning. Evidence of this from the sociolinguistic literature, paired with the results from Pilot Experiments A and B of this dissertation (see sections 3.5 and 3.6), tell us that in a formal context, like my experiments, -ing is the expected form, and -in' is contextually incongruent. The pilot experiments show that with no advance warning that casual pronunciations will be used in the experiment, and explicit affirmation that casual pronunciations still count as real words of spoken American English, and despite the fact that participants use -in' in their daily speech, participants do not endorse words pronounced with an -in' as real words. Even with the explicit instructions, I manage to get participants to recognise -in' words as real words over 80% of the time which makes the data analysable, but it is worth noting that participants recognise -ing words with >90% accuracy. This shows that recognising -in' words in this context is still difficult, even when participants are explicitly prepared to hear casual pronunciations.

Studies on syntactic priming have found that unexpected syntactic constructions actually facilitate the processing of a subsequent target, rather than hinder that processing (Bernolet and Hartsuiker, 2010). If we apply this finding to the results in this dissertation, then, I could hypothesise that hearing an unexpected -in' variant would facilitate the processing of a subsequent -in' variant that has some shared aspects of representation. In this way, we would expect a processing boost for the -in'-in' condition, but not in any of the others. Note here that the unexpectedness account is *not* mutually exclusive with the representation-based account! In the representation-based account, I suggested that shared application of a phonological rule changing -ing to -in' could be responsible for the -in' boost. In principle, the unexpectedness of -in' could enhance processing facilitation from this shared phonological process. The question here is therefore not which of these two accounts is the "correct" account, but whether either or both of them contribute to the ing/in' asymmetry.

What it exactly means for the -in' variant to be unexpected given the context actually requires some additional unpacking. There are in principle three different sources of participant expectations that could be at play here:

1. Expectations created by the experimental context
2. Expectations created by the -ing/-in' proportion that the listener expects to hear from the speaker

3. Expectations created by the -ing/-in' proportion that the listener expects based on their own speech or language experience

The first source is purely contextual in the sense that expectations are derived by the context in which words being perceived, in this case, in isolation in an experimental setting. Participants could reasonably expect in this setting to hear words that are hyper-articulated, or at the very least that are spoken using a citation form, in which case they would expect to hear progressive/gerundive verbs pronounced with an -ing. This source of unexpectedness could manifest itself in a weak or strong way, easily thought of as on a scale between two extremes. On the one hand, this source of unexpectedness could be relatively weak, meaning that it can be easily attenuated through informative instructions and practice trials prior to doing the experiment, or through familiarising participants with -in' words through a higher proportion of -in' words in the experiment. On the other hand, this source of unexpectedness could be extremely strong, in that there is nothing that I as a researcher can do to make -in' less unexpected in an experimental context in which words are presented in isolation. It will simply always be the case that, in this context, -in' is incongruent and will induce a processing boost for an -in'-in' condition.

The second possible source is based on the participants' expectations for what the speaker will sound like. Listeners can use social information about a speaker to predict what they will sound like. For example, if a listener hears a speaker with an Appalachian accent, they may predict that person to use a lot of -in', based on their knowledge of what people from Appalachia sound like (Hazen, 2008). If the proportion of -ing and -in' words in the experiment does not align with what the participant expected to hear from the speaker, then this violation of their expectation could cause an unexpectedness effect. I would expect these kinds of expectations to be sensitive to speaker characteristics and to the congruence between the proportion of -ing and -in' words used in the experiment and the variety used by the speaker.

The third source is based on the participants' own language background. Listeners may have expectations about when and how often -in' is used based on their own linguistic history (i.e. where they grew up, what variety or varieties they use or used, or what variety or varieties their family/friends use or used). For example, a listener who is themselves from Appalachia may have extensive exposure to the use of -in', both in casual and more formal contexts. They may therefore be less surprised to hear an -in' used in an experimental context. By contrast, a listener who is from the Northeast, where -in' is less prolific, may find the use of -in' in an experimental context more surprising, leading to a larger unexpectedness effect. I would expect this type of expectation to be sensitive to the background of the participants and to the congruence between the proportion of -ing and -in' words in the experiment and the linguistic background of the participant.

Again, it is possible here that an unexpectedness affect is caused by multiple of the abovementioned sources. They are in no way mutually exclusive. The question therefore becomes, which, if any, of the above sources may be contributing to the -in' boost? Before I give a more detailed overview of how I can test this in a future line of research, there is one result that speaks to this question; in the experiments in this dissertation I used different proportions of -ing and -in' words across different experiments and found no difference in the magnitude of the -in' boost across all the used proportions. The proportions used were 50% -in' (Experiments 1 and 4), 80% (Experiments 2 and 5), and 100% (Experiment 3, although there was only an -in'-in' condition, and no -ing-in' condition in this experiment from which to calculate the full -in' boost). The magnitude of -in'-in' priming as shown by Table 8.2 remained relatively similar across the experiments (note that no cross-experiment statistics were performed so this is impressionistic, not statistically confirmed). The finding that the -in' boost seems to be insensitive to the proportion of -ing/-in' words in the experiment speaks against an unexpectedness account that has expectations derived from speaker or listener characteristics as source, and from a weak version of the experimental context source (i.e. that with more -in' words in the experiment, familiarity with them would reduce unexpectedness). That being said, I am not willing to discard these sources as potential contributors to the -in' boost until I have tested them further by actually manipulating the speaker and listener characteristics, and by using a variety of different instruction types.

8.3.3 How to probe the unexpectedness of -in'

As discussed above, there are three different sources of expectations that could cause -in' to be processed as an unexpected variant in my experiments. In order to test their potential contributions to the -in' boost, I propose a novel set of experiments that systematically tests the robustness of the -in' boost under conditions meant to alter the unexpectedness of -in'.

Note from the above descriptions of the sources of expectations about -in' that there is one account that I cannot falsify by changing the conditions in these experiments; the strong contextual expectations account. It is possible that, because -in' is only used in running speech (usually casual) and is very rarely heard in an isolated word (let alone in an experimental context), -in' will always induce an unexpectedness effect, whatever the instructions or speaker/listener characteristics are. If this account is accurate, then no changes I make to the experimental design, or speaker/listener characteristics will attenuate the -in' boost. Simultaneously, if the representation-based account is the only factor causing the -in' boost, then the same should happen: no changes I make to the design will change the -in' boost. Earlier in section 8.3.2 I suggested that I could test the representation-based account by comparing my -ing and -in' results to same- and cross-variant priming of the English plural suffix realisations (/z/ and /s/). This could give insight into whether the representation-based account contributes to the -in' boost, and if it does not, could support the idea that a strong contextual expectations account causes the -in' boost. But until that line of research has been pursued, I cannot tease the strong contextual expectations account from the representation-based account for the -in' boost.

That being said, what I can do is test whether the remaining three potential unexpectedness sources contribute to the -in' boost. Starting with the weak contextual expectations account, one of the tests for this account has already been tried in this dissertation: manipulating the proportion of -ing/-in' words in the experiments. This manipulation did not attenuate the -in' boost at all. The second test for this account is to try different instruction types, to see whether different instruction methods can change the unexpectedness of -in'.

The instruction set that I use in the experiments in this dissertation, based on Pilot Experiment B, uses explicit instruction that participants will hear casually pronounced words, and tells them explicitly that "casually pronounced words are still real words of spoken American English". Participants are given four example pairs of formally and casually pronounced words, two pairs of words that end with -ing/-in', and two that end with the suffix -ment, pronounced with an aspirated /t/ versus a glottal stop (e.g. for the word-final /t/ in *basement*). Next, participants are slowly presented with 40 practice items, some of which are pronounced using noncanonical pronunciations, to which they receive feedback on their response: if they correctly selected "real word" or "nonword", they get corresponding feedback with an orthographic representation of the word they heard (i.e. "[Correct/Incorrect], because 'Jim was <u>callin'</u> Mary.' is a real word of spoken American English."). All of these tools were used to ensure that participants knew and understood that they would hear casual pronunciations, and would choose to classify them as real words of spoken American English. This method was successful in raising the accuracy score for -in' words, but it clearly did not attenuate the -in' boost. One option would be to have a second practice round in which participants hear practice items in quicker succession, like they will in the actual experiment, and in which they must correctly respond to X number of -in' targets before being allowed to move on to the experimental stage. A second option would be to make the description of "casual pronunciations" more explicit by giving more background on different casual pronunciations and by giving more examples to help familiarise participants with what they will be hearing. A third option is to make the instructions less explicit, but have them read aloud by my stimulus speaker in two guises: one where he uses a high proportion of -ing and one where he uses a high proportion of -in'. This could familiarise the participants with what he sounds like, and could give them a sense that he is a high -ing or high -in' user, which, in the latter case, could make it less unexpected to hear him using -in' during the actual experiment. All of these manipulations can be done with minimal changes to the experimental designs, and therefore make comparing the results to previously done experiments relatively simple.

Testing expectations based on the listener or speaker's background involves a larger manipulation. Regarding expectations based on the background of the listeners, the simplest way to test whether this is a source of expectation is to change and homogenise the linguistic backgrounds of the listeners. For example, I could take the designs used in Experiments 1 and 2, with the speaker I used then, and run them on two groups of participants: one from the American Northeast, where -in' is not prolific, and one from Appalachia, where -in' is much more common. The former group should be very similar (just more controlled by demographics) to the participants used in this dissertation, whereas the second should be much more accustomed to hearing -in' frequently, and therefore, if listener-based expectations are a source of unexpectedness, should show an attenuated -in' boost. One confound with this design is that it could be tricky to disentangle listener-based expectations here from speaker-based expectations since both groups most likely have an idea of what my speaker will sound like based on his accent (since he is American). An interesting option that could remove strong speaker-based expectations from the equation, then, would be to run this experiment (with my American English speaker) on two groups of listeners from the United Kingdom, who are less familiar with American accents, and perhaps have less of a sense of whether my speaker will use much -ing or -in'. In the UK, as discussed in section 2.2.2, -in' is associated with the north of England and with Scottish English, whereas -ing is associated more with Standard Southern British English (SSBE). The former group should parallel the participants from Appalachia regarding their experience hearing and using -in', whereas the SSBE group will have little -in' exposure, perhaps less even than the participants from the American Northeast. If the -in' boost is caused by the unexpectedness of -in' coming from listener-based expectations, then I would expect listeners with a high familiarity with -in' to show less of an -in' boost.

Finally, testing expectations based on the speaker's background involves a similar manipulation, but for the speaker of my stimuli as opposed to the participant group. To start with, I could have a speaker from Appalachia record my stimuli. If participants recognise the speaker's accent and create an expectation that they will hear a lot of -in' from that speaker, then this could attenuate the -in' boost. This manipulation can be crossed with the listener-based manipulation (starting with the two American listener groups) to give four combinations:

- Appalachian speaker x Appalachian listeners (AxA)
- Appalachian speaker x Northeastern listeners (AxNE)
- Northeastern speaker x Appalachian listeners (NExA)
- Northeastern speaker x Northeastern listeners (NExNE)

The NExNE condition is the closest reflection of the experiments in this dissertation, although note that I did not control for where my participants were from (many will have been from the Northeast by virtue of being students at the University of Pennsylvania). The AxA condition is the condition in which, if speaker and/or listener effects contribute to the -in' boost, I would expect the -in' boost to be reduced the most. Finally, a parallel study crossing speakers and listeners could be done in the United Kingdom, where -ing and -in' have a less salient social evaluation (Levon, 2007). This would give insight into whether the salience of the social meaning of -ing and -in' play a role in the forming of these expectations.

8.4 Conclusion

This dissertation takes questions from sociolinguistic research on naturalistic speech data about the locus of the ING variable, and argues that these are actually questions about the mental representation of -ing and -in'. By adapting a primed lexical decision task from psycholinguistic research on the mental lexicon, and by constructing a framework of aspects of shared representation for words ending with [ɪŋ] or [ɪn], I ask how -ing and -in' are represented and processed. In this way I showed:

- Robust and replicable affix priming for -ing and for -in', both in same-variant (i.e. *jumping-thinking*) and cross-variant (i.e. *jumpin'-thinking*) conditions

- How we can use this method to disentangle which aspects of shared representation contribute to processing facilitation

- That there is a processing asymmetry between -ing and -in' targets; for -ing targets, -ing and -in' primes facilitate the target equally, whereas for -in' targets, same-variant -in' primes facilitate the target more strongly than cross-variant -ing primes do.

In this chapter I discussed the implications of these findings for our understanding of the mental representation of ING. More specifically, the experiments in this dissertation tell us that -ing and -in' are related in such a way that they facilitate the processing of themselves and each other, regardless of whether the stems that they are attached to are in any way related. This tells us that -ing and -in' have shared aspects of representation that do not interact with shared stem representation. Further, I found a short-lived processing boost for -in'-in' pairs over all other -ing/-in' combinations, and also found that surface phonology does not contribute to -ing/-in' processing facilitation. Together, all of these results led me to suggest that the most likely explanation for the representation of variable ING is one in which there is an underlying suffix that has -ing as its underlying phonology, and that this -ing is changed to -in' via a phonological rule. Although a future research programme testing whether the unexpectedness of -in' is a contributing factor is necessary to provide evidence for this theory, at present, I have no evidence that speaks against this phonological analysis of variable ING.

Besides presenting a systematic exploration of the processing and mental representation of variable ING, this work provides a demonstration of an interdisciplinary approach to questions about the locus of variation. The structured framework of teasing apart aspects of shared representation using highly-controllable experimental methods is one that can be applied to other socially meaningful (and not socially meaningful) variables. Future work on the role of morphology and its ties to syntactic and semantic representation will help to expand our understanding of the underlying structural relationships between -ing and -in', and further explorations of the social factors involved in -ing and -in' processing will do the same from a sociolinguistic cognition perspective.

Appendix A

Filler Structure

ItemN	Type [1]	Prime	Target
F1	RR	corner	corn
F2	RR	easter	east
F3	RR	sewer	sue
F4	RR	soccer	sock
F5	RR	archer	arch
F6	RR	tailor	tail
F7	RR	mayor	may
F8	RR	suitor	suit
F9	RR	swimmer	swim
F10	RR	cleaner	clean
F11	RR	mother	scarf
F12	RR	golfer	golf
F13	RR	leader	lead
F14	RR	winner	win
F15	RR	skier	ski
F16	RR	actor	act
F17	RR	department	depart
F18	RR	figment	fig
F19	RR	dorment	door
F20	RR	pigment	pig
F21	RR	ailment	ale
F22	RR	basement	base
F23	RR	parchment	parch
F24	RR	catchment	catch
F25	RR	dancing	valley

[1] (Type: R = real word, N = nonword. e.g. RR = real word prime, real word target)

F26	RR	judgement	judge
F27	RR	movement	move
F28	RR	shipment	ship
F29	RR	pavement	pave
F30	RR	statement	state
F31	RR	placement	place
F32	RR	treatment	treat
F33	RR	monk	tuck
F34	RR	skate	fly
F35	RR	form	throw
F36	RR	milk	push
F37	RR	raise	bag
F38	RR	tart	sing
F39	RR	wipe	flight
F40	RR	snore	blue
F41	RN	author	auth
F42	RN	juror	jur
F43	RN	leather	leath
F44	RN	victor	vict
F45	RN	donor	done
F46	RN	river	riv
F47	RN	blunder	blund
F48	RN	brother	broth
F49	RN	comment	com
F50	RN	moment	mo
F51	RN	torment	tor
F52	RN	segment	seg
F53	RN	garment	gar
F54	RN	ointment	oint
F55	RN	augment	aug
F56	RN	clement	cle
F57	RN	chatting	chaz
F58	RN	grinning	grint
F59	RN	whirling	whirp
F60	RN	pouncing	pount
F61	RN	bursting	bursk
F62	RN	shining	shink
F63	RN	counting	coump

F64	RN	losing	loov
F65	NR	cleanint	earth
F66	NR	breathint	breathe
F67	NR	fishint	fish
F68	NR	sendink	send
F69	NR	plannint	plan
F70	NR	kissint	miss
F71	NR	touchint	much
F72	NR	changint	range
F73	NR	sayink	bay
F74	NR	laughint	half
F75	NR	keepert	keep
F76	NR	jokerk	joke
F77	NR	bankert	thank
F78	NR	roverk	cove
F79	NR	oddmend	odd
F80	NR	claimank	steal
F81	NR	hutmenk	cut
F82	NR	bodemenk	road
F83	NR	cooint	woo
F84	NR	helpint	yelp
F85	NR	snubbink	stub
F86	NR	coaxink	hoax
F87	NR	joinink	loin
F88	NR	foolint	pool
F89	NR	failink	pale
F90	NR	guardint	yard
F91	NN	greetind	drivet
F92	NN	votenk	creepet
F93	NN	ragind	backerp
F94	NN	rentimp	docturk
F95	NN	meltint	glazek
F96	NN	printind	cypherk
F97	NN	fundint	panzerp
F98	NN	spillimp	blazemp
F99	NN	spoilint	zappert
F100	NN	pilint	buzzerp
F101	NN	bruisind	quacket

F102	NN	piercint	knackemp
F103	NN	patchimp	fizzet
F104	NN	urgimp	quavet
F105	NN	aidink	supperk
F106	NN	shieldint	powdet
F107	NN	clutchint	butlep
F108	NN	bulgint	pottelt
F109	NN	clonint	fullent
F110	NN	bannimp	timbelt
F111	NN	commenk	tigrech
F112	NN	demenk	prowent
F113	NN	lomenk	summinch
F114	NN	amemf	flewis
F115	NN	fomemf	deepelt
F116	NN	sarmenz	dragolt
F117	NN	raimenk	polohm
F118	NN	vestmemp	badgeb
F119	NN	lamemp	suitef
F120	NN	absenk	vendose
F121	NN	recenk	pitak
F122	NN	potemp	lorest
F123	NN	cademp	bettulk
F124	NN	attens	bundef
F125	NN	wisens	persit
F126	NN	rodens	bluestam
F127	NN	invemp	chursel
F128	NN	argemp	bruschel
F129	NN	assenk	glamant
F130	NN	advemp	ambuts
F131	NN	dop	rabbisk
F132	NN	liss	spidelk
F133	NN	quib	vapif
F134	NN	moop	crossund
F135	NN	youn	mackremp
F136	NN	swip	bridgom
F137	NN	masp	sorbayn
F138	NN	coom	rawbult

F139	NN	darp	gheetim
F140	NN	hurp	wintuk
F141	NN	kint	fightel
F142	NN	sedge	solix
F143	NN	waske	thwoxit
F144	NN	vowp	snowast
F145	NN	tust	spirenk
F146	NN	resk	crayint
F147	NN	colb	hundram
F148	NN	solm	spannelm
F149	NN	pouk	plighka
F150	NN	foth	tastol
F151	NN	mouk	scuppen
F152	NN	paink	zittel
F153	NN	tolk	preseg
F154	NN	frienk	prinken
F155	NN	playb	girdem
F156	NN	tabe	jummel
F157	NN	beeg	stipet
F158	NN	doorb	ordung
F159	NN	wort	splinten
F160	NN	plun	silep
F161	NN	muts	bluxan
F162	NN	shoon	prisselk
F163	NN	broon	ploufip
F164	NN	tral	smertha
F165	NN	spen	pintor
F166	NN	kiych	bandisp
F167	NN	plaem	stiy
F168	NN	niyn	luhd
F169	NN	gowg	nihldz
F170	NN	raol	graek
F171	NN	lahdz	glown
F172	NN	kleys	jhahm
F173	NN	skihjh	tehjh
F174	NN	traor	glay
F175	NN	hheyv	traet
F176	NN	neyjh	drahl

F177	NN	naol	strown
F178	NN	bihm	spown
F179	NN	plehl	kaek
F180	NN	raes	prihp
F181	NN	kehk	skawn
F182	NN	draed	hhowk
F183	NN	zaed	klaw
F184	NN	plown	feht
F185	NN	grihng	kehngk
F186	NN	klow	waelf
F187	NN	driyz	striyn
F188	NN	wahst	faemp
F189	NN	vawst	kehks
F190	NN	baepth	slaak
F191	NN	kwihsh	cheyd
F192	NN	hhowg	wahm
F193	NN	laent	giym
F194	NN	luhlf	riyn
F195	NN	slihg	trahm
F196	NN	drihjh	deyth
F197	NN	feets	waps
F198	NN	churk	frop

Appendix B

Stimuli Pilot Experiments

ItemN	Target	RepPrime	in'Prime	Control
C1	bending	bending	bendin'	wrestle
C2	crawling	crawling	crawlin'	tissue
C3	itching	itching	itchin'	hassle
C4	nudging	nudging	nudgin'	fuchsia
C5	smearing	smearing	smearin'	lolly
C6	steering	steering	steerin'	holly
C7	twitching	twitching	twitchin'	banjo
C8	cooking	cooking	cookin'	jacket
C9	hugging	hugging	huggin'	pickle
C10	soaking	soaking	soakin'	yoga
C11	tweaking	tweaking	tweakin'	beagle
C12	bumping	bumping	bumpin'	ample
C13	dreaming	dreaming	dreamin'	limit
C14	leaping	leaping	leapin'	tumble
C15	shoving	shoving	shovin'	trumpet
C16	stopping	stopping	stoppin'	traffic
C17	weeping	weeping	weepin'	camel
C18	boasting	boasting	boastin'	medley
C19	draining	draining	drainin'	spiral
C20	mending	mending	mendin'	cello
C21	pasting	pasting	pastin'	bassoon
C22	snoozing	snoozing	snoozin'	facet
C23	swirling	swirling	swirlin'	viral
C24	yielding	yielding	yieldin'	tassel
C25	croaking	croaking	croakin'	toggle
C26	jogging	jogging	joggin'	wrinkle

C27	speaking	speaking	speakin’	pocket
C28	paying	paying	payin’	file
C29	clapping	clapping	clappin’	rubble
C30	dripping	dripping	drippin’	rebel
C31	living	living	livin’	trouble
C32	sipping	sipping	sippin’	pimple
C33	sweeping	sweeping	sweepin’	puppet
C34	chewing	chewing	chewin’	coward
C35	brushing	brushing	brushin’	throttle
C36	drowning	drowning	drownin’	custom
C37	merging	merging	mergin’	tarnish
C38	scanning	scanning	scannin’	parrot
C39	spinning	spinning	spinnin’	native
C40	swooning	swooning	swoonin’	minnow
C41	blinking	blinking	blinkin’	mango
C42	docking	docking	dockin’	regal
C43	knocking	knocking	knockin’	angle
C44	stacking	stacking	stackin’	locket
C45	sighing	sighing	sighin’	foil
C46	climbing	climbing	climbin’	humble
C47	dropping	dropping	droppin’	apple
C48	mopping	mopping	moppin’	tuba
C49	slamming	slamming	slammin’	baboon
C50	swooping	swooping	swoopin’	toffee
C51	growing	growing	growin’	towel
C52	burning	burning	burnin’	fellow
C53	glaring	glaring	glarin’	judo
C54	mixing	mixing	mixin’	fury
C55	scowling	scowling	scowlin’	neuron
C56	lagging	lagging	laggin’	okra
C57	teaching	teaching	teachin’	bury
C58	clicking	clicking	clickin’	jerky
C59	faking	faking	fakin’	donkey
C60	picking	picking	pickin’	legal
C61	thinking	thinking	thin’kin’	ugly
C62	blaming	blaming	blamin’	triple
C63	combing	combing	combin’	timid
C64	jumping	jumping	jumpin’	sample

C65	napping	napping	nappin’	trombone
C66	sleeping	sleeping	sleepin’	double
C67	thriving	thriving	thrivin’	dribble
C68	snowing	snowing	snowin’	steward

Appendix C

Stimuli Experiment 1

ItemN	ingTargets	inTargets	ingPrime	inPrime	Control
C1	stealing	stealin	bending	bendin	wrestle
C2	crawling	crawlin	holding	holdin	busy
C3	itching	itchin	roaring	roarin	hassle
C4	nudging	nudgin	shunning	shunnin	riddle
C5	smearing	smearin	clashing	clashin	vary
C6	steering	steerin	rising	risin	fiddle
C7	twitching	twitchin	gliding	glidin	worry
C8	cooking	cookin	breaking	breakin	argue
C9	hugging	huggin	clanging	clangin	pickle
C10	soaking	soakin	risking	riskin	tackle
C11	tweaking	tweakin	clogging	cloggin	heckle
C12	bumping	bumpin	coping	copin	cripple
C13	dreaming	dreamin	carving	carvin	limit
C14	leaping	leapin	burping	burpin	tumble
C15	shoving	shovin	bluffing	bluffin	trumpet
C16	stopping	stoppin	saving	savin	level
C17	weeping	weepin	skimming	skimmin	lobby
C18	boasting	boastin	launching	launchin	burrow
C19	draining	drainin	bouncing	bouncin	empty
C20	mending	mendin	charring	charrin	huddle
C21	snoozing	snoozin	hoisting	hoistin	facet
C22	swirling	swirlin	forging	forgin	study
C23	yielding	yieldin	belching	belchin	scurry
C24	croaking	croakin	smirking	smirkin	toggle
C25	jogging	joggin	shrugging	shruggin	wrinkle
C26	speaking	speakin	hiking	hikin	pocket

C27	paying	payin	crying	cryin	file
C28	clapping	clappin	whooping	whoopin	grapple
C29	dripping	drippin	filming	filmin	copy
C30	pasting	pastin	hoping	hopin	trouble
C31	sipping	sippin	limping	limpin	stymy
C32	sweeping	sweepin	flaming	flamin	puppet
C33	chewing	chewin	mowing	mowin	equal
C34	brushing	brushin	folding	foldin	throttle
C35	drowning	drownin	ruining	ruinin	tarnish
C36	scanning	scannin	waltzing	waltzin	hurry
C37	spinning	spinnin	messing	messin	pity
C38	swooning	swoonin	skidding	skiddin	tidy
C39	blinking	blinkin	pecking	peckin	giggle
C40	docking	dockin	clucking	cluckin	boggle
C41	knocking	knockin	bragging	braggin	angle
C42	stacking	stackin	linking	linkin	cackle
C43	sighing	sighin	spraying	sprayin	foil
C44	climbing	climbin	blooming	bloomin	shimmy
C45	dropping	droppin	drumming	drummin	envy
C46	mopping	moppin	bribing	bribin	levy
C47	swooping	swoopin	delving	delvin	cobble
C48	growing	growin	plowing	plowin	towel
C49	burning	burnin	wasting	wastin	fancy
C50	glaring	glarin	jousting	joustin	bully
C51	mixing	mixin	waxing	waxin	carry
C52	scowling	scowlin	munching	munchin	nestle
C53	lagging	laggin	basking	baskin	crackle
C54	teaching	teachin	washing	washin	bury
C55	clicking	clickin	trucking	truckin	bargain
C56	faking	fakin	lacking	lackin	wiggle
C57	picking	pickin	begging	beggin	muddle
C58	thinking	thinkin	working	workin	jiggle
C59	jumping	jumpin	gleaming	gleamin	sample
C60	napping	nappin	gulping	gulpin	triple

Appendix D

Interveners Experiment 2

ItemN	Intervener
C1 & C31	pale
C2 & C32	yard
C3 & C33	road
C4 & C34	monk
C5 & C35	fish
C6 & C36	hoax
C7 & C37	milk
C8 & C38	raise
C9 & C39	tart
C10 & C40	wipe
C11 & C41	snore
C12 & C42	tuck
C13 & C43	fly
C14 & C44	bag
C15 & C45	flight
C16 & C46	throw
C17 & C47	sing
C18 & C48	form
C19 & C49	blue
C20 & C50	earth
C21 & C51	pool
C22 & C52	range
C23 & C53	bay
C24 & C54	half
C25 & C55	keep
C26 & C56	joke

C27 & C57	cove
C28 & C58	push
C29 & C59	yelp
C30 & C60	stub

Appendix E

Stimuli Experiment 3

ItemN	Target	in' Prime	Phonological Prime	Control
C1	stealin	bendin	dungeon	wrestle
C2	crawlin	holdin	onion	busy
C3	itchin	roarin	bargain	hassle
C4	nudgin	shunnin	chicken	riddle
C5	smearin	clashin	zeppelin	vary
C6	steerin	risin	cousin	fiddle
C7	twitchin	glidin	cushion	worry
C8	cookin	breakin	goblin	argue
C9	huggin	clangin	dolphin	pickle
C10	soakin	riskin	penguin	tackle
C11	tweakin	cloggin	dozen	heckle
C12	bumpin	copin	melon	cripple
C13	dreamin	carvin	mason	limit
C14	leapin	burpin	heaven	tumble
C15	shovin	bluffin	omen	trumpet
C16	stoppin	savin	vixen	level
C17	weepin	skimmin	cabin	lobby
C18	boastin	launchin	toxin	burrow
C19	drainin	bouncin	urchin	empty
C20	mendin	charrin	pigeon	huddle
C21	snoozin	hoistin	passion	facet
C22	swirlin	forgin	gremlin	study
C23	yieldin	belchin	kelvin	scurry
C24	croakin	smirkin	lemon	toggle
C25	joggin	shruggin	session	wrinkle
C26	speakin	hikin	fashion	pocket

C27	payin	cryin	heron	file
C28	clappin	whoopin	linen	grapple
C29	drippin	filmin	salmon	copy
C30	pastin	hopin	villain	trouble
C31	sippin	limpin	captain	stymy
C32	sweepin	flamin	aspirin	puppet
C33	chewin	mowin	person	equal
C34	brushin	foldin	ramen	throttle
C35	drownin	ruinin	gibbon	tarnish
C36	scannin	waltzin	potion	hurry
C37	spinnin	messin	bourbon	pity
C38	swoonin	skiddin	talon	tidy
C39	blinkin	peckin	haven	giggle
C40	dockin	cluckin	lesion	boggle
C41	knockin	braggin	foreign	angle
C42	stackin	linkin	pollen	cackle
C43	sighin	sprayin	reason	foil
C44	climbin	bloomin	lotion	shimmy
C45	droppin	drummin	prison	envy
C46	moppin	bribin	sermon	levy
C47	swoopin	delvin	mansion	cobble
C48	growin	plowin	kitchen	towel
C49	burnin	wastin	mission	fancy
C50	glarin	joustin	hyphen	bully
C51	mixin	waxin	chaplain	carry
C52	scowlin	munchin	carbon	nestle
C53	laggin	baskin	turban	crackle
C54	teachin	washin	urban	bury
C55	clickin	truckin	margin	bargain
C56	fakin	lackin	vermin	wiggle
C57	pickin	beggin	ocean	muddle
C58	thinkin	workin	falcon	jiggle
C59	jumpin	gleamin	gallon	sample
C60	nappin	gulpin	region	triple

Appendix F

Stimuli Experiment 5

ItemN	Target	ingRep	inRep	ingRhyme	inRhyme	ingUR	inUR	Control
C1	stealing	stealing	stealin	feeling	feelin	bending	bendin	wrestle
C2	crawling	crawling	crawlin	calling	callin	holding	holdin	busy
C3	itching	itching	itchin	switching	switchin	roaring	roarin	hassle
C4	nudging	nudging	nudgin	budging	budgin	shunning	shunnin	riddle
C5	smearing	smearing	smearin	sneering	sneerin	clashing	clashin	vary
C6	steering	steering	steerin	cheering	cheerin	rising	risin	fiddle
C7	twitching	twitching	twitchin	stitching	stitchin	gliding	glidin	worry
C8	cooking	cooking	cookin	looking	lookin	breaking	breakin	argue
C9	hugging	hugging	huggin	lugging	luggin	clanging	clangin	pickle
C10	soaking	soaking	soakin	joking	jokin	risking	riskin	tackle
C11	tweaking	tweaking	tweakin	reeking	reekin	clogging	cloggin	heckle
C12	bumping	bumping	bumpin	thumping	thumpin	coping	copin	cripple
C13	dreaming	dreaming	dreamin	steaming	steamin	carving	carvin	limit
C14	leaping	leaping	leapin	bleeping	bleepin	burping	burpin	tumble
C15	shoving	shoving	shovin	loving	lovin	bluffing	bluffin	trumpet

C16	stopping	stopping	stoppin	shopping	shoppin	saving	savin	level
C17	weeping	weeping	weepin	peeping	peepin	skimming	skimmin	lobby
C18	boasting	boasting	boastin	hosting	hostin	launching	launchin	burrow
C19	draining	draining	drainin	gaining	gainin	bouncing	bouncin	empty
C20	mending	mending	mendin	fending	fendin	charring	charrin	huddle
C21	snoozing	snoozing	snoozin	schmoozing	schmoozin	hoisting	hoistin	facet
C22	swirling	swirling	swirlin	twirling	twirlin	forging	forgin	study
C23	yielding	yielding	yieldin	wielding	wieldin	belching	belchin	scurry
C24	croaking	croaking	croakin	cloaking	cloakin	smirking	smirkin	toggle
C25	jogging	jogging	joggin	blogging	bloggin	shrugging	shruggin	wrinkle
C26	speaking	speaking	speakin	sneaking	sneakin	hiking	hikin	pocket
C27	paying	paying	payin	staying	stayin	crying	cryin	file
C28	clapping	clapping	clappin	flapping	flappin	whooping	whoopin	grapple
C29	dripping	dripping	drippin	skipping	skippin	filming	filmin	copy
C30	pasting	pasting	pastin	basting	bastin	hoping	hopin	trouble
C31	sipping	sipping	sippin	clipping	clippin	limping	limpin	stymy
C32	sweeping	sweeping	sweepin	creeping	creepin	flaming	flamin	puppet
C33	chewing	chewing	chewin	brewing	brewin	mowing	mowin	equal
C34	brushing	brushing	brushin	blushing	blushin	folding	foldin	throttle
C35	drowning	drowning	drownin	frowning	frownin	ruining	ruinin	tarnish
C36	scanning	scanning	scannin	tanning	tannin	waltzing	waltzin	hurry
C37	spinning	spinning	spinnin	winning	winnin	messing	messin	pity
C38	swooning	swooning	swoonin	crooning	croonin	skidding	skiddin	tidy
C39	blinking	blinking	blinkin	winking	winkin	pecking	peckin	giggle
C40	docking	docking	dockin	flocking	flockin	clucking	cluckin	boggle
C41	knocking	knocking	knockin	blocking	blockin	bragging	braggin	angle

C42	stacking	stacking	stackin	whacking	whackin	linking	linkin	cackle
C43	sighing	sighing	sighin	prying	pryin	spraying	sprayin	foil
C44	climbing	climbing	climbin	rhyming	rhymin	blooming	bloomin	shimmy
C45	dropping	dropping	droppin	swapping	swappin	drumming	drummin	envy
C46	mopping	mopping	moppin	flopping	floppin	bribing	bribin	levy
C47	swooping	swooping	swoopin	drooping	droopin	delving	delvin	cobble
C48	growing	growing	growin	flowing	flowin	plowing	plowin	towel
C49	burning	burning	burnin	learning	learnin	wasting	wastin	fancy
C50	glaring	glaring	glarin	flaring	flarin	jousting	joustin	bully
C51	mixing	mixing	mixin	fixing	fixin	waxing	waxin	carry
C52	scowling	scowling	scowlin	prowling	prowlin	munching	munchin	nestle
C53	lagging	lagging	laggin	sagging	saggin	basking	baskin	crackle
C54	teaching	teaching	teachin	reaching	reachin	washing	washin	bury
C55	clicking	clicking	clickin	flicking	flickin	trucking	truckin	bargain
C56	faking	faking	fakin	raking	rakin	lacking	lackin	wiggle
C57	picking	picking	pickin	sticking	stickin	begging	beggin	muddle
C58	thinking	thinking	thinkin	drinking	drinkin	working	workin	jiggle
C59	jumping	jumping	jumpin	pumping	pumpin	gleaming	gleamin	sample
C60	napping	napping	nappin	zapping	zappin	gulping	gulpin	triple
C61	sleeping	sleeping	sleepin	beeping	beepin	shipping	shippin	double
C62	thriving	thriving	thrivin	jiving	jivin	jabbing	jabbin	dribble
C63	snowing	snowing	snowin	glowing	glowin	clawing	clawin	growl

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