Journal of Memory and Language 103 (2018) 58–73

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Listener sensitivity to probabilistic conditioning of sociolinguistic variables: The case of (ING)

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ARTICLE INFO

Keywords:
Speech perception
Sociolinguistic variables
Expectation
Listener knowledge
Grammatical conditioning
Stylistic/phonetic congruence

ABSTRACT

This paper investigates the extent to which listeners are cued into the systematicity of variability in speech, particularly the grammatical conditioning constraints of the English sociolinguistic variable (ING) (e.g., *talking* vs. *talkin*). Listeners' sensitivity to the realization of (ING) words embedded in sentences was tested under various conditions. Comprehenders demonstrated expectations about the grammatical category constraints conditioning the realization of (ING) even though such knowledge may not be very informative about word recognition (Experiment 1). As more reliable phonetic information was available, listeners weighted grammatical expectations less, favoring other cues in the signal (Experiments 2 and 3). Bridging a gap between psycholinguistic and sociolinguistic accounts of probabilistic conditioning, these results suggest that factors beyond utility for word recognition may contribute to the probabilistic monitoring of a variable, and underscore the opportunistic nature of the speech comprehension system, where listeners make use of whatever information they have to process the signal.

Introduction

During speech perception, listeners regularly encounter variability across many acoustic cues. The process of language comprehension more generally is thought to be guided by comprehenders' prior experiences, which provide information about what interpretations of the signal are most likely (cf. Fine, Jaeger, Farmer, & Qian, 2013; Zarcone, Van Schijndel, Vogels, & Demberg, 2016). For example, listeners track probabilistic associations between the linguistic and social contexts in which sounds occur, and how sounds are realized (e.g., Goldinger, 1996; Johnson, 1997; Pierrehumbert, 2006). Listeners can then use these probabilistic expectations to aid in the task of ambiguity resolution, a central component of language comprehension (cf. Kuperberg & Jaeger, 2016). However, phonetic variability in production does not *always* result in mismatches that could result in ambiguous interpretations or disrupt word recognition; for many variables studied by sociolinguists, such as the stopping of interdental fricatives (e.g., *dat* for *that*) and velar nasal fronting, also known as variable (ING) (e.g., *runnin* for *running*), listeners may not need to accurately interpret the phonetic realization of the variable in order to accurately recognize words. Thus, although it is clear that listeners' expectations based on probabilistic conditioning are valuable for resolving systematic variation that can result in misparsing (e.g., a gross category mismatch along the VOT continuum), it is unknown whether listeners form and use expectations about the kind of systematic variation that does *not* create ambiguity as a rule (e.g., encountering *–in* for *–ing*). In this study, we explore an example of the latter type of systematic variation, variable (ING), to ask whether listeners still form and use expectations about what conditions variation.

The sociolinguistic research tradition has established that (ING) realization depends probabilistically on both social (e.g., gender) and linguistic (e.g., grammatical category) conditioning factors (e.g., Campbell-Kibler, 2007; Fischer, 1958; Forrest, 2015; Hazen, 2008; Houston, 1985; Kendall, 2010, 2013; Labov, 1966, 2001; Tagliamonte, 2004; Wald & Shopen, 1981). In particular, grammatical category conditioning constraints have been shown to be the most important linguistic predictor of (ING) realization across communities, such that progressive verb forms (e.g., "he's *lying*") are more likely to be realized as *–in* than, for instance, adjectival or nominal forms (e.g., "an unexpected *ending*", which will be referred to as "noun-like" forms). Gerunds (e.g., "I like *cooking*") are often found to pattern in-between verb-like and noun-like forms (Kendall, 2013; Tagliamonte, 2004). And, certain pronouns, namely *something* and *nothing*, have been shown not to follow expected noun-like patterns, exhibiting high *–in* rates, while *anything* and *everything* strongly disfavor *–in* (Kendall, 2010; Labov, 2001). A range of other linguistic factors have also been examined (e.g.,

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https://doi.org/10.1016/j.jml.2018.07.006
Received 1 August 2017; Received in revised form 22 July 2018

phonological environment, number of syllables and word frequency of (ING) word) but none have been as consistently found to influence (ING) realizations as strongly as grammatical category, and we concentrate on (ING)'s grammatical conditioning constraints in this study.

Despite the extensive evidence for grammatical category effects on (ING) in production, it is not known whether these probabilistic conditioning factors are also used by listeners in perception, though the possibility of such a relationship has long been suspected (cf. Bresnan & Ford, 2010). Thus, we investigate whether probabilistic patterns of (ING) variation in production are detectable in comprehension. In doing so, the present study addresses two main research questions: (RQ1) How sensitive are comprehenders to probabilistic constraints conditioning (ING) realization?, and (RQ2) When are comprehenders more or less likely to make use of such information?

RQ1: How sensitive are comprehenders to probabilistic constraints conditioning (ING) realization?

Comprehenders have been shown to use the systematic variability inherent in speech to generate probabilistic expectations about upcoming information, which facilitates language comprehension (see Fine et al., 2013; Zarcone et al., 2016 for recent reviews). Comprehenders' use of expectations has been demonstrated on a variety of levels of linguistic processing, from syntactic (e.g., Garnsey, Pearlmutter, Myers, & Lotocky, 1997; Trueswell, Tanenhaus, & Kello, 1993) to phonetic (Allen & Miller, 2004; Clayards, Tanenhaus, Aslin, & Jacobs, 2008; Theodore, Myers, & Lomibao, 2015) to social (Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008; Walker & Hay, 2011). For example, comprehenders are less likely to succumb to a garden path effect if the main verb is most often used in an embedded-clause context (which would be congruent with the correct reading of the sentence) than if the main verb is most often used in direct object contexts (which would point down the garden path) (cf. Garnsey et al., 1997; Trueswell et al., 1993). Knowledge about probabilistic conditioning may reduce the search space such that not all candidate lexical items need to be given equal consideration as potential matches.

The work reviewed in the previous paragraph generally investigates variability that regularly causes potential problems for the comprehender, lexical ambiguity or gross category mismatches. However, as mentioned above, the alternation between *–ing* and *–in* is unlikely to have major consequences for word recognition for several reasons. First, both *–ing* and *–in* realizations are mapped to the same referent (i.e., *running* and *runnin* have the same propositional meaning). And, (the few) minimal pairs resulting from the *–ing/–in* alternation are unlikely to cause confusion, especially in sentential context (e.g., *bobbing/bobbin* or *robbing/robin*). Second, since spoken words are processed incrementally, information presented at word onset is known to constrain lexical recognition more than information later in the word (e.g., Allopenna, Magnuson, & Tanenhaus, 1998; Marslen-Wilson & Zwitserlood, 1989). Therefore, when hearing an (ING) word, the listener is likely to settle on the accurate resolution of the word before actually reaching the (ING) variant (though cf. Luce, 1986). Finally, (ING) variants represent a nasal place distinction, which is known to be hard to perceive (Hura, Lindblom, & Diehl, 1992), likely especially so in running speech. This collection of factors, then, makes (ING) a prime case of a variable whose variants are largely irrelevant for accurate word recognition.

How would such a variable be treated in speech perception? Many current models of prediction and expectation in speech perception suggest that the primary factor relevant in weighting the utility of tracking and then forming expectations about a variable is its importance for word recognition (e.g., Baayen, Hendrix, & Ramscar, 2013; Cutler, 2012; Goldinger & Azuma, 2004; Kleinschmidt & Jaeger, 2015; Levy, 2008; McMurray & Jongman, 2011). Certainly, assessing linguistic variants' utility for linguistic processing is of primary interest to language comprehension. However, given an assumption of finite cognitive resources, theories must predict the conditions under which the system tracks and uses conditional probabilities. In this paper we ask: to what end this is done? This question is less about how specific models of prediction could account for a potential finding that listeners are sensitive to the grammatical category conditioning of (ING), but rather whether models need to account for such a result in the first place. If comprehenders do show evidence of sensitivity to (ING)'s constraints, even though that information is not particularly important for lexical access, this indicates either that much more probabilistic information is stored than is used for word recognition, or that theoretical models of prediction and expectation ought to entertain that comprehenders' behavior is affected by factors beyond just what is useful for word recognition.

Work on variables similar to (ING) that do not generally create ambiguity suggests that listeners may indeed generate expectations about the realization of (ING) based on probabilistic linguistic conditioning. Listeners are sensitive to context-specific variant frequencies of allophonic variation in variables like flapping and schwa deletion (e.g., Bürki, Ernestus, & Frauenfelder, 2010; Connine, 2004; Connine, Ranbom, & Patterson, 2008; Pinnow & Connine, 2014; Pitt, 2009; Pitt, Dilley, & Tat, 2011). Connine et al. (2008), for instance, found that words with high schwa-deletion rates in a corpus showed different patterns of processing than words with low schwa-deletion rates, reflecting listener sensitivity to lexically-specific phonological conditioning of variants.

Further, we know that listeners socially evaluate speakers based on how they use variation (e.g., Bresnahan, Ohashi, Nebashi, Liu, & Shearman, 2002; Preston, 2013), and there is suggestive evidence that this is true for how variation is conditioned as well (Bender, 2005). In terms of our variable of interest, previous findings show that listeners are sensitive to rates of (ING) realization in their assignment of social judgments to speakers (e.g., Campbell-Kibler, 2007, Labov et al., 2011; Levon & Fox, 2014; Loudermilk, 2013). For example, using a matched guise paradigm, Labov et al. (2011) found that as a speaker's *–in* rate increased, listeners judged them as less suitable to be a TV newscaster. Thus, although evidence indicates that listeners are capable of attending to differences in rates of (ING) realization when asked to make social judgments, it is not known whether listeners' percepts of (ING) realizations are conditioned on the probabilistic production norms of (ING) realization, or whether these conditioning factors are used in making linguistic judgments.

Based on the work reviewed in this section, it may be that the kind and amount of probabilistic conditioning information used to generate expectations that guide processing is not *solely* determined by how informative the information is for word recognition. Thus, for RQ1 we predict that listeners will demonstrate expectations about the grammatical factors that condition when a given (ING) word will be realized as *–in* versus *–ing*.

RQ2: When are comprehenders likely to use expectations about probabilistic linguistic conditioning?

Any finding that comprehenders' expectations about (ING) realization are in line with constraints in production would support our hypothesis for RQ1. But, even if that is confirmed, it is likely that comprehenders' behavior will not *always* reflect what they have tracked. Thus, RQ2 asks when comprehenders will be more or less likely to make use of their top-down information about (ING) variation.

Previous work suggests that comprehenders are differentially reliant on their previous experience-based expectations (equivalent here to top-down information) depending on various factors. That is, first, prediction based on top-down information is most likely to occur when uncertainty about the bottom-up information is highest (e.g., Brouwer, Mitterer, & Huettig, 2013; Connine & Clifton, 1987; Connine et al., 2008; Ganong, 1980; Huettig, 2015; Kuperberg & Jaeger, 2016; McQueen & Huettig, 2012; Pitt & Samuel, 1993; Warren, 1970). For