Available online at www.sciencedirect.com

ScienceDirect

Lingua 159 (2015) 47–69

Lingua

www.elsevier.com/locate/lingua

Subjective perception of affixation: A test case from Spanish

Anne Pycha *

Department of Linguistics, University of Wisconsin, Milwaukee, Box 413, Milwaukee, WI 53201-0413, United States

Received 10 March 2014; received in revised form 11 March 2015; accepted 12 March 2015
Available online

Abstract

Cross-linguistically, prefixes and suffixes differ in both frequency and in phonological behavior. These differences could plausibly have their source in listeners' subjective perceptual experiences of prefixes and suffixes, an idea that we pursued using a noise-rating task in Spanish. Participants heard minimally-different Spanish words such as *me patea* 's/he kicks me' versus *patéame* 'kick me', where the clitic pronoun *me* behaves phonologically like a prefix versus a suffix, and rated the loudness of white noise overlaid on either the pronoun or the verb stem. Results demonstrated that participants assigned significantly different ratings to noise occurring on prefixes versus suffixes, and on prefixed versus suffixed stems, even when the signal-to-noise ratio remained constant across conditions. That is, listeners' subjective perceptual experience of the noise differed according to what morpheme type the noise occurred on, suggesting that morphological structure can act as a cognitive variable affecting perceptual clarity.

Keywords: Spanish; Morphology; Prefix; Suffix; Perception; Typology

1. Introduction

Prefixes and suffixes act as morphological equivalents in many ways. Both types of affix can be derivational or inflectional, both can encode similar syntactic and semantic representations, and both come from closed classes that typically contain only a subset of a language's phonological inventory. Nevertheless, the literature has noted many differences between these two types of morphemes. One difference lies in frequency: overall, prefixing morphology is far less frequent than suffixing morphology, and is overwhelmingly restricted to languages with verb-object ordering (Dryer, 2013; Hawkins and Cutler, 1988; Hawkins and Gilligan, 1988). Another difference lies in phonological behavior: cross-linguistically, prefixes tend to participate in fewer alternations than suffixes do (Hyman, 2008), even though morphological boundaries are generally active sites for such alternations.

Given the similarities between prefixes and suffixes, their differences seem rather puzzling, but previous research has offered some provocative explanations from both functional and formal perspectives. For example, Hawkins and Cutler (1988) examine the typological distribution of prefixing and suffixing morphology, and offer an explanation grounded in speech processing (see also Colé et al., 1989; Cutler et al., 1985, and more recently Himmelmann, 2014). They cite evidence that the initial portions of a word drive the process of recognition (Grosjean, 1980; Marslen-Wilson, 1984, 1987; Marslen-Wilson and Welsh, 1978; Marslen-Wilson and Zwitserlood, 1989; Nooteboom, 1981, and many others), and also observe that listeners prefer to interpret the semantic information encoded in roots before they interpret the syntactic

* Tel.: +1 414 229 6166.
E-mail address: pycha@uwm.edu.

http://dx.doi.org/10.1016/j.lingua.2015.03.004
0024-3841/

information typically encoded in affixes (as the authors point out, this observation holds mostly for inflectional affixes, but they argue that a similar observation should apply to derivational affixes). According to their logic, then, suffixing morphology should provide a perceptual advantage because it temporally aligns the important information of the root with the perceptually-prominent position of the word onset. Prefixing morphology, on the other hand, should suffer from a disadvantage because the root and the word onset are temporally mis-aligned. Hawkins and Cutler (1988) put forth these proposed perceptual differences to account for the different frequencies of prefixing versus suffixing languages.

Previous research has also tackled differences in phonological behavior. Whereas suffixes generally participate in both regressive and progressive alternations, prefixes do not. Specifically, although prefixes often undergo regressive alternations triggered by roots, they rarely trigger progressive alternations on the following root (Hyman, 2008). To illustrate by way of simple voicing examples from English, we see cases where suffixes trigger regressive assimilation (*lea*[f], *lea*[v]-*es*), where suffixes undergo progressive assimilation (*cat*-[s], *dog*-[z]), and where prefixes undergo regressive assimilation (*tran*[s]-*sexual*, *tran*[z]-*national*), but we do not see cases where prefixes trigger progressive assimilation (**off*-[p]*eat* for *off-beat,* **sub*-[b]*ar* for *sub-par*). The nasal assimilation process in Luganda is an example of this otherwise rare occurrence: *m-báànj-a* → *m-<u>m</u>ááànj-a* 'I demand payment', Hyman and Katamba (1999:397). The ''Alternation Asymmetry'', as we refer to it, holds for a heterogeneous set of processes, including local assimilations, long-distance assimilations such as consonant harmony (Hansson, 2001) and vowel harmony (Walker, 2011), and vowel elision (Casali, 1997), suggesting the need for a very general explanation.

Research in theoretical phonology, particularly in Optimality Theory, has used the concept of positional faithfulness to approach this problem. The idea is that certain positions within a word possess a privileged status, and faithfulness constraints preserve the underlying identity of segments in those positions. When ranked above the relevant markedness constraints, then, positional faithfulness constraints prevent alternations from occurring in certain positions, even if the alternation remains active elsewhere. McCarthy and Prince (1995) initially proposed a positional faithfulness constraint that preferentially preserves segments in roots but not affixes. Beckman (1997) and Casali (1997) took a step further and proposed constraints that preserve segments specifically in the *initial* portions of roots. These analyses can competently model the Alternation Asymmetry because they preferentially protect just those root segments which are closest to the prefix (namely, the initial segments most likely to undergo any putative progressive alternations triggered by the prefix). For example, the constraint IDENT-σ_1(VOICE) would state that segments in root-initial syllables should have identical voicing values in the input and the output, thereby mitigating specifically against changes such as *off-beat* → *off*-[p]*eat.* Furthermore, because faithfulness constraints can prevent any type of surface alternation, including local and long distance assimilations as well as other changes, this theoretical solution seems to be a satisfyingly general one.

1.1. Conflicting evidence from word recognition studies

In many ways, these previous proposals – one functional, one formal – represent significant progress in our understanding of the differences between prefixes and suffixes. In other ways, however, these proposals simply do not fit with the existing evidence about how listeners perceive spoken words. For example, Hawkins and Cutler (1988) conclude that suffixing morphology should offer a perceptual advantage over prefixing morphology, but they do not test this idea explicitly. In fact, the few studies that do examine this issue suggest the opposite pattern. In priming experiments, prefixed forms prime their stems (*insincere* primes *sincere*) as well as related prefixed forms (*unfasten* primes *refasten*). Suffixed forms also prime their stems (*punishment* primes *punish*), but they do <u>not</u> prime related suffixed forms (*confession* does not prime *confessor*) (Marslen-Wilson et al., 1994). Feldman and Larabee (2001) demonstrated a similar prefixation advantage across several modalities and inter-stimulus intervals. Not only does prefixing morphology appear to offer a processing advantage over suffixing morphology, it also appears to offer an advantage over bare roots. Schriefers et al. (1991) asked listeners to perform gating and phoneme monitoring tasks while listening to spoken Dutch words containing early versus late uniqueness points. To their surprise, however, results showed no effect of uniqueness point. Instead, in gating tasks, listeners needed significantly more sensory information to identify bare roots versus prefixed words, regardless of early versus late uniqueness points. Similarly, in phoneme monitoring tasks, listeners responded more slowly in the bare root condition compared to the prefixed condition, again regardless of uniqueness point. Interestingly, even though their study did not explicitly test the question of affixed words versus bare roots, Marslen-Wilson et al. (1994) report a compatible result: ''[p]refixed pairs prime each other as well as, if not better than, pairs made up of a free stem and a prefixed form'' (1994:27, with specific reference to their Experiment 4). Taken together, these experimental findings suggest a prefixation advantage that is at odds with Hawkins and Cutler's (1988) processing proposal.

The OT concept of positional faithfulness also raises problems when we attempt to translate it into perceptual terms. Essentially, the theory claims that if segments occupy root-initial positions, those segments should not alternate. The implication – sometimes made explicit, as in Beckman (1997) – is that alternations somehow interfere with accurate segmental perception, and such interference cannot be tolerated in a position that is so important for word recognition. But it is not clear whether this implication really holds. The initial portions of a word drive the process of recognition (works cited above), and therefore possess an important status. But the perceptual consequence of alternations in this position remains an open question. Previous studies examining alternations in word-medial or final positions have found that they do not interfere with word recognition (Coenen et al., 2001; Gaskell and Marslen-Wilson, 1996; Snoeren et al., 2008). In fact, in some circumstances, alternations may even facilitate recognition (Gow, 2001; Gow and Im, 2004). If similar findings hold for alternations in word-initial position, then the perceptual basis for positional faithfulness constraints would appear to be rather tenuous, a point that Becker et al. (2012) also make in their investigation of alternations on monosyllabic versus polysyllabic words.

These problems suggest that a very basic issue remains unresolved: we simply do not know how listeners perceive prefixes versus suffixes. Most of the literature on processing of complex words has focused on a different problem, namely *whether* listeners perceive prefixes and suffixes at all. There is good evidence that they do. Results from lexical decision experiments have repeatedly shown that morphologically related words – whether prefixed or suffixed – prime one another, strongly suggesting that people decompose spoken words into their constituent roots and affixes (Feldman and Larabee, 2001; Marslen-Wilson et al., 1994; Taft and Forster, 1975, and many others, although see Tyler et al., 1988). Evidence for decomposition exists for both derived and inflected words in English (Fowler et al., 1985, although see Stanners et al., 1979). For derived words, the process is modulated by individual lexical characteristics, such as productivity (Marslen-Wilson et al., 1994) and relative frequency of base versus derived forms (Caramazza et al., 1988; Hay, 2001, 2003; Hay and Baayen, 2002; Laudanna and Burani, 2013).

Researchers focusing on Spanish report largely similar findings (for an overview, see Domínguez et al., 2000), although it is important to note that most of these studies examine printed, rather than auditory, word recognition. Sánchez-Casas et al. (2003) compared inflectionally related words such as *niño* - *niña* (‘boy-girl’), derivationally related words such as *rama* - *ramo* (‘branch-bunch’), and non-related but orthographically overlapping words such as *foco* - *foca* (‘floodlight-seal’). Results from visually masked priming with short stimulus-onset asynchronies showed that both inflectionally and derivationally related words produce a significant facilitation effect, of an equivalent size, but that this effect was not observed with forms that were merely similar orthographically. Álvarez et al. (2011) used similar stimuli in an event-related potential (ERP) investigation, and showed that inflectionally and derivationally-related words triggered events with a similar time course, but different locations. Domínguez et al. (2006) also used ERP to demonstrate that participants process Spanish words which share a prefix (as in *reacción-REFORMA* ‘reaction-reform’) differently than those which share a pseudo-prefix (*regalo-REFORMA* ‘gift-reform’); this result fits with those reported for primed lexical decision of prefixed and pseudo-prefixed words (Domínguez et al., 2010). In a similar vein, Allen and Badecker (2002), Domínguez et al. (2002), and Beyersmann et al. (2013) all report results suggesting that participants decompose morphologically complex Spanish words during processing. As in English, the relative frequency of Spanish base versus Spanish derived forms affects lexical decision times (López-Villaseñor, 2012).

1.2. The current study: Subjective perceptual experience

Given that listeners *can* perceive prefixes and suffixes as distinct from the roots they attach to, we turn in the current study to the question of *how* they perceive them. Our research goal is to characterize the subjective experience that people have when listening to a prefix or a suffix – put somewhat crudely, do they experience relatively good perception when listening to a particular affix type, or do they experience relatively poor perception? A motivation for this focus on subjective perceptual experience comes from the work of Ohala (1993), Blevins (2004), and others, who argue that diachronic sound changes – and the resulting synchronic phonological alternations – originate in the mind of listeners as they attempt to interpret the variability inherent in speech. For example, when listeners hear a partially nasalized vowel in a VN sequence, they may attribute the nasalization to the adjacent nasal consonant. Alternatively, if they fail to attend to the consonant, they may misinterpret this contextual variation and attribute nasalization to the vowel itself. Such a scenario could give rise to phonemically nasal vowels; in such cases, the nasal consonant typically disappears (cf. French *brun* [brœ̃] ‘brown’, Ohala, 1993:243). Certain sequences of vowels and consonants encourage misperception more than others, giving rise to alternation types that recur across languages (Blevins, 2004). In the current research, we extend this idea by hypothesizing that certain sequences of morphemes could also encourage misperception more than others, with the aim of taking a step forward in explaining the differences between prefixes and suffixes.

To investigate this hypothesis, we conducted an experiment using a noise-rating task with spoken Spanish stimuli. Native Spanish-speaking participants heard verbal phrases such as *~~me~~ patea* [~~me~~ paˈtea] ‘s/he kicks me’ or *paté*a~~*me*~~ [paˈtea ~~me~~] ‘kick me’, where strikethrough indicates the presence of white noise, and assigned a rating indicating how loud they thought the noise sounded, on a scale from 1 to 5. Comparing the examples, both of which contain the morphemes *me* ‘1SG.OBJ’and *patea* ‘kick’, we see that Spanish personal object pronouns change positions depending upon the status of the verb: such pronouns occur before regularly conjugated verbs, but after imperatives, infinitives, and gerunds. Importantly, the pronoun has the same segmental content and meaning in either position, and it can attach in both instances to a segmentally and prosodically identical verb stem. By comparing listeners' responses to stimuli like *~~me~~ patea* versus *patéa~~me~~*, then, we can factor out extraneous differences among morphemes and focus more clearly on the morphological status of the affixes themselves. More specifically, given that the objective noise levels in *~~me~~ patea* versus *patéa~~me~~* are equivalent, we ask whether the subjective noise levels are also equivalent. Do listeners perceive the noise differently depending upon the position of the pronoun? To evaluate the same question with regards to stems, we also presented stimuli in which noise had been overlaid on the verb, e.g. *me ~~patea~~* versus *~~patéa~~me.*[1]

According to some analyses of Romance languages, the Spanish pronouns are technically clitics, not affixes, because they can represent syntactic constituents (e.g. Kayne, 1975; Rizzi, 1986). Thus, procliticized examples like *me patea* 's/he kicks me' and encliticized examples like *patéame* 'kick me' constitute complete sentences in which *me* represents the direct object argument to the verb. From a syntactic perspective, then, the Spanish pronoun clitics differ from inflectional affixes, which can agree with other constituents in the sentence but cannot independently represent them (although some researchers have argued that the Spanish clitics do not, in fact, differ from affixes at all; see Franco, 2013). From a phonological perspective, however, the Spanish pronoun clitics are straightforwardly affixes. They do not occur as independent words, do not take primary stress, and do not take phrasal accent even under conditions of contrastive focus (Hualde, 2005:258–9). They do not normally take secondary stress, either, although the enclitics can do so optionally (Hualde, 2012:162). Thus, while *me patea* and *patéame* are complete sentences, they are nevertheless single phonological words (for more comprehensive discussion of clitics, see Anderson, 2005). The phonologically-dependent status of Spanish pronouns renders them comparable to prefixes and suffixes and therefore suitable candidates for pursuing our research question.

In addition to minimal pairs for clitic position, Spanish has two more characteristics that make it a good test language for probing the general differences between prefixes and suffixes. First, more than one Spanish pronoun can attach to the same verb root: *se me pisa* [se me ˈpisa] 'I am stepped on', *písamelo* [ˈpisa me lo] 'step on it for me'. In these examples, the pronoun *me* is procliticized or encliticized to the verb stem, but it does not occupy the absolute initial or final position in the word. Crucially, this allows us to treat word-edge proximity and morphological status as separate factors. Thus, if listeners' responses to stimuli like *~~me~~ patea* versus *se ~~me~~ pisa* (analogously, *patéa~~me~~* versus *písa~~me~~lo*) are equivalent, then word-edge proximity would appear to be irrelevant, and we could focus our attention only on potential differences between proclitics and enclitics; conversely, if responses to such stimuli differ, then word-edge proximity would appear to play a role.

Second, Spanish provides an interesting test of our general hypotheses for another reason: most varieties exhibit spirantization of voiced stops. The details differ from one variety to another, but the basic pattern is one in which underlying /b, d, g/ alternate to [β, ð, ɣ] after a vowel (Hualde, 2005:138–9). Note that this alternation is structure-changing, because [β, ð, ɣ] do not occur in the underlying inventory. Spirantization is relatively insensitive to positional restrictions, and may occur at the beginning or end of syllables, at the beginning or end of words, and in stressed or unstressed positions. As a consequence, Spanish proclitics can trigger alternations on the initial edge of verb roots, in precisely the position where they are cross-linguistically rare (and in precisely the position where positional faithfulness constraints would mitigate against them): *batéame* [baˈtea me] 'hit me (with a bat)' versus *me batea* [me βaˈtea] 's/he hits me (with a bat)'. We can therefore use Spanish to investigate whether alternations in this position affect listeners' perceptual experiences. If listeners respond differently to stimuli such as *me ~~[p]atea~~*, *~~[p]atéa~~me* on the one hand versus *me ~~[β]atea~~*, *~~[b]atéa~~me* on the other, we could potentially begin to offer perceptually-based explanations for the origins of the Alternation Asymmetry.

Previous authors have noted that many Spanish prefixes exhibit special behavior with regard to syllabification, in a manner potentially relevant to the current experiment (Face, 2002; Hualde, 2005, see also Harris, 1983). In general, within word boundaries, syllabification creates consonant clusters, as long as such clusters are permissible word onsets: for example, *broma* [bro.ma] 'joke', *abro* [a.bro] 'I open' (Hualde, 2005:74). Across word boundaries, however, syllabification does not create such clusters: *club romano* 'Roman club' [kluβ.romano] (Hualde, 2005:88). In this regard, certain prefixes behave as independent words, resisting the formation of clusters in a similar manner: *subregión* 'subregion' /sub.rexion/ (Hualde, 2005:95, following his transcription in phonemic brackets). This pattern suggests that Spanish prefixes constitute a separate phonological domain whose morpheme and syllable edges are aligned (Face, 2002), and furthermore that prefixes occur outside the prosodic word of the following stem (Selkirk, 1996, see also Himmelmann, 2014). If so, prefixed stems without suffixes exhibit perfect alignment with prosodic word boundaries (while suffixed stems do not, since the prosodic word extends to the suffix), potentially enhancing their perception. Such an argument could conceivably apply to procliticized stems without enclitics, of the kind used here.

[1] Throughout this paper, we include phonetic transcriptions at the first mention of each Spanish example, and also when necessary to discuss phonetic properties of the stimuli.

1.3. The noise-rating task

The current experiment uses a noise-rating task, whose logic is relatively straightforward. Noise interferes with the recognition of the word, and loudness ratings probe the extent to which listeners actually experience this interference. Previous studies have used this task to explore the effect of prior exposure. Jacoby et al. (1988) presented listeners with old and new sentences against a background of white noise at varying intensities, and found that listeners assigned lower ratings to noise on the sentences they had heard previously, even when they were not required to identify those sentences. Goldinger et al. (1999) used the same technique with individual words and found that listeners assigned lower ratings to noise on words they had heard previously, even when they failed to correctly recognize those words as old. In both studies, then, listeners misattributed the relative ease with which they could interpret the old spoken stimuli to a difference in noise level – a perceptual illusion. In the current study, we continue with the assumption that listeners will misattribute relative perceptual ease to differences in noise level, and ask whether listeners experience more (or less) ease for proclitics versus enclitics, and procliticized stems versus encliticized stems.

Although the noise-rating task used in the current experiment differs from the techniques more commonly used to investigate the perception of complex words, such as primed lexical decision and gating, its features are well-suited to the research question at hand. To begin with, as Jacoby et al. (1988) point out, the task does not require participants to report or reflect on the words they have heard, making it unlikely that they will use linguistic knowledge to strategically alter their judgments. This is important for the current experiment because we are investigating a process that listeners are not consciously aware of – specifically, whether they have different perceptual experiences of different morpheme types – but in order to do so, we are obliged to use stimuli that differ in ways which listeners are consciously aware of (most people could probably report, or reflect upon, the fact that the pronoun *me* occurs in different positions in *me patea* versus *patéame*).

Even more importantly, the outcome variable of the noise-rating task represents a subjective judgment on the part of the participant, which distinguishes it from primed lexical decision or gating tasks, where the outcome variables are accuracy and reaction time. As Jacoby et al. (1988) point out, the subjective experience underlying equally accurate or equally fast results may differ. As an example, consider Marslen-Wilson et al.'s finding (1994:27) that prefix–suffix and suffix–prefix pairs facilitate each other equally well in a cross-modal priming task. Specifically, spoken English primes like *dis-trust* facilitate lexical decision for printed English words like *trust-ful* by an average of 30 milliseconds, while spoken primes like *judg-ment* facilitate lexical decision for printed words like *mis-judge* by an average of 31 milliseconds. What these nearly-equal RT results do not reveal is whether listeners had different subjective experiences of, for example, listening to the prefixed primes *dis-trust* versus suffixed primes like *judg-ment.* It is entirely possible that they did; if so, such differences either failed to exert an effect on reaction times, or exerted effects that were masked by additional differences in reaction times later on in the task, such as the time necessary to read the printed targets. Either way, the subjective experience of the participants as they encountered these words – a worthy topic of investigation in its own right – remains largely hidden in the RT data.

In the current experiment, then, the noise-rating task provided an advantage over other methodologies because it allowed us to collect the types of judgments that were most closely related to the question at hand, namely, do listeners experience spoken procliticized forms differently than encliticized forms? In using the noise-rating task to pursue this question, we are extending it in several ways. From a simple methodological perspective, we are extending it to a smaller linguistic unit, and to a different language. Thus, while Jacoby et al. (1988) presented listeners with noisy English sentences and Goldinger et al. (1999) presented noisy English words, the current study presents noisy Spanish morphemes. Extending the task in this way highlights its versatility: we can use noise to ''isolate'' one morpheme while keeping the whole word intact, thus addressing a significant methodological challenge in the study of spoken complex words. As a consequence, though, the current experiment uses sequences of noisy and clear speech within the same stimulus, a departure from previous work that should be borne in mind when interpreting the results.

We are also extending the noise-rating task to a new predictor variable. Whereas previous work examined the effects of prior exposure (old versus new), the current experiment examines the effects of morphological status (proclitic versus enclitic, and procliticized versus encliticized). As Jacoby et al. (1988) point out, prior exposure is just one of many cognitive variables that affect our subjective perception of a stimulus. If we read the lyrics of a rock song before we listen to it, those lyrics seem clearer. If we talk with a friend at a party, their voice seems louder than that of other people nearby. In these instances, the true difference lies in attention or prior experience, but the subjective difference is one of increased clarity. We can characterize the current experiment, then, as a test of the hypothesis that morphological structure acts as a ''cognitive variable'' that influences our subjective perception of spoken words.

1.4. Hypotheses

In light of the broad considerations outlined above, we formulated several hypotheses about this test case with spoken Spanish verbs. First, for the clitics themselves, we hypothesized that listeners would experience relatively poor perception of proclitics compared to enclitics. If poor perception can lead to diachronic loss, then poor perception of proclitics/prefixes would help explain the greater frequency of encliticizing/suffixing languages cross-linguistically. To be consistent with this hypothesis, our results should demonstrate higher noise loudness ratings for stimuli such as *~~me~~ patea* compared to *paté~~ame~~*. Second, for the verbs stems that clitics attach to, the hypothesis is somewhat more tentative. Previous experimental results demonstrate an overall processing advantage for prefixed forms (e.g., Schriefers et al., 1991), although it is not clear to what extent the results from phoneme-monitoring and gating studies bear on the subjective judgments from a noise-rating task. If they do have some bearing, then these findings would suggest that listeners should experience relative clarity during the perception of procliticized stems compared to encliticized stems, an idea that also finds some support in the distinct pattern of Spanish prefix syllabification, discussed in Section 1.2. Results consistent with this hypothesis would show lower noise loudness ratings for stimuli such as *me ~~patea~~* compared to *~~paté~~ame.* Third and finally, we hypothesize that listeners' perceptual experiences of verb phrases will not differ when stem-initial segments alternate, a somewhat counter-intuitive notion that nevertheless fits with previous experimental results demonstrating potentially beneficial effects of alternations (e.g., Gow, 2001) and with the general insensitivity of Spanish spirantization to prominent positions. Results consistent with this hypothesis would show equivalent loudness ratings for stimuli such as *me* ~~[p]*atea*~~, ~~[p]*até*~~*ame* versus *me* ~~[β]*atea*~~, ~~[b]*até*~~*ame* although we must bear in mind that null results do not definitively rule out the presence of an effect.

2. Materials and methods

2.1. Word lists

As shown in Table 1 (in Table 1 and in subsequent text, we have phonetically transcribed Spanish words according to how they were pronounced by the speaker who recorded the stimuli for the experiment), three primary predictor variables governed the design of the word lists: clitic position relative to the verb stem (proclitics versus enclitics), clitic location relative to the edges of the word (edge vs. medial) and alternation status for the initial consonant of the verb root (non-alternating [p, t, k] vs. alternating [b, d, g] ~ [β, ð, ɣ]).

For the stems, we selected thirty-six Spanish verbs that met the following criteria: (a) the third-person singular present form is identical to the imperative form, both in segmental content and stress placement, allowing us to manipulate clitic position while keeping the verb stem constant, (b) the initial segment is a stop consonant, allowing us to compare responses to stems with voiceless, non-alternating segments versus voiced, alternating segments, (c) the frequency of the cliticized form is less than that the frequency of the base (e.g., *me patea* < *patea*), making it likely that listeners would parse each word into individual morphemes (Hay, 2001), and (d) native speakers judged that the resulting cliticized forms are permissible. The verbs are listed in Appendix A.

The verbs' initial stops were balanced across three places of articulation: labial, dental, and velar. The stops were also balanced for voicing, such that half of the verbs occurred in the voiceless, non-alternating condition (e.g., *patea* [pa'tea] 'kick', *tantea* [tan'tea] 'try out', *castiga* [kas'tiɣa] 'punish') while half occurred in the voiced, alternating condition (e.g., *baraja* [ba'raha] 'shuffle', *decide* [de'siðe] 'decide', *golpea* [gol'pea] 'hit'). Furthermore, in order to ensure that every complex word had exactly four syllables, the verbs were evenly divided into three-syllable versus two-syllable stems. The three-syllable stems always occurred in the word-edge condition, where they combined with a single clitic pronoun: *me patea*, *patéame*. The two-syllable stems always occurred in the word-medial position, where they combined with two clitic pronouns: *se me pisa*, *písamelo.*

Table 1
Basic design of the cliticized stimulus words.

		Proclitic	Enclitic
Non-alternating	Word-edge	*me patea* [me pa'tea] 's/he kicks me'	*patéame* [pa'tea me] 'kick me'
	Word-medial	*se me pisa* [se me 'pisa] 'I am stepped on'	*písamelo* ['pisa me lo] 'step on it for me'
Alternating	Word-edge	*me batea* [me βa'tea] 's/he hits me with a bat'	*batéame* [ba'tea me] 'hit me with a bat'
	Word-medial	*se me borra* [se me 'βora] 'it gets erased on me'	*bórramelo* ['bora me lo] 'erase it for me'

Table 2
Sample paradigm for three-syllable Spanish verb stem, with the relevant clitic in word-edge position.

Proclitics		Enclitics	
me patea [me pa'tea]	's/he kicks me'	*patéame* [pa'tea me]	'kick me'
te patea [te pa'tea]	's/he kicks you'	*patéate* [pa'tea te]	'kick yourself'
lo patea [lo pa'tea]	's/he kicks him/it (masc.)'	*patéalo* [pa'tea lo]	'kick him/it (masc.)'
la patea [la pa'tea]	's/he kicks her/it (fem.)'	*patéala* [pa'tea la]	'kick her/it (fem.)'
nos patea [nos pa'tea]	's/he kicks us'	*patéanos* [pa'tea nos]	'kick us'
los patea [los pa'tea]	's/he kicks them (masc.)'	*patéalos* [pa'tea los]	'kick them (masc.)'
las patea [las pa'tea]	's/he kicks them (fem.)'	*patéalas* [pa'tea las]	'kick them (fem.)'

Table 3
Sample paradigm for two-syllable Spanish verb stem, with the relevant clitic in word-medial position.

Proclitics		Enclitics	
se me pisa [se me 'pisa]	'I am stepped on'	*písamelo* ['pisa me lo]	'step on it for me'
se te pisa [se te 'pisa]	'you are stepped on'	*písatelo* ['pisa te lo]	'step on it for yourself'
se lo pisa [se lo 'pisa]	'he is stepped on'		
se la pisa [se la 'pisa]	'she is stepped on'		
se nos pisa [se nos 'pisa]	'we are stepped on'	*písanoslo* ['pisa nos lo]	'step on it for us'
se los pisa [se los 'pisa]	'they (masc.) are stepped on'		
se las pisa [se las 'pisa]	'they (fem.) are stepped on'		

For each of the eighteen three-syllable verbs, we created two sets of seven words each, one procliticized and one encliticized. For the proclitics, we placed each of seven Spanish pronouns *me*, *te*, *lo*, *la*, *nos*, *los*, *las* [me, te, lo, la, nos, los, las] before the third-person singular present verb stem. For the enclitics, we placed each of these seven pronouns after the imperative verb stem. As an example, Table 2 shows the full paradigm created for *patea* 'kick'.

For each of the eighteen two-syllable verbs, we also created two sets of phrases, one set with seven procliticized verbs and another with three encliticized verbs. For the proclitics, we combined the pronoun *se* with one of the seven object pronouns. Depending upon the verb in question, this either creates a passive construction, in which the personal pronoun is the patient of the verb (*se me pisa* 'I am stepped on') or a pronominal construction, in which the personal pronoun is the direct object of the verb (*se la guarda* [se la 'ɣwarða] 's/he saves it [fem.] for her/himself').[2] For the enclitics, we combined the object pronouns *me*, *te*, and *nos* with the pronoun *lo.* This creates a double-object construction, in which the first pronoun is the indirect object and the second pronoun is the direct object: *písamelo* 'step on it for me'.

We omitted the remaining four Spanish pronouns from the encliticized set because they undergo a neutralizing morphological alternation to *se*, followed by dissimilation: /pisa le lo/ → *písaselo* ['pisa se lo] 'step on it for him/her/them (masc.)/them(fem.)/you(sing.)/you(pl.)'. As a result, the stimuli were not fully crossed for each individual pronoun in the word-medial condition, a limitation that we accepted in order to maintain strict identity between pronouns across proclitic and enclitic conditions. Table 3 shows the full paradigm for *pisa* 'step on'.

Prior to recording, all of the stimulus words were reviewed by a male native speaker of Colombian Spanish and judged to be acceptable. After the experiment was conducted, two additional speakers conducted post hoc reviews. A second

[2] The semantic interpretation of Spanish pronominal verbs varies considerably. See Butt and Benjamin (2013).

Table 4
Frequency statistics, reported as log frequency (+1), for cliticized stimuli.

	Two-syllable stems		Three-syllable stems	
	Procliticized	Encliticized	Procliticized	Encliticized
Bare verb stem	2.83 (0.80)	2.83 (0.80)	2.10 (0.84)	2.10 (0.84)
Inflected verb (averaged across all pronouns)	0.08 (0.15)	0.11 (0.43)	0.30 (0.41)	0.35 (0.68)

male native speaker of Colombian Spanish judged all of the stimuli acceptable, but noted that the word *bautízate* [bau'tisa te] 'baptize yourself' is somewhat awkward since people are usually baptized by others, not themselves. A female native speaker of Mexican Spanish also judged all of the stimuli acceptable, but noted that the three-syllable stem *garante* [ga 'rante] 'guarantee' is not part of her dialect. A reviewer states that most dialects use the four-syllable stem *garantiza* [garan 'tisa] 'guarantee' instead.

In order to increase the likelihood that listeners would parse each word into individual morphemes, rather than employing a whole-word access strategy, we selected verb stems such that the frequency of the cliticized verb was always less than that the frequency of the isolated verb stem (e.g., *me patea* < *patea)* (Hay, 2001). Table 4 displays the frequency statistics, which were calculated using two corpora (Cuetos et al., 2011; Davies, 2002 [searches restricted to modern Spanish]).

Thirty-two Spanish words containing pseudo-clitics at either the beginning or end of the word were also included. For example, *mecanismo* [meka'nismo] 'mechanism' contains a pseudo-proclitic resembling the first person singular *me*, and *uniforme* [uni'forme] 'uniform' contains a comparable pseudo-enclitic. The pseudo-cliticized words included all seven pronouns in both procliticized and encliticized positions, and the words all contained four syllables, thus matching the truly cliticized words. However, the rarity of such words in the Spanish lexicon made it impossible to control any of their other characteristics, such as frequency. Furthermore, virtually no Spanish words contain sequences of two pseudo-clitics (i.e., very few monomorphemic four-syllable words begin with *se me* [seme] or end with *melo* [melo]), so this type of word could not be included. The simplex pseudo-cliticized words are listed in Appendix B.

Finally, forty-eight high-frequency monomorphemic Spanish words containing two or four syllables, such as *aqui* [a'ki] 'here' and *cuidado* [kwi'ðaðo] 'care', were used as fillers.

2.2. Stimulus preparation

A female native speaker of the Colombian coastal variety of Spanish, who was not aware of the purpose of the experiment, recorded each word in a sound-proof booth. The speaker consistently spirantized voiced stops after vowels. In the first pass of the recording, she also changed coda /s/ to [h] for some words but not others, suggesting that this rule is optional for her. In the second pass, conducted immediately afterwards, we asked her to re-record these words and pronounce [s] in all positions, which she did with no difficulty.

With the Praat program (Boersma and Weenink, 2012), we used waveforms and spectrograms to segment each recorded word into clitic and verb stem portions. We report the acoustic measurements for the complex words in Table 5 for clitics and Table 6 for verb stems; we report measurements for the simple words in Table 7. Intensity and F0 measurements were averaged across the entire duration of the relevant constituent.

Table 5 through 7 suggest that the acoustic properties of our recorded stimuli are not strictly equivalent across conditions, a point to which we return in Section 4.5.

As shown in Table 5 through 7, we calculated the average intensity of each stem and clitic separately. Based on these calculations, we used the Akustyk program (Plichta, 2012) to add white noise to either the verb stem or the clitic at one of three signal-to-noise ratios: +24 dB, +17 dB, or +10 dB (following Goldinger et al., 1999). Thus, for each word such as *me*

Table 5
Mean values (standard deviations) of acoustic measurements for the recorded clitics in complex words, such as *me* in medial position (proclitic: *se me pisa*, enclitic: *písamelo*) and in edge position (proclitic: *me patea*, enclitic: *patéame*).

	Medial clitics		Edge clitics	
	Proclitic	Enclitic	Proclitic	Enclitic
Duration (ms)	18.93 (2.74)	19.40 (3.94)	17.12 (3.98)	28.15 (7.34)
Intensity (dB)	65.68 (2.17)	65.45 (2.13)	68.66 (1.74)	64.06 (2.25)
F0 (Hz)	212.26 (7.74)	240.99 (19.60)	229.11 (5.89)	247.35 (23.89)

Table 6
Mean values (standard deviations) of acoustic measurements for the recorded verb stems in complex words, including two-syllable stems such as *pisa* (procliticized: *se me pisa*, encliticized: *písamelo*) and three-syllable stems such as *patea* (procliticized: *me patea*, encliticized: *patéame*).

	Two-syllable stems		Three-syllable stems	
	Procliticized	Encliticized	Procliticized	Encliticized
Duration (ms)	51.83 (5.26)	34.57 (5.04)	69.57 (6.88)	57.26 (6.84)
Intensity (dB)	65.91 (2.11)	69.81 (2.13)	65.95 (1.57)	67.99 (1.90)
F0 (Hz)	228.24 (11.19)	236.31 (8.68)	225.21 (8.77)	227.40 (7.19)

Table 7
Mean values (standard deviations) of acoustic measurements for the recorded simple words, separated according to pseudo-clitic status (e.g., *me* is a ''proclitic'' in *mecanismo* and an ''enclitic'' in *uniforme*) or pseudo-stem status (e.g., *canismo* is ''procliticized'' and *unifor* is ''encliticized'').

	Pseudo-clitics		Pseudo-stems	
	''Proclitic''	''Enclitic''	''Procliticized''	''Encliticized''
Duration (ms)	17.80 (7.65)	26.15 (6.42)	66.37 (12.57)	57.89 (10.98)
Intensity (dB)	68.46 (2.86)	64.40 (2.14)	66.75 (1.69)	68.40 (1.88)
F0 (Hz)	237.72 (27.77)	250.54 (34.92)	226.41 (10.65)	225.62 (8.94)

patea, six stimuli were created: three with noise on the clitic (*~~me~~ patea* at +24 dB, +17 dB, or +10 dB S/N ratios) and three with noise on the verb stem (*me ~~patea~~* at +24 dB, +17 dB, or +10 dB S/N ratios). Phrases in the word-medial condition contained more than one clitic, but we only created stimuli with noise on the medial clitic (*se ~~me~~ pisa*, *písa~~me~~lo*) as well as on the stem (*se me ~~pisa~~*, *~~písa~~melo*), each at the three different signal-to-noise ratios. For the pseudo-cliticized words, six stimuli were also created: three with noise on the pseudo-clitic (*~~me~~canismo*) and three with noise on the pseudo-verb stem (*me~~canismo~~*). And finally for the fillers, six stimuli were created, three with noise on the first half of the word's duration, and three with noise on the second half.

2.3. Design

Each participant heard thirty-six complex cliticized words, thirty-two simple pseudo-cliticized words, and forty-eight fillers. The complex cliticized words were selected randomly for each participant from the master list of 432 words ([18 three-syllable stems $\times$ 14 clitics] + [18 two-syllable stems $\times$ 10 clitics]) with the constraint that each verb stem was selected only once for each participant (e.g., after hearing *me patea*, they would not hear any other word with the verb stem *patea*). This procedure automatically created a strict balance of the factors clitic location (edge vs. medial, plus the corresponding presence of three-syllable versus two-syllable stems) and alternation status (none vs. stem-initial) within each participant. It also created a strict balance for stem-initial place of articulation.

For each of the thirty-six verb stems, the program randomly selected either a procliticized or encliticized form of that stem, and a noise level of +24, +17, or +10 dB S/N ratio. It also randomly selected a noise location of clitic or stem, and a particular clitic (*me*, *te*, *lo*, etc.). This procedure created an effective, although not perfect, balance of the factors of clitic position and noise level within each participant, as well as an effective balance of noise location. Specifically, for the thirty-six complex stimuli, each participant listened to an average of 20.93 (2.89) procliticized words and 14.64 (2.76) encliticized words, reflecting the greater number of procliticized complex words in the stimulus set as a whole, as depicted in Tables 2 and 3. Also, each participant listened to an average of 11.34 (2.00) words at +24 dB S/N ratio, 11.68 (2.28) words at +17 S/N ratio, and 12.54 (2.32) words at +10 S/N ratio. Finally, each participant listened to an average of 18.07 (2.00) words with noise overlaid on the clitic, and 17.50 (1.95) words with noise overlaid on the stem. A similar randomization procedure was used with the thirty-two simple words and forty-eight fillers, such that, while each participant listened to a unique list of stimuli, every list was representative of the stimulus set as a whole.

Each participant was seated in an individual carrel in a quiet laboratory dedicated to this purpose, in front of a computer workstation equipped with Sennheiser HD 280 headphones. The experiment was delivered with E-Prime® 2.0 software from Psychology Software Tools, Inc. Printed Spanish instructions on the computer screen guided participants through each step of the experiment, and they were instructed to attend carefully to each word, because the experimenter would ask about them later.

At the beginning of each trial, an individual auditory stimulus was played. The screen was blank during this time, and no orthographic or other visual stimuli were presented. After a 500 ms delay from the offset of the auditory stimulus, a screen appeared with five buttons labeled 1, 2, 3, 4, 5. The printed phrase *más bajo* appeared underneath button 1 to indicate that it corresponded to the softest noise on the scale, while the printed text *más alto* appeared underneath button 5 to indicate that it corresponded to the loudest noise on the scale. Printed Spanish instructions asked participants to rate the loudness of the white noise on the stimulus by clicking on one of the buttons, which they did with a computer mouse.

2.4. Participants

Forty-four adult members of the University of Wisconsin, Milwaukee community participated in the experiment, which lasted approximately 15 minutes, and received either course credit or $5 as compensation. Nineteen participants were male, twenty-four were female, and one participant did not report a gender. Their ages ranged from 18 to 40. All participants spoke Spanish as their native language. Their countries of origin varied, with Mexico represented most heavily. Some participants grew up exclusively in Mexico ($n = 9$), some grew up partly in Mexico and partly the United States ($n = 13$), and some grew up in United States while speaking Mexican Spanish at home ($n = 3$). Other countries of origin included Bolivia ($n = 1$), Colombia ($n = 3$), Chile ($n = 1$), El Salvador ($n = 1$), Honduras ($n = 1$), Panama ($n = 1$), Peru ($n = 1$), Puerto Rico ($n = 2$), and Spain ($n = 5$). Additional participants grew up partly in Cuba and partly in the United States ($n = 1$), and partly in Argentina and partly in the United States ($n = 1$). One participant did not report his/her country of origin.

Because our research question does not hinge crucially on linguistic features that vary from one variety of Spanish to another, we did not exclude participants on this basis. However, a reviewer points out that Spanish speakers from Argentina, where *vos* forms are used instead of *tú* forms, would potentially respond differently to the second-person imperative *tú* stimuli used in this experiment. Similar reasoning could apply to speakers from Honduras, El Salvador, and certain parts of Bolivia, where both *vos* and *tú* forms are used. Because only four participants listed Argentina, El Salvador, Honduras, or Bolivia as a country of origin, we did not analyze these participants' data separately.

In addition to their native Spanish, all of the participants spoke fluent English. This potentially influenced their responses to the experimental task, although we made some attempt to diminish such influence by presenting consent forms and on-screen experiment instructions in Spanish.

3. Results

A total of 5104 judgments were collected ([36 complex words + 32 simple words + 48 fillers] $\times$ 44 participants]). From this total, 2950 judgments were to complex or simple words rather than fillers ([[36 complex words + 32 simple words] $\times$ 44 participants] $-$ 42 stray mouse clicks) and therefore included in the final analysis.

3.1. Procedure for analysis

The outcome variable for the experiment is an ordered categorical variable (i.e., a noise level rating from 1 to 5), suitable for analysis with a proportional odds logistic regression model (Agresti, 2010). The R resources for such models have limitations that we worked to overcome. We used the procedure clmm() from the ordinal package (Christensen, 2013) because, to our knowledge, it is the only procedure that permits the inclusion of random effects in such models (Agresti, 2011). However, the random effects are limited to intercepts, not slopes; furthermore, only a single random effect can be included at a time. As a consequence, we could not fit a single model with random slopes for both participant and item, as recommended by Barr et al. (2013). Therefore, we decided to report coefficients for two clmm() models, one with a random intercept for participant and one with a random intercept for item. Although we do not know of other studies that use this specific work-around for clmm(), it draws upon the traditional technique of reporting both by-participants and by-items analyses in ANOVAs. In the discussion that follows, we consider an effect to be significant only when both the model with random participant intercept and the model with random item intercept indicate it to be so.

Models were run on two separate data sets. The first set included only stimuli in which noise occurred on clitics, while the second set included only stimuli in which noise occurred on verb stems. This allowed us to address the specific comparisons we were interested in: that is, between proclitics vs. enclitics on the one hand, and between procliticized verb stems vs. encliticized verb stems on the other. The models used five predictor variables and their interactions, displayed in Table 8. We used sum coding for the four binary predictors and Helmert coding for the three-way predictor of S/N Ratio. These coding schemes were appropriate because, in this experiment, we did not have reason to assume that any given level of a predictor served as an untreated baseline. Levels were coded in the order listed in Table 8. For example, ''Proclitic'' was coded as the first level of the clitic position predictor, while ''Enclitic'' was coded as the second level.

As mentioned, we analyzed the data for clitics and stems separately. This is because, in comparing stimuli such as *me patea* vs. *patéame*, we are pursuing two related but separate research questions: first, we want to characterize the

Table 8
Predictors, levels, and coding schemes used in the clmm() implementation of proportional odds logistic regression models in R.

Predictor	Levels	Coding scheme
Clitic position (relative to verb stem)	Proclitic, Enclitic	Sum
Clitic location (relative to edge of word)	Edge, Medial	Sum
Alternation status (initial consonant of verb)	Non-alternating, Alternating	Sum
Word type (truly or pseudo cliticized)	Simple, Complex	Sum
Signal-to-noise-ratio	+24 dB, +17 dB, +10 dB	Helmert

difference between the proclitic *me* and the enclitic *me*, and second, we want to characterize the difference between procliticized *patea* and encliticized *patéa.* These questions are related because in both cases we aim to compare constituents that are morphologically and phonologically equivalent, exhibiting only a minimal difference according to their preposed or postposed position within the word. But these questions are also separate, because clitics and stems differ from one another in ways that preclude a direct comparison, and our stimulus design did not aim to minimize these differences. Morphologically, for example, clitics serve as direct objects while stems serve as predicates. Phonologically, clitics occupy a single syllable that cannot take primary stress, while our stimulus stems occupy two or three syllables, one of which must take primary stress. In addition, clitics use a closed class of segments (*me*, *te*, *lo*, *la*, *nos*, *los*, *las*) that do not match those found in our stimulus stems (e.g., *patea*, *pisa*). Phonetically, our stimulus clitics exhibit shorter duration than our stimulus stems, producing corresponding differences in duration of overlaid white noise. Thus, any differences in how listeners respond to noise on a clitic such as *me* versus noise on a stem such as *patea* could be due to morphological, phonological, and/or phonetic differences which do not concern us here. Therefore, although we collected listener responses to clitics and stems in the same experimental session, we analyze these responses separately.

3.2. Results for rating of noise on clitics

Participants' ratings for noise overlaid on clitics were somewhat skewed toward the lower end of the five-point scale: Level 1 (36% of responses), Level 2 (26%), Level 3 (20%), Level 4 (13%), Level 5 (5%). The key results for these stimuli are depicted in Fig. 1.

The statistical models indicated two main effects and no interactions. First, decreases in signal-to-noise ratio increased listeners' ratings for loudness of the noise. Second, noise overlaid on proclitics increased listeners' ratings for loudness. As shown in Table 9, these effects were significant in the model with participant as a random factor, and also in the model with item as a random factor.

In the model with participant as a random factor, two additional main effects emerged. Noise overlaid on clitics in word-edge position increased listeners' loudness ratings, while stimuli with non-alternating consonants decreased loudness ratings. These effects were not significant in the model with item as a random factor. No other effects reached significance.

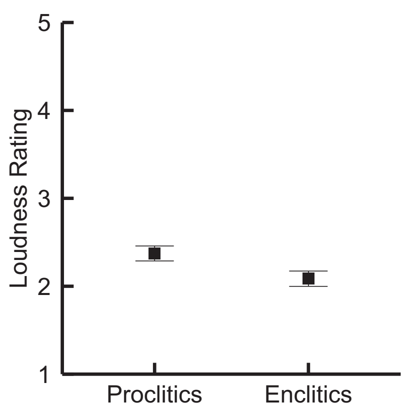

Fig. 1. Results for clitics. Mean loudness ratings for noise occuring on proclitics (~~me~~ *patea*, *se* ~~me~~ *pisa*) versus enclitics (*paté*~~ame~~, *písa*~~me~~*lo*).

Table 9
Results of proportional odds logistic regression models displaying significant predictors for participants' rating of noise on clitics. The first model contained a random intercept for participant, while the second model contained a random intercept for item.

Random intercept	Predictor	Est.	Std. error	*z*	*p*	
Participant	S/N ratio (+24 dB)	0.81	0.11	7.35	<0.05	*
	S/N ratio (+17 dB)	0.74	0.06	12.47	<0.05	*
	Position (Proclitic)	0.35	0.08	4.17	<0.05	*
	Location (Edge)	0.18	0.07	2.41	<0.05	*
	Alternation (None)	−0.16	0.07	−2.21	<0.05	*
Item	S/N ratio (+24 dB)	0.68	0.10	6.56	<0.05	*
	S/N ratio (+17 dB)	0.55	0.06	9.84	<0.05	*
	Position (Proclitic)	0.27	0.09	2.89	<0.05	*
	Location (Edge)	0.14	0.07	1.92	0.06	n.s.
	Alternation (None)	−0.13	0.07	−1.69	0.09	n.s.

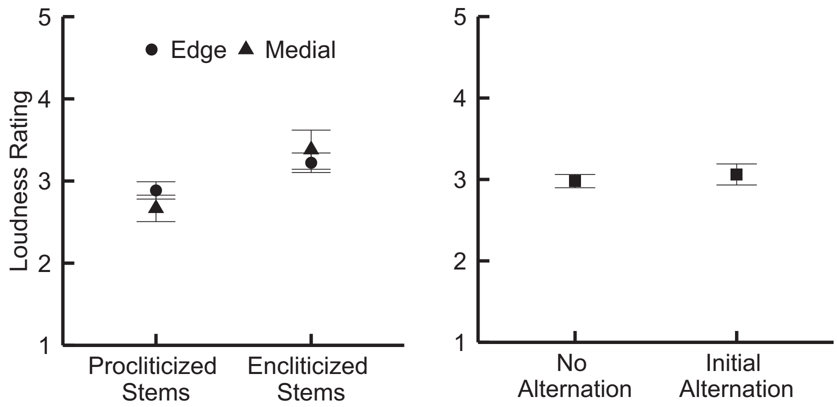

Fig. 2. Results for verb stems. Left panel: Mean loudness ratings for noise occuring on procliticized stems (edge: *me* ~~*patea*~~, medial: *se me* ~~*pisa*~~) versus encliticized stems (edge: ~~*patéa*~~*me*, medial: ~~*písa*~~*melo*). Right panel: Mean loudness ratings for noise occuring on verb stems with no alternation (*me* ~~[p]*atea*~~, ~~[p]*atéa*~~*me*) versus stems with initial alternation (*me* ~~[β]*atea*~~, ~~[b]*atéa*~~*me*).

3.3. Results for rating of noise on verb stems

Participants' ratings for noise on verb stems were relatively evenly distributed across the five-point scale: Level 1 (16% of responses), Level 2 (23%), Level 3 (23%), Level 4 (20%), Level 5 (18%). The key results for these stimuli are depicted in Fig. 2.

The statistical models indicated three main effects and one interaction. First, decreases in signal-to-noise ratio increased listeners' ratings for loudness of the noise. Second, noise overlaid on procliticized verb stems decreased listeners' ratings for loudness. An interaction showed that this decrease was greater when the stimuli contained two clitics (i.e., in the ''medial'' condition) compared to when it contained one clitic (i.e., in the ''edge'' condition). Third, noise overlaid on a non-alternating verb stem decreased listeners' ratings for loudness. As shown in Table 10, these effects were significant in the model with participant as a random factor, and also in the model with item as a random factor.

In the model with participant as a random factor, one additional main effect emerged, namely that noise overlaid on roots in simple words increased listeners' loudness ratings. This effects was not significant in the model with item as a random factor. No other effects reached significance.

3.4. Summary

The key findings of the experiment can be summarized as follows. First, listeners judged noise on proclitics to be louder than noise on enclitics (~~*me*~~ *patea*, *se* ~~*me*~~ *pisa* > *patéa*~~*me*~~, *písa*~~*me*~~*lo*). Second, they judged noise on procliticized verb stems to be softer than noise on encliticized stems (*me* ~~*patea*~~, *se me* ~~*pisa*~~ < ~~*patéa*~~*me*, ~~*písa*~~*melo*). An interaction showed that this difference in judgments was greater for doubly-cliticized stems (i.e., medial condition: *se me* ~~*pisa*~~ ≪ ~~*písa*~~*melo*) than it was for singly-cliticized stems (i.e., edge condition: *me* ~~*patea*~~ < ~~*patéa*~~*me*). Third, listeners judged noise on

Table 10
Results of proportional odds logistic regression models displaying significant predictors for participants' rating of noise on stems. The first model contained a random intercept for participant, while the second model contained a random intercept for item.

Random intercept	Predictor	Est.	Std. error	*z*	*p*	
Participant	S/N ratio (+24 dB)	0.88	0.10	8.48	<0.05	*
	S/N ratio (+17 dB)	1.01	0.06	16.05	<0.05	*
	Position (Procliticized)	−0.55	0.08	−6.60	<0.05	*
	Alternation (None)	−0.22	0.07	−3.06	<0.05	*
	WordType (Simple)	0.22	0.08	2.73	<0.05	*
	Position * Location	0.15	0.07	2.09	<0.05	*
Item	S/N ratio (+24 dB)	0.76	0.10	7.44	<0.05	*
	S/N ratio (+17 dB)	0.90	0.06	14.52	<0.05	*
	Position (Proclitic)	−0.51	0.10	−5.10	<0.05	*
	Alternation (None)	−0.19	0.08	−2.47	<0.05	*
	WordType (Simple)	0.18	0.10	1.93	0.05	n.s.
	Position * Location	0.15	0.08	2.01	<0.05	*

non-alternating verb stems to be softer than noise on stems with initial alternation (*me* ~~[p]*atea*~~, ~~[p]*até*~~*ame* < *me* ~~[β]*atea*~~, ~~[b]*até*~~*ame*). Finally, listeners judged noise on both clitics and stems to be louder when the signal-to-noise ratio decreased, confirming that subjective ratings increased when objective noise levels increased.

4. Discussion

Overall, the results of the noise-rating task on Spanish verb phrases provide support for two of the hypotheses outlined in the introduction. Listeners appeared to experience poorer perception when listening to proclitics, compared to enclitics. And they appeared to experience better perception when listening to procliticized stems, compared to encliticized stems. These findings suggest that morphological constituency affects listeners' subjective perception of speech sounds. An additional hypothesis concerning segmental alternations was not supported. Contrary to many previous findings, listeners appeared to experience more perceptual clarity when listening to non-alternating stems, compared to alternating stems. It is important to consider these results in light of the particular language under investigation (Spanish) and the particular task employed (loudness ratings of noise overlaid on speech), both of which limit the scope of our conclusions but also point the way to future research in this area.

4.1. Perception of clitics

We had hypothesized, first, that listeners would assign higher loudness ratings to noise occurring on proclitics compared to noise occurring on enclitics. This hypothesis followed a rather crude but nevertheless straightforward logic: cross-linguistically, prefixing morphology is infrequent compared to suffixing morphology. Such a typological pattern would make sense if, in general, listeners perceive proclitics/prefixes with less clarity than enclitics/suffixes, and if poor perception leads to diachronic loss. As the results depicted in Fig. 1 indicate, this hypothesis was borne out. Listeners subjectively perceived noise on proclitics to be louder than noise on enclitics, even though the objective noise levels were equivalent across these conditions.

Does this result represent a true morphological effect? Our results are equivocal on this point. On the one hand, the statistical analysis did not reveal an interaction between clitic position (proclitic vs. enclitic) and word type (truly cliticized versus pseudo-cliticized). Thus, participants responded to noise on any ''proclitic'' element with a relatively high loudness rating, regardless of whether the stimulus was complex (~~*me*~~ *patea* 's/he kicks me') or simple (~~*me*~~*canismo* 'mechanism'). And, participants responded to noise on any ''enclitic'' element with a relatively low loudness rating, again regardless of whether the stimulus was complex (*patéa*~~*me*~~ 'kick me') or simple (*unifor*~~*me*~~ 'uniform'). Thus, we might conclude that noise simply sounds louder when it masks earlier elements in the word, regardless of what morphemes are involved. This interpretation would be consistent with previously-cited work on the perceptual importance of word-initial elements, and suggests that the perceptual asymmetry between proclitics and enclitics represents an effect of linear ordering, rather than morphological constituency per se.

On the other hand, the statistical analysis revealed no interaction between clitic position (proclitic vs. enclitic) and clitic location (word-edge versus word-medial). Thus, participants responded to noise on proclitics with a relatively high loudness rating, regardless of whether the clitic occurred at the initial edge of the word (~~*me*~~ *patea*) or in the middle of the word (*se* ~~*me*~~ *pisa*). And, participants responded to noise on enclitics with a relatively low loudness rating, again regardless of whether the clitic occurred at the final edge of the word (*patéa~~me~~*) or in the middle of the word (*písa~~melo~~*). This result is consistent with the idea that listeners' perceptual experiences of clitics do not crucially depend upon their positioning relative to the edge of the word, and suggests that the asymmetry between ratings for noise on proclitics versus enclitics is a true morphological effect. In other words, it suggests that listeners respond to proclitics as a morpheme type, whether or not they occur in absolute word-initial position.

One reason to favor this latter interpretation is that both the isolated and cliticized frequencies of verb stems were reasonably balanced for the complex stimuli, facilitating a direct comparison between phrases like *me patea* and *se me pisa.* This was not possible for the simple stimuli, so any comparison between *me patea* and *mecanismo* is imperfect at best; therefore, the similar ratings that listeners assigned to stimuli across the complex and simple stimuli could potentially originate from an uncontrolled factor.

Further research could help to resolve this issue. One obvious approach would be to evaluate listeners' judgments to noise overlaid on medial portions of simplex words. The current experiment did not include such stimuli because the lexicon of Spanish contains relatively few four-syllable words with double pseudo-clitics (such as *compromete* [kompro'mete] 's/he comprises', or *caramelo* [kara'melo] 'candy' where *me, te*, and *lo* are segmentally identical to Spanish pronouns). Nevertheless, in future work it could still be possible to evaluate listeners' responses to noise on other controlled positions in the middle of a simple word, perhaps by relaxing the requirement for double pseudo-clitics and using words with medial pseudo-clitics such as *amenazar* [amena'sar] 'to threaten' (where *me* is segmentally identical to the Spanish first-person singular object pronoun). Another goal for future work would be to match the complex and simple stimuli for frequency characteristics. Since the set of suitable simple Spanish words is extremely limited, we would be obligated to use this set as the starting point, and select complex stimuli with frequencies to match them.

4.2. Perception of verb stems

Our second hypothesis focused not on the clitics themselves, but rather on the stems to which they attach. We hypothesized that listeners would assign lower loudness ratings to noise occurring on procliticized stems compared to noise occurring on encliticized stems. Previous results in primed lexical decision, gating, and phoneme monitoring paradigms, as well as syllabification patterns specific to Spanish prefixes, had all suggested a perceptual advantage for prefixed roots, and we therefore predicted that this advantage would extend to the noise-rating paradigm with clitics. As the left panel of Fig. 2 indicates, this hypothesis was confirmed. Listeners subjectively perceived noise on procliticized roots to be softer than noise on encliticized roots, even though the objective noise levels were equivalent across these conditions.

The statistical analysis revealed no interaction between clitic position and word type (truly cliticized versus pseudo-cliticized). Listeners appeared to treat true and pseudo procliticized stimuli in the same way, assigning relatively low ratings to noise on *me ~~patea~~* and *me~~canismo~~* regardless of morphological structure. Similarly, they appeared to treat true and pseudo encliticized stimuli in the same way, assigning relatively high ratings to *~~paté~~ame* and *~~unifor~~me*, again regardless of morphological structure. The fact that complex and simple words patterned together would suggest that linear order, not morphological structure per se, is responsible for this effect – although the caveat regarding imperfect matches for lexical statistics across complex and simplex stimuli applies again here.

The statistical analysis revealed an interaction between clitic position and location. The difference in ratings for noise on procliticized versus encliticized stems was greater for doubly-cliticized stems (i.e., medial condition: *se me ~~pisa~~* ≪ *~~písa~~melo*) than it was for singly-cliticized stems (i.e., edge condition: *me ~~patea~~* < *~~paté~~ame*). As the left panel of Fig. 2 suggests, this difference seems to arise both from an advantage for doubly-procliticized stems, which had the lowest noise ratings of any stem type, as well as from a disadvantage for doubly-encliticized stems, which had the highest noise ratings of any stem type. We might therefore argue that since proclitics in general provide a perceptual advantage for the following stem, as shown by the main effect for clitic position, the presence of an additional proclitic enhances this advantage. Likewise, since enclitics in general create poor perception for the preceding stem, the presence of an additional enclitic enhances the disadvantage. In order to make this argument in favor of a pure morphological effect, however, we would need to rule out the effects of linear order and noise duration. It is possible, for example, that the perceptual advantage for doubly-procliticized stems (and the disadvantage for doubly-encliticized stems) occurs simply because more spoken material occurs before (or after) the stem compared to singly-cliticized words, and that the morphological constituency of this spoken material plays no role. It is also possible that the interaction arises from the fact that the doubly-cliticized stems in our experiment were two syllables long, while singly-cliticized stems were three syllables long, potentially affecting the perception of the spoken stem and/or the noise overlaid onto it. Further research comparing complex to simplex words could clarify the issue of linear order, and further research employing verb stems of different syllable counts could clarify the issue of duration.

In a related vein, we must also consider whether word edge positions exerted a basic psycho-acoustic effect on perception of the overlaid noise. Previous work suggests that listeners perceive noise to be louder when it occurs synchronously with speech onset compared to when it occurs asynchronously (Bregman, 1978, 1994; Darwin, 1984; Rasch, 1978). If this psycho-acoustic effect was operative in the current experiment, it could account for the significantly different ratings that participants gave to noise on procliticized stems (where noise always occurred asynchronously with speech onset) compared to encliticized stems (where it always occurred synchronously). Note that the results from stimuli with noisy clitics give some reason to doubt this conclusion: as we have seen, participants gave lower loudness ratings to noise on proclitics compared to noise on enclitics, even though noise on proclitics occurred at speech onset for the majority of these stimuli. This suggests that morphological effects might have the capacity to modify, or counter-act, the psycho-acoustic effects of noise occurring at different positions in the speech stream. Note also that our finding about the relatively enhanced perceptual clarity of procliticized stems is consistent with previous work using other experimental paradigms such as lexical decision and gating (cited in Introduction), where the (a)synchronicity of noise and speech was not an issue.

In Section 1.2, we briefly considered the idea that Spanish prefixed roots without suffixes align perfectly with prosodic word boundaries, potentially enhancing their perception (Face, 2002; Selkirk, 1996). Although our results are consistent with this notion, further research is required in order to determine if the apparent perceptual clarity of procliticized stems actually has its source in prosodic alignment. A key comparison would be between procliticized stems without enclitics, of the kind examined here, and procliticized stems with enclitics, where a proclitic is still present but the alignment of prosodic and morpheme boundaries is no longer perfect.

4.3. Perceptual consequences of alternations

Our third and final hypothesis concerned segmental alternations. Based on previous research demonstrating that alternations do not deter from word recognition, and on the general insensitivity of Spanish spirantization to prominent positions, we hypothesized that listeners' perceptual experiences of verb phrases would not differ when stem-initial segments alternate. However, our results were not consistent with this hypothesis. Alternation status exerted a main effect on ratings of stem noise. Participants assigned softer loudness ratings for noise on non-alternating verb stems compared to noise on alternating stems (*me* ~~[p]*atoa*~~, ~~[p]*atéa*~~*me* < *me* ~~[β]*atoa*~~, ~~[b]*atéa*~~*me*). Although this difference was significant, it was not particularly large: the mean rating for noise on non-alternating stems was 2.98, while the mean rating for noise on alternating stems was 3.06, as depicted in Fig. 2, right panel. Alternation status did not interact with clitic location, suggesting that the very fact of alternation led to poorer perception of the stem regardless of the specific surface realization of the initial consonant. That is, listeners treated alternating stems with initial fricatives ([β, ð, ɣ] in procliticized stems) and initial stops ([b, d, g] in encliticized stems) in an equivalent manner, although such a null finding should be interpreted with caution.

These results have the potential to shed light on the typological differences between prefixed and suffixed words, with particular relevance to the Alternation Asymmetry, which is the generalization that prefixes rarely trigger progressive phonological alternations on the following root (Hyman, 2008). As discussed in the Introduction, the OT concept of positional faithfulness can model this pattern by preventing alternations in root-initial position. Although perceptual grounding is not a strict prerequisite for this concept (e.g. Becker et al., 2012), such grounding nevertheless remains a desirable goal, and many previous proposals have implied that alternations are banned in these positions precisely because they are detrimental to perception (e.g. Beckman, 1997; Casali, 1997). The current results provide evidence that this could indeed be the case.

Why, however, do our results indicate that alternations interfere with perception, when previous results have indicated that they do not (Coenen et al., 2001; Gaskell and Marslen-Wilson, 1996; Gow, 2001; Gow and Im, 2004; Snoeren et al., 2008)? There are several possible reasons. One is that most previous studies have focused primarily on regressive alternations (e.g., /np/ → [mb]) while the current experiment focused on progressive alternations (e.g., /eb/ → [eβ]). As Gow (2001) and others have pointed out, regressive alternations have predictive value that may enhance perception: upon hearing [m], for example, the listener may predict that the next consonant will also be labial. Progressive alternations lack this advantage. A second possible reason for the conflicting results is that previous studies have focused primarily on word-final position (English: *gree*[m] *beans*) while the current experiment focused on word-initial position (Spanish: *me* [β]*atea*). Because segments in word-final position play a less important role in word recognition compared to segments in word-initial position (Grosjean, 1980; Marslen-Wilson, 1984, 1987; Marslen-Wilson and Welsh, 1978; Marslen-Wilson and Zwitserlood, 1989; Nooteboom, 1981, and many others), the perceptual consequences of alternations may differ for final versus initial positions. Indeed, one previous study (Coenen et al., 2001) that did include progressive assimilation in word-initial positions (German /hab not/ → [hab mot]) reported that such alternations can interfere with perception, as we found here. A third possible reason is that the Spanish alternations examined here are structure-changing, producing surface consonants [β, ð, ɣ] that are not part of the underlying inventory, while many previously-studed alternations are structure-preserving, producing surface consonants (e.g. English word-final [m, ŋ]) that are part of the underlying inventory.

A deeper and potentially more interesting difference between previous research and the current study concerns the experimental task. Previous researchers primarily used phoneme monitoring tasks (did you hear the target sound?) or primed lexical decision tasks (is this a word or non-word?), which probe listeners for either basic detection of a stimulus or a meta-linguistic judgment, and report accuracy and reaction times. These tasks align with the research goal of characterizing activation – that is, understanding which stimuli cause greater or lesser activation of underlying lexical representations. By contrast, the current experiment used a noise-rating task, which probes listeners for a subjective judgment and reports a rating on a scale from 1 to 5. This task aligns with a different goal, which is to characterize the subjective experiences that people have when listening to different types of words – that is, to determine the circumstances under which listeners experience relatively good perception, or relatively poor perception. As pointed out in the introduction, subjective perception and activation need not go hand-in-hand: the subjective experience underlying equally accurate or equally fast results may differ (Jacoby et al., 1988). Thus, it is possible that alternating words provide a poor perceptual experience, as suggested by the current results, but that this experience is not poor enough – or not of the right kind – to interfere with lexical activation, as suggested by reaction time studies.

4.4. The role of stress placement

A reviewer points out that in our stimuli, clitic position correlates with stress position, and asks whether this could potentially account for the asymmetric results we report for noise on verb stems. Specifically, procliticized stimuli always exhibited stress on the penultimate syllable (*me patea* [me pa'tea], *se me pisa* [se me 'pisa]) while the encliticized stimuli exhibited stress on either the second or first syllable (*patéame* [pa'tea me], *písamelo* ['pisa me lo]). In Spanish verbs without clitics, stress placement occurs only on penultimate or ultimate syllables: for example, *pateo* [pa'teo] 'kick.1sg. Present' and *pateó* [pate'o] 'kick.3sg.Preterit' are both attested, but hypothetical *['pateo] is not. If stimuli conforming to this canonical pattern are more perceptually salient, the reviewer suggests, then the lower ratings that participants assigned to noise on procliticized stems could potentially be due to canonical stress, rather than to morphological structure.

Such a scenario, however, seems unlikely. While a few studies have reported that Spanish speakers are indeed sensitive to canonical stress patterns – for example, they consistently assign penultimate stress to nonsense stimuli such as *beloga* (Face, 2004, 2006 and references cited therein) – these findings concern explicit judgments about stress placement on nonsense words. The current study focuses on a different issue, namely subjective perceptual clarity on real words. For perception of real words, the evidence for sensitivity to canonical stress is largely negative, although unfortunately we must rely on evidence from other languages because, to our knowledge, no study has directly examined this issue in Spanish.

In Italian, canonical stress is penultimate. Colombo (1992) reported faster visual lexical decision times for real words with canonical stress (*buf 'fone*) compared to those with irregular stress (*'canone*), but this effect was limited to low-frequency words. For high-frequency words (*co'lore* vs. *'camera*), no difference was found. Approaching the question from a slightly different angle, Burani and Arduino (2004) report no difference in visual lexical decision for Italian words with different numbers of stress 'neighbors' (number of phonologically-similar words sharing the same stress pattern). Both of the Italian studies use visual stimuli, so their applicability to perception of spoken words remains unclear.

In English, canonical stress is final on verbs, and initial on nouns. Cutler and Clifton (1984) showed that listeners respond to spoken canonical verbs such as *arrive* [ə'ɹaʲv] just as quickly as non-canonical verbs such as *borrow* ['bɑɹoʷ]. Similarly, they respond to spoken canonical nouns such as *apple* ['æpl̩] just as quickly as non-canonical nouns such as *cigar* [sɪ'gɑɹ]. At least two subsequent studies replicate this finding (Arciuli and Cupples, 2003; Davis and Kelly, 1997). Another study (Arciuli and Cupples, 2004) does report an advantage for canonically-stressed words in a gating task. Participants recognized canonical words at earlier gates, as measured in milliseconds from word onset, compared to later gates in non-canonical words. However, no such advantage was evident in error rates, as measured by the accuracy of participants' responses. As Arciuli and Cupples (2004) themselves point out, gating measurements probe behavior in the middle of the word recognition process, while error rates probe behavior after recognition is complete. As such, the negative error rate results are actually more relevant to the current experiment, which also probes behavior after recognition, not during it.

Overall, then, the existing literature offers very little support for the idea that canonically-stressed spoken words are more perceptually clear to listeners. Even if it did, such a finding would not necessarily be relevant to the current experiment. Our complex stimuli all contained multiple morphemes: a third-person present or imperative verb stem, plus one or more clitics. As cited in Section 1.1, a large body of research on English, Spanish, and other languages demonstrates that, during the recognition process, listeners decompose complex words into their constituent morphemes. Thus, words like *me patea* [me pa'tea] and *patéame* [pa'tea me] would decompose into at least two constituents, *patea* [pa 'tea] and *me* [me]. In assessing the role of stress during the perception of procliticized versus encliticized stems, then, the relevant constituent would likely be the individual stem itself (i.e., an isolated *patea* [pa'tea]), not the entire cliticized form. Crucially, in our experiment, individual stems contained identical stress patterns across conditions: as the decomposed example makes clear, the stem *patea* [pa'tea] is identical for the procliticized and encliticized stimuli. Furthermore, the stem's stress pattern is always canonical (i.e., penultimate).

Even if one subscribed to a theory in which listeners did not decompose complex words into constituent morphemes, it is still unclear how a notion of ''canonical'' stress, established on the basis of non-cliticized verb stems, could or should apply to fully-cliticized forms. As Hualde (2005: 222, 233) and others have described, Spanish clitics simply do not take primary stress, a point also reflected in the orthographic rule for indicating stress with acute accent marks (*pisa* 'step on', *písalo* 'step on it', *písamelo* 'step on it for me'). For verbs, the domain of stress placement is restricted to the stem, and proclitics and enclitics alike are ignored. Therefore, any judgments that speakers make about primary stress placement in Spanish verbs should logically exclude clitics.

Given that the concept of stress canonicity does not convincingly apply to cliticized words, and given the largely negative evidence for the perceptual role of canonicity in any type of word, we feel comfortable concluding that our asymmetric results for procliticized versus encliticized stems do not originate in stress differences.

4.5. The noise-rating task

The noise-rating task has limitations. In addition to those touched on above, it is possible that participants attended only to the white noise and not to the words themselves, which would negate the effect of the predictor variables besides S/N ratio. We worked to avoid this scenario by giving participants explicit instructions to attend to the words, and also by making the experiment relatively short so as to avoid fatigue. Results, which show significant effects of predictors besides S/N ratio, suggest that this effort succeeded, and are also consistent with previous work demonstrating that loudness ratings for noise overlaid on speech are similar in conditions where participants are asked to recognize or identify the speech content compared to conditions where they are not (Goldinger et al., 1999; Jacoby et al., 1988). It is also possible that participants mistakenly rated the loudness of the speech signal, not the white noise. Again, we worked to avoid this scenario with explicit instructions and practice trials. Results show that participants gave increasingly louder ratings as S/N ratio decreased, strongly suggesting that listeners did indeed rate the loudness of noise, not the speech.

Another issue with the noise-rating task is that acoustic intensity does not remain constant across a single spoken word, but can fluctuate. As Table 5 through 7 showed, some morphemes in our stimuli were spoken at a relatively soft intensity compared to others, leading to differences in perceptual experience. During stimulus preparation, we controlled for these natural fluctuations by calculating average intensity separately for each morpheme before adding noise at a particular S/N ratio. Therefore, what remained constant across the +24, +17, and +10 dB S/N ratio conditions was not the actual intensity of the white noise, but the intensity of that noise relative to the particular speech segments that it masked. The disadvantage of this approach is that, within a particular S/N ratio condition, the actual noise intensities could differ somewhat, but the advantage is that the relationship between speech segments and noise remained constant. Given that we were ultimately interested in listeners' assessment of this relationship (i.e., we wanted to know under what conditions the relative clarity of certain speech segments led to the perception of diminished interference by noise), this seemed the appropriate trade-off to make.

In addition to intensity, the morphemes in our stimuli also varied in duration and F0, as shown in Table 5 through 7. We must therefore ask if our results could be due to these acoustic variations, rather than to morphological constituency per se. This is a difficult question to answer because proclitics and enclitics, by definition, occupy specific positions within the word, as do procliticized and encliticized stems; concomitantly, phonetic processes such as final lengthening (Klatt, 1975 and many others), by definition, target specific positions within the word (for an overview, see Lehiste, 1970). As a result, it becomes difficult to disentangle abstract word positions from their concrete acoustic realizations, and it becomes difficult to know if we should even attempt to do so. We could conduct a version of the current experiment using synthesized Spanish speech in which the acoustic characteristics of proclitics and enclitics are rendered equivalent. But it is not clear what the results of such an experiment would tell us. If, for example, enclitics always undergo some degree of final lengthening in natural speech, then neutralizing this effect in an experimental situation would seem to remove a set of acoustic cues that listeners probably use during everyday perception (Salverda et al., 2003). In the current experiment, we opted to use natural speech, such that each stimulus morpheme had an ecologically valid acoustic realization; future experiments may attempt to quantify the distinct contributions of various factors, both acoustic and abstract, that contribute to the perception of a given morpheme.

An important goal for future work will be to demonstrate effects similar to those we report here, but with different experimental tasks. One variation would be to use a different type of noise, such as ''cocktail party'' noise consisting of overlapping, indistinct voices that differ from target speech. Another variation would be to use a completely different type of interference that does not involve noise at all, such as reduced spectral structure (see Nooteboom and Van der Vlugt, 1988) or softer amplitude. Such investigations would operate under the same assumption that we have used in the current study, namely that listeners mis-attribute perceptual clarity to a reduction in interference, but they would crucially alter the psycho-acoustic principles that are operative with white noise, freeing us from some of the caveats mentioned above. One methodological challenge with such experiments concerns the task instructions: while it is a straightforward matter for participants to ''listen to the noise'' overlaid on a specific morpheme, it is less clear how we would instruct them to ''listen to the reduced spectral structure.'' Once this challenge is overcome, the hypothesis would be similar to that pursued in the current study: namely, that listeners will assign ratings to the interference – whether noise, reduced spectral structure, or reduced amplitude – in a manner which suggests that certain spoken morphemes are perceived differently than others.

Another experimental approach would be to examine subjective experience in a manner that does not involve interference. For example, Witherspoon and Allan (1985) presented participants with printed words, either previously-read or new, at varying presentation durations. The participants then estimated how long each word had remained on the screen, and results showed that they gave shorter estimates for old (previously-read) words compared to new words. Thus, prior exposure acted as a cognitive variable that influenced people's subjective experience of presentation duration (and, by extension, of word clarity). We could potentially use this duration-estimation task to ask whether morphological constituency also acts as a variable that influences people's experience of presentation duration (and, by extension, of morpheme clarity). One methodological challenge concerns the adaptation of this task to spoken words, where the effects of presentation duration are very different than they are with printed words. Once this challenge is overcome, the hypothesis would be that listeners will estimate duration in a manner which suggests, again, that certain spoken morphemes are perceived differently than others.

4.6. The role of linear order

Overall, the results of the current study provide some support for the idea that morphological structure could act as a cognitive variable which influences listeners' subjective perceptions of words, although the extent to which morphological structure reduces to effects of linear order remains unsettled. If we follow the logic of the noise-rating task as laid out by Jacoby et al. (1988) and Goldinger et al. (1999) – namely, listeners will mis-attribute relative perceptual clarity to differences in noise level – then the current study suggests that certain morphemes provide more perceptual clarity than others. Specifically, our results suggest that enclitics provide more perceptual clarity than proclitics, even when the segmental content and meaning of the clitic remains the same. Furthermore, our results suggest that procliticized verb stems provide more perceptual clarity than encliticized verb stems, again, even when segmental content and (most of the) meaning of the verb remains the same.

It is possible, however, to re-state the gist of these results in a way that does not make reference to morphemes: early elements in a word (proclitics and encliticized stems) provide less perceptual clarity than later elements (enclitics and procliticized stems). Previous research into word recognition offers a simple logic to underlie this statement. Cohort theory (Marslen-Wilson and Welsh, 1978), for example, argues convincingly that early segments drive recognition. Upon hearing a fragment of speech such as [slæn], all of the words whose initial phonemes match this fragment, such as *slant* and *slander*, get activated and form a cohort. Candidates get de-activated, and eliminated from the cohort, as soon as mis-matching information from the speech stream arrives, ultimately leading to recognition of a single word. Thus, hearing [slæn] followed by [d] eliminates *slant*, leaving only *slander*; as this example demonstrates, we can often recognize entire words based only on their initial segments. Although developed for monomorphemic words, this basic outline of Cohort theory seems to fit with the linear-order interpretation of the current results. Early elements, whether proclitics or encliticized stems, seem relatively unclear because the listener does not yet know what they are hearing, and is actively engaged in the early steps of recognition. By contrast, later elements, whether enclitics or procliticized stems, seem relatively clear because the listener has established a good prediction about what they are hearing, and may even have concluded the process of recognition.

Some aspects of the current study support the linear order interpretation, but others do not. As noted above, listeners generally gave louder ratings to noise occurring on early elements versus noise on later elements, and gave similar ratings to noise on complex versus simple words, results which suggest no need to appeal to morphemes per se. Yet other observations mitigate against this interpretation. For example, the linear order account predicts an interaction between noise location (early versus late in the word) and signal-to-noise ratio that is not borne out in the statistical analysis. As S/N ratio decreases, the overlaid noise becomes louder and it becomes more difficult to understand the underlying speech. If early segments play a more important role in recognition than later segments, decreases in S/N ratio should disproportionately affect listeners' ratings of noise on early elements. But the results do not reveal such a finding; changes to S/N ratio affected both early and late elements in an equivalent manner, although this null result should be interpreted with caution.

Furthermore, the linear account also relies upon the greater predictability of later elements, given the early elements: once the listener has identified the early element [slæn], for example, she can narrow her predictions for the later element to [t] (*slant*) or [dɚ] (*slander*). But the Spanish pronouns and verbs used in the current study do not fit into this scenario. For example, for a procliticized verb stem such as *me patea*, once the listener identifies an early element *me*, this does not lead to any prediction about the verb that follows. It could be any transitive verb, and – given that we constructed the stimuli such that derived forms such as *me patea* were always less frequent than isolated forms such as *patea* – a verb form such as *voy* [boi] or *gusta* [ˈgusta] is more strongly predicted than *patea*, because these verbs occur in frequently-used derived forms like *me voy* [me βoi] 'I'm going' and *me gusta* [me ˈɣusta] 'I like (it)'. Finally, as discussed above, the current study indicates that listeners responded similarly to noise on early proclitics (*~~me~~ patea*) and noise on later proclitics (*se ~~me~~ pisa*), a result that is unexpected under the linear ordering account because the two stimulus types differ with respect to the clitic's position relative to word onset. Future research, some proposals for which we sketched above, is necessary to more fully test the hypothesis that proclitics and prefixes, as well as enclitics and suffixes, possess a morphological status that is independent of their position relative to word edge.

4.7. Implications of subjective perception research for morphology

If future work on other languages, and with different experimental tasks, supports the idea that morphological structure affects subjective perception, these findings could help us better understand why prefixes and suffixes differ in the ways that they do. For example, as we pointed out in the introduction, prefixing morphology occurs far less frequently in languages of the world than does suffixing morphology. Hawkins and Cutler (1988) made an interesting case that the origins of this pattern lie in speech processing. Because suffixed words align the crucial semantic information of the root with the prominent perceptual position of word onset, they argued, such words are easier for listeners to process and therefore more favored. Although we agree that speech processing offers a promising way to approach the typological differences between prefixes and suffixes, our results suggest a very different scenario. To begin with, the current study suggests that it is procliticized/prefixed stems which are perceived with more clarity, a finding at odds with Hawkins & Cutler's proposal but completely in line with previous experimental results (Schriefers et al., 1991; Marslen-Wilson et al., 1994; Feldman and Larabee, 2001). Furthermore, the current study also suggests that proclitics/prefixes themselves are perceived relatively poorly compared to enclitics/suffixes, which leads to a much simpler explanation – if prefixes are difficult to perceive, they are vulnerable to diachronic loss.

Prefixes and suffixes also differ in phonological behavior, with prefixes exhibiting an Alternation Asymmetry. That is, cross-linguistically, root-suffix combinations exhibit alternations in both directions, but prefix-root combinations tend to exhibit alternations in just a single direction, regressively from root to prefix. Alternations occurring in the opposite direction, namely progressively from prefix to root, are rare. The current study suggests that this asymmetry may have a perceptual underpinning, because surface alternations create poor perception in root-initial positions. As tested here, however, this underpinning only applies to local processes: it suggests that, for example, a local progressive assimilation such as *off-beat* → *off*-[p]*eat* might be disfavored. But recall that the Alternation Asymmetry applies more broadly. Long-distance processes such as vowel harmony (Walker, 2011) and consonant harmony (Hansson, 2001) also resist progressive alternations from prefix to root. Why should this be the case?

As proposed by Ohala (1993) and others (Beddor, 2009; Blevins, 2004; Yu, 2010, 2013), one way to approach such a problem – that is, to understand why some phonological patterns occur frequently while others do not – is to analyze the conditions under which listeners are likely to misinterpret what the speaker intends to say, because these conditions can lead to phonologization over time. Ohala (1993) and others develop the logic of ''misinterpretation'' and apply it to situations in which listeners must interpret context-induced variation in the speech stream. Yu (2010) uses the straightforward example of voiceless sibilants in English: when the consonant /s/ occurs in the context of the vowel [u], as in the word *sue*, speakers tend to pronounce it more like [ʃ]. Listeners must then interpret this variation between [s] and [ʃ], and there are two basic strategies for doing so. They can attend to the surface details of the consonant, attributing the variation to the consonant itself, a scenario that can potentially lead to reanalysis of /s/ as underlying /ʃ/. Or they can attend to the surface details of the vowel, attributing the variation to the vowel, a scenario that can lead to phonologization of the rule whereby /s/ alternates to [ʃ] before [u]. As Yu (2010) shows, different people exhibit different biases toward one scenario or the other.

If we extend this logic to complex words with multiple morphemes, we might say that different morphemes introduce different biases toward one scenario or the other. Suppose, for example, that /s/ and /u/ straddle a prefix-root boundary, $[\ldots s]_{\text{Prefix}}$ – $[u\ldots]_{\text{Root.}}$ If prefixes are perceptually unclear, as the current results suggest, then listeners may be biased to ignore the surface [s]$\sim$[ʃ] variation, which is contained within the prefix. Furthermore, if prefixed roots are perceptually clear, again as the current results suggest, listeners may be biased to attend carefully to the surface [u], which is contained within the root. This is a scenario which could lead to phonologization of the rule whereby /s/ alternates to [ʃ] before [u], a well-attested pattern in which a root triggers a regressive alternation on a prefix. The opposite scenario, in which listeners are biased to attend to surface [s]$\sim$[ʃ], is less likely because the varying segments occur in the perceptually unclear prefix. Morpheme-level perceptual conditions could thus mitigate against the development of alternations in which prefixes trigger alternations on roots. Furthermore, because we are characterizing the perceptual conditions created not just by a single consonant or vowel, but by an entire morpheme type, this logic can potentially expand beyond local alternations to encompass the long-distance alternations that also participate in the Alternation Asymmetry, such as vowel harmony and consonant harmony.

The current experiment represents one step in an ongoing effort to flesh out such speculations, and to characterize the processing and perceptual biases that might underlie broader typological patterns in morphology. In this research effort, the focus on subjective experience of the listener offers a key advantage. Accuracy and reaction times, while useful in their own right, can mask underlying differences in subjective perception. Yet, in examining the potential origins of cross-linguistic patterns, it is precisely these subjective differences that we are most interested in.

Acknowledgments

I thank Alison Garcia for her excellent research assistance with this project, and I thank her extended family members for their Spanish language judgments. I thank Gabriela Caballero and Raúl Aranovich for their Spanish language expertise, Blanca Rosa Romero Ruhss for recording the stimuli, and Sandra Pucci for help in recruiting participants. For feedback on the development of these ideas, I thank Christian DiCanio, Andrew Garrett, Sharon Inkelas, Keith Johnson, John Kingston, Jenny Lederer, Hanyong Park, Jae Yung Song, Kari Whittenberger-Keith, Suzanne van der Feest, and Alan Yu, as well as audiences at the University of Wisconsin, Milwaukee, University of Wisconsin, Madison, University of Chicago, the Mid-Phon 18 Conference, the 2013 International Congress on Acoustics, the 40th Annual Meeting of the Berkeley Linguistic Society, the 16th International Morphology Meeting, and the 14th Conference on Laboratory Phonology. I thank three anonymous reviewers for comments that helped me to significantly improve the paper. Flaws are mine. The University of Wisconsin, Milwaukee provided financial support for this research.

Appendix A. Verb stems used in complex stimuli

Spanish verb stems occurred in either the third person singular present or the imperative, which were always phonologically identical.

Three syllables		Two syllables	
Stem	Gloss	Stem	Gloss
patea [pa'tea]	'kick'	*para* ['para]	'stop'
perdona [per'ðona]	'forgive'	*pica* ['pika]	'prick'
permite [per'mite]	'permit'	*pisa* ['pisa]	'step on'
baraja [ba'raha]	'shuffle'	*baja* ['baha]	'lower'
batea [ba'tea]	'hit with a bat'	*borra* ['bora]	'erase'
bautiza [bau'tisa]	'baptize'	*busca* ['buska]	'seek'
tantea [tan'tea]	'try'	*talla* ['taʎa]	'carve'
termina [ter'mina]	'finish'	*tapa* ['tapa]	'cover'
tolera [to'lera]	'tolerate'	*tasa* ['tasa]	'measure'
decide [de'siðe]	'decide'	*daña* ['daɲa]	'damage'
declara [de'klara]	'declare'	*dobla* ['doβla]	'bend'
define [de'fine]	'define'	*dona* ['dona]	'donate'
castiga [kas'tiɣa]	'punish'	*cura* ['kora]	'cure'[3]
corteja [kor'teha]	'court, woo'	*quema* ['kema]	'burn'
cultiva [kul'tiβa]	'cultivate'	*quita* ['kita]	'remove'
garante [ga'rante]	'guarantee'	*gana* ['gana]	'win'
golpea [gol'pea]	'hit'	*gasta* ['gasta]	'spend'
gradua [gra'ðua]	'graduate'	*guarda* ['gwarða]	'guard'

[3] Our speaker lowered [u] to [o] before liquids. Therefore, although the canonical pronuncation of *cura* 'cure' contains a high back vowel [u], our speaker pronounced it with [o]. The effect of this rule can also be seen in two other transcriptions in Appendix B, namley [disi'mola] 'he/she/it hides' and [deam'bolas] 'you wander'.

Appendix B. Simplex stimuli with pseudo-clitics

Pseudo-Procliticized		Pseudo-Procliticized	
Word	Gloss	Word	Gloss
mecanismo [mekaˈnismo]	‘mechanism’	*uniforme* [uniˈforme]	‘uniform (adj).’
mejoraba [mehoˈraβa]	‘he/she/it was improving’	*reprograme* [reproˈɣrame]	‘he/she/it reprograms-SUBJUNCTIVE’
mecanógrafo [mekaˈnoɣrafo]	‘typist’		
tesorero [tesoˈrero]	‘treasure’	*compromete* [komproˈmete]	‘he/she/it compromises’
televisa [teleˈβisa]	‘he/she/it televizes’	*acertante* [aserˈtante]	‘winning’
tecleado [tekleˈaðo]	‘typing’		
logreaba [loɣreˈaβa]	‘s/he was lending money’	*cocodrilo* [kokoˈðrilo]	‘crocodile’
locomoción [lokomoˈsjon]	‘locomotion’	*apuñalo* [aˈpuɲalo]	‘I stab’[4]
logarítmo [loɣaˈriðmo]	‘logarithm’		
lamentaba [lamenˈtaβa]	‘he/she was sorry	*camomila* [kamoˈmila]	‘chamomile’
lapicero [lapiˈsero]	‘mechanical pencil’	*disimula* [disiˈmola]	‘he/she/it hides’
laminado [lamiˈnaðo]	‘laminated’		
nostalgia [nostalˈhia]	‘nostalgia’	*mexicanos* [mehiˈkanos]	‘mexicans’
nociones [nosiˈones]	‘notions’	*artesanos* [arteˈsanos]	‘artisans’
nostradamus [nostraˈðamus]	‘nostradamus’		
lociones [loˈsiones]	‘lotions’	*gladiolos* [glaðiˈolos]	‘gladiolas’
		hoyuelos [ojuˈelos]	‘dimples’
lascivia [lasiˈβia]	‘lewdness’	*cabriolas* [kabriˈolas]	‘skips, prances’
lastimaba [lastiˈmaβa]	‘he/she was hurting’	*deambulas* [deamˈbolas]	‘you wander’

References

Agresti, A., 2010. Analysis of Ordinal Categorical Data, 2nd ed. Wiley.

Agresti, A., 2011. Examples of using R for modeling ordinal data. Suppl. Agresti 2010 .

Allen, M., Badecker, W.B., 2002. Stem homographs and lemma level representations. Brain Lang. 81, 79–88.

Álvarez, C.J., Urrutia, M., Domínguez, A., Sánchez-Casas, R., 2011. Processing inflectional and derivational morphology: electrophysiological evidence from Spanish. Neurosci. Lett. 490 (1), 6–10.

Anderson, S.R., 2005. Aspects of the Theory of Clitics. Oxford University Press, Oxford.

Arciuli, J., Cupples, L., 2003. Effects of stress typicality during speeded grammatical classification. Lang. Speech 46 (4), 353–374.

Arciuli, J., Cupples, L., 2004. Effects of stress typicality during spoken word recognition by native and nonnative speakers of English: evidence from onset gating. Mem. Cognit. 32 (1), 21–30.

Barr, D.J., Levy, R., Scheepers, C., Tily, H.J., 2013. Random effects structure for confirmatory hypothesis testing: keep it maximal. J. Mem. Lang. 68, 255–278.

Becker, M., Nevins, A., Levine, J., 2012. Asymmetries in generalizing alternations to and from initial syllables. Language 88 (2), 231–268.

Beckman, J.N., 1997. Positional faithfulness, positional neutralisation and Shona vowel harmony. Phonology 14 (01), 1–46.

Beddor, P.S., 2009. A coarticulatory path to sound change. Language 85 (4), 785–821.

[4] Although the canonical pronunciation of present-tense Spanish verbs uses penultimate stress (Hualde, 2005:229), our speaker (mis-)pronounced this word with antepenultimate stress.

Beyersmann, Elisabeth, et al., 2013. Early morphological decomposition of suffixed words: masked priming evidence with transposed-letter nonword primes. Appl. Psycholinguist. 34 (05), 869–892.
Blevins, J., 2004. Evolutionary Phonology: The Emergence of Sound Patterns. Cambridge University Press.
Boersma, P., Weenink, D., 2012. Praat: doing phonetics by computer, Version 5.3.29. http://www.praat.org/ (accessed November 2012).
Bregman, A.S., 1978. Auditory streaming: competition among alternative organizations. Percept. Psychophys. 23 (5), 391–398.
Bregman, A.S., 1994. Auditory Scene Analysis: The Perceptual Organization of Sound. MIT Press, Cambridge, MA.
Burani, C., Arduino, L.S., 2004. Stress regularity or consistency? Reading aloud Italian polysyllables with different stress patterns. Brain Lang. 90 (1), 318–325.
Butt, J., Benjamin, C., 2013. A New Reference Grammar of Modern Spanish Routledge (Chapter 26).
Caramazza, A., Laudanna, A., Romani, C., 1988. Lexical access and inflectional morphology. Cognition 28 (3), 297–332.
Casali, R.F., 1997. Vowel elision in hiatus contexts: which vowel goes? Language 73 (3), 493–533.
Christensen, R.H.B., 2013. Ordinal: regression models for ordinal data. Available at: http://cran.r-project-org/package=ordinal
Coenen, E., Zwitserlood, P., Bölte, J., 2001. Variation and assimilation in German: consequences for lexical access and representation. Lang. Cognit. Process. 16 (5–6), 535–564.
Colé, P., Beauvillain, C., Segui, J., 1989. On the representation and processing of prefixed and suffixed derived words: A differential frequency effect. J. Mem. Lang. 28 (1), 1–13.
Colombo, L., 1992. Lexical stress effect and its interaction with frequency in word pronunciation. J. Exp. Psychol. Hum. Percept. Perform. 18 (4), 987.
Cuetos, Vega F., González, Nosti M., Barbón, Gutiérrez A., Brysbaert, M., 2011. SUBTLEX-ESP: Spanish word frequencies based on film subtitles. Psicológica 32 (2), 133–143.
Cutler, A., Clifton, C.E., 1984. The use of prosodic information in word recognition. In: Bouma, H., Bouwhuis, D.G. (Eds.), Attention and Performance X: Control of Language Processes. Erlbaum, Hillsdale, NJ, pp. 183–196.
Cutler, A., Hawkins, J.A., Gilligan, G., 1985. The suffixing preference: a processing explanation. Linguistics 23 (5), 723–758.
Darwin, C.J., 1984. Perceiving vowels in the presence of another sound: constraints on formant perception. J. Acoust. Soc. Am. 76, 1636.
Davies, Mark, 2002. Corpus del Español: 100 million words, 1200s–1900. Available at: http://www.corpusdelespanol.org
Davis, S.M., Kelly, M.H., 1997. Knowledge of the English noun–verb stress difference by native and nonnative speakers. J. Mem. Lang. 36 (3), 445–460.
Domínguez, A., Cuetos, F., Segui, J., 2000. Morphological processing in word recognition: a review with particular reference to Spanish data. Psicológica 21 (2), 375–401.
Domínguez, A., Segui, J., Cuetos, F., 2002. The time-course of inflexional morphological priming. Linguistics 40 (2), 235–260.
Domínguez, A., Alija, M., Cuetos, F., de Vega, M., 2006. Event related potentials reveal differences between morphological (prefixes) and phonological (syllables) processing of words. Neurosci. Lett. 408 (1), 10–15.
Domínguez, A., Alija, M., Rodriguez-Ferreiro, J., Cuetos, F., 2010. The contribution of prefixes to morphological processing of Spanish words. Eur. J. Cognit. Psychol. 22 (4), 569–595.
Dryer, M.S., 2013. Prefixing vs. suffixing in inflectional morphology. In: Dryer, M.S., Haspelmath, M. (Eds.), The World Atlas of Language Structures Online. Max Planck Institute for Evolutionary Anthropology, Leipzig. Available at: http://wals.info
Face, T.L., 2002. Re-examining Spanish resyllabification. Amsterdam studies in the theory and history of linguistic science series 4, pp. 81–94.
Face, T.L., 2004. Perceiving what isn't there: non-acoustic cues for perceiving Spanish stress. In: Face, T.L. (Ed.), Laboratory Approaches to Spanish Phonology. Mouton de Gruyter, New York, pp. 117–141.
Face, T.L., 2006. Cognitive factors in the perception of Spanish stress placement: implications for a model of speech perception. Linguistics 44 (6), 1237–1267.
Feldman, L.B., Larabee, J., 2001. Morphological facilitation following prefixed but not suffixed primes: lexical architecture or modality-specific processes? J. Exp. Psychol. Hum. Percept. Perform. 27 (3), 680.
Fowler, C.A., Napps, S.E., Feldman, L., 1985. Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. Mem. Cognit. 13 (3), 241–255.
Franco, J., 2013. The morphological, syntactic and semantic agreement status of Spanish object clitics. Anuario del Seminario de Filología Vasca' Julio de Urquijo'' 28 (3), 707–789.
Gaskell, M.G., Marslen-Wilson, W.D., 1996. Phonological variation and inference in lexical access. J. Exp. Psychol. Hum. Percept. Perform. 22 (1), 144.
Goldinger, S.D., Kleider, H.M., Shelley, E., 1999. The marriage of perception and memory: creating two-way illusions with words and voices. Mem. Cognit. 27 (2), 328–338.
Gow Jr., D.W., 2001. Assimilation and anticipation in continuous spoken word recognition. J. Mem. Lang. 45 (1), 133–159.
Gow Jr., D.W., Im, A.M., 2004. A cross-linguistic examination of assimilation context effects. J. Mem. Lang. 51 (2), 279–296.
Grosjean, F., 1980. Spoken word recognition processes and the gating paradigm. Percept. Psychophys. 28 (4), 267–283.
Hansson, G.Ó., 2001. Theoretical and typological issues in consonant harmony (Doctoral dissertation). University of California, Berkeley.
Harris, J.W., 1983. Syllable Structure and Stress in Spanish. MIT Press, Cambridge, MA.
Hawkins, J.A., Cutler, A., 1988. Psycholinguistic factors in morphological asymmetry. In: Hawkins, J.A. (Ed.), Explaining Language Universals. Basil Blackwell, Oxford, pp. 280–317.
Hawkins, J.A., Gilligan, G., 1988. Prefixing and suffixing universals in relation to basic word order. Lingua 74 (2), 219–259.
Hay, J., 2001. Lexical frequency in morphology: is everything relative? Linguistics 39 (6), 1041–1107.
Hay, J., 2003. Causes and Consequences of Word Structure. Routledge, New York.
Hay, J., Baayen, H., 2002. Parsing and productivity. Yearb. Morphol. 2001, 203–235.
Himmelmann, N.P., 2014. Asymmetries in the prosodic phrasing of function words: another look at the suffixing preference. Language 90 (4), 927–960.
Hualde, J.I., 2005. The Sounds of Spanish. Cambridge University Press.

Hualde, J.I., 2012. Stress and rhythm. In: Hualde, J.I., Olarrea, A., O'Rourke, E. (Eds.), The Handbook of Hispanic Linguistics, vol. 69. Wiley, pp. 153–172.

Hyman, L.M., 2008. Directional asymmetries in the morphology and phonology of words, with special reference to Bantu. Linguistics 46 (2), 309–350.

Hyman, L.M., Katamba, F.X., 1999. The syllable in Luganda phonology and morphology. Syllable 45, 349.

Jacoby, L.L., Allan, L.G., Collins, J.C., Larwill, L.K., 1988. Memory influences subjective experience: noise judgments. J. Exp. Psychol. Hum. Percept. Perform. 14 (2), 240.

Kayne, R., 1975. French Syntax: The Transformational Cycle. MIT Press, Cambridge, MA.

Klatt, D.H., 1975. Vowel lengthening is syntactically determined in a connected discourse. J. Phonet. 3 (3), 129–140.

Laudanna, A., Burani, C., 2013. Distributional properties of derivational affixes: implications for processing. Morphol. Asp. Lang. Process. 345.

Lehiste, I., 1970. Suprasegmentals. MIT Press, Cambridge, MA.

López-Villaseñor, M.L., 2012. The effects of base frequency and affix productivity in Spanish. Span. J. Psychol. 15 (02), 505–512.

Marslen-Wilson, W.D., 1984. Function and process in spoken word-recognition. In: Bouma, H., Bouwhuis, D.G. (Eds.), Attention and Performance X: Control of Language Processes. Erlbaum, Hillsdale, NJ.

Marslen-Wilson, W.D., 1987. Functional parallelism in spoken word-recognition. Cognition 25 (1–2), 71–102.

Marslen-Wilson, W.D., Welsh, A., 1978. Processing interactions and lexical access during word recognition in continuous speech. Cognit. Psychol. 10 (1), 29–63.

Marslen-Wilson, W., Zwitserlood, P., 1989. Accessing spoken words: the importance of word onsets. J. Exp. Psychol. Hum. Percept. Perform. 15 (3), 576.

Marslen-Wilson, W., Tyler, L.K., Waksler, R., Older, L., 1994. Morphology and meaning in the English mental lexicon. Psychol. Rev. 101 (1), 3.

McCarthy, J.J., Prince, A., 1995. Faithfulness and reduplicative identity. In: Beckman, J., Walsh Dickey, L., Urbanczyk, S. (Eds.), Papers in Optimality theory. Graduate Linguistic Student Association, Amherst, MA, pp. 249–384.

Nooteboom, S.G., 1981. Lexical retrieval from fragments of spoken words: beginnings vs. endings. J. Phonet. 9 (4), 407–424.

Nooteboom, S.G., Van der Vlugt, M.J., 1988. A search for a word-beginning superiority effect. J. Acoust. Soc. Am. 84, 2018.

Ohala, J.J., 1993. The phonetics of sound change. In: Charles Jones (Eds.), Historical Linguistics: Problems and Perspectives. Longman, London, pp. 237–278.

Plichta, B., 2012. Akustyk, Version 1.9.3. http://bartus.org/akustyk/index.php (accessed November 2012).

Rasch, R.A., 1978. The perception of simultaneous notes such as in polyphonic music. Acta Acust. Unit. Acust. 40 (1), 21–33.

Rizzi, L., 1986. On chain formation. In: Borer, H. (Ed.), Syntax and Semantics 19 The Syntax of Pronominal Clitics. Academic Press, Orlando, pp. 65–95.

Salverda, A.P., Dahan, D., McQueen, J.M., 2003. The role of prosodic boundaries in the resolution of lexical embedding in speech comprehension. Cognition 90 (1), 51–89.

Sánchez-Casas, R., Igoa, J.M., García-Albea, J.E., 2003. On the representation of inflections and derivations: data from Spanish. J. Psycholinguist. Res. 32 (6), 621–668.

Schriefers, H., Zwitserlood, P., Roelofs, A., 1991. The identification of morphologically complex spoken words: continuous processing or decomposition? J. Mem. Lang. 30 (1), 26–47.

Selkirk, E., 1996. The prosodic structure of function words. Signal to syntax: Bootstrapping from speech to grammar in early acquisition, 187. pp. 214–267.

Snoeren, N.D., Segui, J., Hallé, P.A., 2008. Perceptual processing of partially and fully assimilated words in French. J. Exp. Psychol. Hum. Percept. Perform. 34 (1), 193–204.

Stanners, R.F., Neiser, J.J., Hernon, W.P., Hall, R., 1979. Memory representation for morphologically related words. J. Verb. Learn. Verb. Behav. 18 (4), 399–412.

Taft, M., Forster, K.I., 1975. Lexical storage and retrieval of prefixed words. J. Verb. Learn. Verb. Behav. 14 (6), 638–647.

Tyler, L.K., Marslen-Wilson, W., Rentoul, J., Hanney, P., 1988. Continuous and discontinuous access in spoken word-recognition: the role of derivational prefixes. J. Mem. Lang. 27 (4), 368–381.

Walker, R., 2011. Vowel Patterns in Language. Cambridge University Press.

Witherspoon, D., Allan, L.G., 1985. The effect of a prior presentation on temporal judgments in a perceptual identification task. Mem. Cognit. 13 (2), 101–111.

Yu, Alan C.L., 2010. Perceptual compensation is correlated with individuals' ''autistic'' traits: implications for models of sound change. PLoS ONE 5 (8), e11950.

Yu, A.C.L. (Ed.), 2013. Origins of Sound Change: Approaches to Phonologization. Oxford University Press.