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RESEARCH ARTICLE

Processing and production of affixes in Georgian and English: Testing a processing account of the suffixing preference

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Abstract
The hypothesis that affixes following a stem are easier to process than ones preceding has not been tested in a straightforward manner in any language, as far as we know. Cutler, Hawkins & Gilligan (1985) and Hawkins & Cutler (1988) adduce some evidence that supports this hypothesis indirectly, but they do not conduct experiments to test it directly. They use this hypothesis to explain in part the suffixing preference. Some others, such as Asao (2015), continue to assume the correctness of the hypothesis. We do not aim to explain the suffixing preference at all but to test the hypothesis that affixes preceding the stem (informally, prefixes) disrupt the comprehension of a word more than affixes that follow (informally, suffixes) do. In this paper we test this hypothesis (henceforth the 'Cutler--Hawkins hypothesis') on Georgian, because it has a wide variety of prefixes and suffixes, and in a single experiment on English. In Georgian we test a prefix and a suffix that mark the person of the subject in a verb, a circumfix and a suffix that mark derivation in nouns, and a prefix and a suffix that form intransitive verbs (usually called 'passives' in Georgian). Across the set of experiments, we find little support for the Cutler--Hawkins hypothesis.

1. Introduction

It has long been known that more languages have suffixes than prefixes, and that languages that have both use suffixes more (Greenberg 1957, 1963). This is known as the 'suffixing preference', and Cutler, Hawkins & Gilligan (1985), Hawkins & Cutler (1988), and Hawkins & Gilligan (1988) propose to explain it in part in terms of research showing that spoken word recognition relies most heavily on the beginnings of words, making it advantageous to have nothing preceding the stem. These authors propose the hypothesis that affixes following the stem are processed more easily than ones preceding it and suggest that this hypothesized cross-linguistic regularity explains the suffixing preference. This hypothesis, however, has not been thoroughly tested.

To understand how complex words are processed, we need to better understand the psycholinguistics of affixes in different positions. Our goals are to analyze the processing and production differences between affixes that precede the base (informally, prefixes) and those that follow the base (informally, suffixes) and to expand the set of languages in which the processing and production of affixes has been studied. We aim to provide a thorough test of part of the Hawkins--Cutler hypothesis, namely that suffixes are easier to process than prefixes.

Siewierska & Bakker (1996), Enrique-Arias (2000, 2002), and Asao (2015) demonstrate that agreement affixes do not show the suffixing preference to the same extent as other morphemes. Because our goal is to learn about the processing and production of prefixes versus suffixes, this interesting observation suggests that we would find more robust results for derivational than for inflectional morphology. We therefore test both in Georgian, where both exist.

Prefixes, unlike suffixes, may give an early cue about the word. For example, if participants in an experiment hear the English prefix *un-* they may expect a verb (like *untie*) or an adjective (like *unhappy*); this onset belongs to very few nouns (e.g. *onion*) or other words (*under*). We will call this 'cuing'. A suffix, such as *-est*, might provide information, but by the time it is heard, the participant will have identified the word; suffixes do not provide cuing. Thus, prefixes have a characteristic, cuing, that suffixes do not share. Whether cuing is an advantage or a disadvantage, it is part of the nature of prefixes. Cuing is a (possible) characteristic of prefixes in any language, and in the work reported here we are trying to learn more about the processing and production of different types of affixes. Although it is important to keep cuing in mind, it is not a property that we should try to avoid, nor is it a confound in the search to understand the differential processing and production of prefixes and suffixes.

2. Literature

Hawkins & Cutler (1988) cite work that shows that the beginnings of words are 'psychologically most salient', the ends less so, and the middles least salient. Nooteboom (1981), working on Dutch, showed that the beginning of a word is more effective in cuing retrieval of the word than is the end. Broerse & Zwaan (1966) and Horowitz, White & Atwood (1968) showed, respectively, that beginnings of Dutch and English words of high frequency trigger better recall from a list than do middles and ends of words. Horowitz, Chilian & Dunnigan (1969) studied this in words of medium and low frequency and showed that the generalization can be extended to all words. Brown & MacNeil (1966) found that participants in a 'tip-of-the-tongue' (TOT) state could often recall the initial consonant (or more generally the beginning of the word), the number of syllables, the position of stress, and the end of the word, noting that suffixes played a role in recall. Thus, investigators have studied which part of a word most effectively cues retrieval and which part of the word is best recalled in TOT states.

Note that all of the sources that Hawkins & Cutler (1988) cite investigated the beginnings of words such as *native*, *simple*, or Dutch *kannibaal* 'cannibal', not prefixes per se, although a few words had suffixes (*fibber, pugnacity* from Horowitz et al. 1969). Generally, the presence of prefixes and suffixes was not controlled for. For example, Browman (1978) was based on naturally occurring TOT examples and included the experimental item *disintegration* beside unanalyzable names. Most of the examples given in Grosjean (1980) have no

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affixes. Many older articles do not list the stimuli. Because these studies have not focused on affixes *per se*, it is an extrapolation to assume that prefixes, for example, share the characteristics listed previously for the beginnings of words.

The importance of the beginning of words in lexical access may depend on the fact that most words in Germanic languages have strong initial syllables (Cutler & Carter 1987, for English). Most of the articles cited by Hawkins & Cutler (1988) are based on experiments on English. Cutler & Norris (1988) show that real words embedded in nonsense are detected more quickly when they have strong syllables followed by weak ones. The importance of word beginnings in access may therefore reflect the stressed-syllable characteristics of English.

Cutler et al. (1985) suggest that the order stem -- suffix reflects the order in which the parts of a word are processed. On the other hand, Friederici, Hahne & Mecklinger (1996), in an EEG (electroencephalogram) study of German using both written and auditory stimuli, found that suffixes are processed before stems when the former encode word-category.

Cutler et al. (1985) observe that the uniqueness point (Marslen-Wilson 1980) plays a role in processing of prefixes and suffixes, apparently providing an advantage to suffixes. The uniqueness point is the point, left to right, at which a word is identifiable. For example, in *pivot*, the uniqueness point is at *v*, as no other word beginning with the sequence *pi* continues with this consonant. In *corrupt*, on the other hand, the uniqueness point comes much later, given the word *corrugated.* Words with prefixes will systematically push the uniqueness point further back in the word, and in principle this will slow recognition of the word.

Bridgers & Kacinik (2017) interpret certain EEG evidence as demonstrating that prefixed words are processed faster than suffixed words, citing mostly Dutch and German. They also point out that other researchers have found that prefixes slow word recognition, and they attribute this to ambiguity due to the short length of prefixes and resemblance to word beginnings that do not include a prefix. Most of the studies cited were of western European languages, but Korean was also included (Kim, Wang & Taft 2015). Of course, neither short length nor resemblance to stems is necessarily found in prefixes in other languages. Bridgers & Kacinik's own results, based on written Italian, support the Cutler--Hawkins hypothesis, finding that suffixes are recognized more rapidly and with greater accuracy than are prefixes.

Hupp, Sloutsky & Culicover (2009) suggest that the suffixing preference is a general cognitive preference for processing temporal sequences with attention to variation at the END of the sequence. They find the same preference in visual and musical domains. Their experiments involving language, run on a population of English speakers, were not language-specific, as they used artificial words. The task was for participants to determine which was more similar to a target -- a sequence that differed at the beginning or one that differed at the end. Martin & Culbertson (2020) replicated these results, using artificial words and shapes with English-speaking participants. They also used the same materials and procedures to conduct the same experiments with a population of speakers of Kîîtharaka, a predominantly prefixing Bantu language, finding attention to variation at the BEGINNING of a sequence in all domains. They conclude that speakers most attend to variation where it most occurs in their native language.

Many studies examining morphological issues, especially since Taft & Forster (1975), have used the visual medium (reading). One robust line of research, usually using priming paradigms, has focused on the manner in which morphologically related words (typically words sharing one morpheme) exert influence on access to each other. For example, Dominguez, Alija, Rodríguez, Ferreiro & Cuetos (2010), examining prefixes in Spanish

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through priming experiments, found that morphology (a prefix) provides access to written words. Beyersmann, Ziegler & Grainger (2015) found that in written words of French, the processing of prefixes is different from that of suffixes. They suggest that prefixes have a more word-like status. Although some other studies such as Grainger, Colé & Segui (1991) explicitly compare prefixes with suffixes, they do not provide information relevant to our questions. Though this line of research addresses the interesting problem of how words influence access to other words, priming does not provide basic information on differences between prefixes and suffixes, such as whether processing or production of one or the other is easier (more accurate or faster).

The dynamics of spoken words (serial presentation in time) and printed words (simultaneous presentation) are fundamentally different. Moreover, spoken language is 'natural' and acquired by essentially all children, whereas reading is a skill that must be taught through years of training. In addition, there is enormous variation across languages in the level of transparency of the mapping between the written and spoken language, with languages like Spanish being relatively transparent, versus languages like English that have much less predictable mappings between orthography and phonology.

Cross-modal priming (e.g. auditory prime for a visual target) may tap into stored word structure without bias toward any single modality (Marslen-Wilson, Tyler, Waksler & Older 1994). Marslen-Wilson et al. (1994), using auditory primes for visual targets (AV), show that response latencies for a suffixed target (e.g. *payment*) were shorter with a prefixed prime (e.g. *prepay*) than with a suffixed prime (e.g. *payable*). Suffixes in both the prime and the target, but not prefixes, can inhibit word recognition. Feldman & Larabee (2001) worked with visual primes for auditory targets (VA) in English, as well as auditory--visual (AV) and visual--visual (VV) protocols, testing whether cross-modal priming really tests modality-neutral lexical structure. They presented prefixed (*prepay*) and suffixed (*payable*) primes, as well as simple primes (*pay*) and unrelated primes. In the AV condition, their results confirmed those of Marslen-Wilson et al. (1994); however, in VA conditions, both facilitation by the prefixed prime and inhibition by the suffixed prime were stronger, relative to the unrelated prime (the control). In the VV condition, all primes facilitated recognition with no significant differences. Thus, failure of suffixed primes to facilitate recognition appears to depend on modality.

3. Problems inadequately addressed in past research

3.1 English only

Nearly all of the work described in Section 2 has been based on English only (with a little work on a handful of European languages that are very similar to English -- Dutch, German, Spanish, French, Italian). There is work on the morphology of Hebrew and other Semitic languages that have root-and-pattern morphology (Frost, Forster & Deutsch 1997; Deutsch, Frost & Forster 1998; Frost, Deutsch, Gilboa, Tannenbaum & Marslen-Wilson 2000). Other exceptions include Finnish (e.g. Bertram, Laine & Carvinen 1999) and Sesotho (Kgolo & Eisenbeiss 2015). For work on the processing of morphology, English has specific problems: English has very simple inflectional morphology, and the overall complexity of words is low compared with that of many other languages. English has no inflectional prefixes and only a few inflectional suffixes. Most affixes in English consist of at least one syllable (*-(e)s* and *-(e)d* are exceptions). English has a huge number of borrowed Latinate words, and consequently

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its vocabulary is divided into two parts (Germanic and Latinate) with very different characteristics (see Pounder 2000). The orthography of English was designed for a different language (Latin); for this reason and because of many changes in English, the spelling of words has a low correlation with pronunciation.

The current study addresses the problems of working only on English by focusing primarily on a language outside the Indo-European family. Georgian is a member of the small Kartvelian family. In contrast to English, Georgian has complex inflectional morphology, and the overall complexity of words is high. Georgian has inflectional prefixes and suffixes as well as derivational prefixes, suffixes, and circumfixes (combining a pre-stem and a post-stem portion). Georgian has affixes that consist of a syllable or more (e.g. *mo-* 'hither', derivational; *i-*, reflexive benefactive; *-es*, third person plural subject; *-eb,* noun pluralizer) as well as affixes that are less than a syllable (e.g. *v-*, first person subject; *-s*, third person singular subject; *-s*, dative case).[1] Although Georgian has borrowed words, it does not have a fundamental split in its vocabulary. The orthography of Georgian was designed for Georgian, and the spelling of words is highly correlated with pronunciation.

3.2. Transferability

Psycholinguists have observed differences in the ways speakers of different languages process a variety of features (e.g. Frost et al. 2000, Martin & Culbertson 2020). The question of whether users of different languages process and/or produce types of affixes differently can only be addressed by studying these issues in a variety of languages. Feldman & Larabee (2001: 689) similarly note the need to study a variety of languages:

> Claims about processing asymmetries between prefixed and suffixed forms ultimately need to be systematically evaluated in a variety of languages as well as in a variety of modality configurations and tasks so that language universals as well as the idiosyncrasies of particular languages and of particular tasks can be reconciled.

3.3. The problem of a language unsuitable for researching these issues

Giraudo & Grainger (2003) found differences between processing of prefixes and suffixes in their priming experiments on French (in the written medium). They suggest three reasons for these differences (2003: 225). 'Prefixes have a more predominantly compositional character than suffixes'. 'Prefixes have an exclusively semantic function whereas derivational suffixes have both semantic and syntactic functions'. 'Prefixes never phonologically or orthographically transform the base to which they attach, whereas suffixes do'. Examining test items in other papers, we find another problem: 'prefixed' text items also contained suffixes. For example, in Beauvillain (1996), while the suffixed items contained only suffixes, most of the items characterized as prefixed also contained suffixes, as in *transformé* and *supporter.* This could hardly be avoided in French, where most prefixed words also contain a suffix. Furthermore, in French it is impossible to compare prefixes and suffixes that are inflectional,

[1] We use one conventional system for transcribing Georgian; it differs from the IPA in the following ways: š = IPA ʃ, č = IPA ʧ, c = IPA ʦ, ʒ = ʤ, ž = IPA ʒ, j = IPA ʤ. As in the IPA, an apostrophe indicates an ejective. /v/ can be realized as [v], [f], or [w].

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and for consistency most studies use derivational affixes only. Clearly, to investigate language universals it would be good to be able to study differences between prefixes and suffixes in languages where these four problematic characteristics do not exist.

Georgian is a language that largely satisfies this goal, and thus the bulk of the work we report here was conducted on Georgian. Before we turn to Georgian, we report a single experiment in English, an experiment that serves to demonstrate our agenda in a language that will be familiar to most readers. As we have noted, English has a number of serious limitations for pursuing our question in detail, but it is possible to design a basic investigation of the question as a starting point. Moreover, despite English (and closely related Dutch) having been the language that initially prompted the Hawkins--Cutler hypothesis, prefixes and suffixes have actually not been explicitly compared in English. We therefore decided to run a single lexical decision experiment to see whether it would confirm the claims of Hawkins & Cutler (1988). Cutler et al. (1985) discussed the 'beginning', 'end', and 'middle' of words, but it was not made clear whether the 'beginning', for example, referred to the first sound, the first syllable, the first third of the word, or to some other portion. In some of the experiments cited, a few experimental items had a prefix or suffix, but this was not systematic. In our implementation, the presence of prefixes and suffixes is systematic and tightly controlled.

4. Description of the affixes in the English study

Inherited Germanic words and affixes in English have properties different from those of words and affixes borrowed from Latin or French. To keep these properties from being a confound, we compared Latinate prefixes and Germanic prefixes, on the one hand, with Latinate suffixes and Germanic suffixes, on the other. The affixes selected are each one syllable.

In both parts of the vocabulary, we eschewed words that had both a prefix and a suffix, such as *untimely*, with the prefix *un-* and the suffix *-ly*, and words with two prefixes or two suffixes, such as *fittingly*, with suffixes *-ing* and *-ly.* We looked for affixed words that corresponded closely to an unaffixed base, avoiding, for example, *create*, which lacks corresponding bases such as **cre* or **creare* in English, even though *-ate* is otherwise a suffix. We included words like *mislay* but avoided *mistake*, where the two morphemes do not have a simple compositional meaning; that is, *mis-* 'badly, wrongly' does not combine in a simple way with the ordinary meaning of *take.* We tried to avoid words that combine a Germanic affix with a Latinate base, such as *mistreat.* We have limited our critical items to ones with stem invariance. We included Germanic items such as *unwrap, tonight, thicken,* and *funny* and Latinate items *dethrone, enjoy, pulsate,* and *normal.*

5. Experiment 1: English auditory lexical decision

We constructed a standard auditory lexical decision experiment using English words to compare the ease of processing words with prefixes versus those with suffixes. In a lexical decision task, participants hear real words and nonce words and decide for each whether it is a real word (Yes) or not (No). This task is used widely to study word recognition. If recognizing words with one kind of affix is easier than recognizing words with the other kind, this should be reflected in faster and/or more accurate responses for one kind of affix

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than for the other. Our experiment was auditory, as this represents a more natural use of language. The study was approved by the Stony Brook Institutional Review Board, and we obtained informed consent before the experiment began.

Prior research (e.g. Kuperman, Bertram & Baayen 2010) has shown that response time can be affected by differences between derivational and inflectional morphology, the productivity of an affix, and both root and whole-word frequencies. To accommodate the first two factors, we have used only derivational morphology and only productive affixes. With respect to frequency, although we list only whole-word frequencies here in selecting the items, we were also sensitive to root frequencies.

5.1. Materials

To test Germanic words, we constructed a set of 24 prefixed words, mostly using the prefixes *mis-* and *un-*, both with verbs (e.g., *unlearn*) and with adjectives (e.g., *unwell*). We constructed a comparable set of 24 suffixed words with a variety of suffixes: *-en, -ful, -less, -ness, -ly, -y,* and others (e.g. *thicken*, *wakeful, skinless*). All affixes are a single syllable, and all bases also have a single syllable. To these we added 48 two-syllable fillers, most of them having no affix. These critical items and matched fillers are listed in Appendix A, together with their frequencies. All frequencies are taken from the SUBTLEXus database (http://www.lexique.org/shiny/openlexicon/), based on words appearing in movie subtitles. The frequencies we have listed are the words' log frequencies per million ('log10WF' in the database).

To test Latinate words, we constructed a set of 24 prefixed words using a variety of prefixes (e.g. *restate, cohost, indent*) and a comparable set of 24 suffixed words (e.g. *porous, tonal, plumage*). Again, all affixes are a single syllable. In each set of 24 stimuli, 19 bases have one syllable, and five bases have two syllables (e.g. *venomous*). We added 48 fillers, matching the number of syllables to the critical items. For example, matching *venomous*, with three syllables, we included the filler *placebo.* The fillers serve to 'dilute' the presence of affixed items to make the purpose of the study less apparent to the participants. For example, even the most used affix (*un*-) only occurred in 15 of the 384 stimuli that listeners heard. These critical items and fillers are listed in Appendix B with frequencies.

To the 192 Germanic and Latinate items we added 192 nonce words. These were chosen to match the lengths of the real words (i.e. 172 were two syllables long, and 20 were three syllables.) They are listed in Appendix C.

All items were recorded by the second author, a native speaker of American English.

5.2. Method

We recruited 22 participants, undergraduates at Stony Brook University. Participants self-identified as being native English speakers with no known hearing problems. They received either $5 or credit toward a class requirement. Experiments were carried out in a laboratory at Stony Brook University with high-quality headphones in a sound-shielded chamber. However, the chamber door was kept open to provide better air flow during the coronavirus disease 2019 pandemic. One participant was tested at a time. Participants were instructed to press one labeled button on a response pad to respond Yes (real word), and another labeled button to respond No (nonce word). The 384 experimental items were randomized for each

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participant. The experiment, including instructions and debriefing, lasted less than 25 minutes.

5.3. Results and discussion

For each participant, for both accuracy and response times, means were computed for the 2 x 2 crossing of affix type (prefix vs. suffix) and language family (Latinate vs. Germanic). These values were submitted to two analyses of variance (ANOVAs): one for error rates and one for reaction times. Figure 1 shows the resulting means. Before reporting the details of each ANOVA, we note that with respect to the prefix versus suffix issue, the error rates and response times show a clear speed--accuracy trade-off: Prefixed words produced lower error rates than suffixed words, but they were responded to more slowly.

The error rate analysis confirmed that prefixed words (3.4% error) were responded to significantly more accurately than suffixed words (10.0% error; $F(1,21) = 20.531$; $p < .001$). Overall, accuracy did not differ between the Latinate stimuli (6.7% error) and the Germanic stimuli (6.8% error; $F(1,21) = 0.019$; $p = .891$). However, there was a significant interaction between the two factors, reflecting a bigger difference between prefixed and suffixed Latinate words (1.5% error vs. 11.8% error) than for Germanic words (5.3% error vs. 8.2% error; $F(1,21) = 16.121$; $p = .001$).

For the response times, the pattern reversed, with prefixed words (1,097 msec) responded to more slowly than suffixed words (1,061 msec; $F(1,21) = 6.860$; $p = .016$). Latinate words (1,061 msec) produced faster responses than Germanic ones (1,097 msec; $F(1,21) = 15.486$; $p = .001$). There was no interaction in the response times ($F(1,21) = 0.052$; $p = .822$).

The comparison of prefixed versus suffixed words in English thus yields no clear evidence for a suffixing advantage in processing. Although there is an advantage in response accuracy, it trades off against a disadvantage in response speed. This experiment illustrates the kind of test that can be conducted to explore the possibility of there being a suffixing advantage grounded in perceptual processing, but as we noted previously, there are multiple reasons to think that English is not the best language to pursue this question. Thus, in the remainder of this paper, we use a language that is better suited to addressing it -- Georgian.

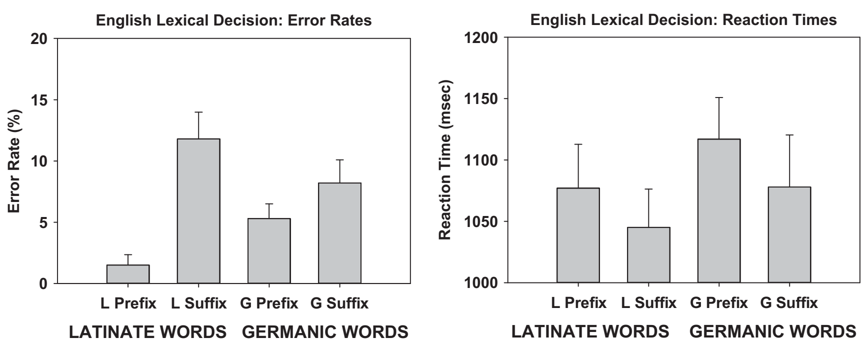

Figure 1. Error rates (left panel) and response times (right panel) for lexical decision judgments for English words. Error bars represent standard errors.

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6. Description of the affixes and bases used in the Georgian study

Georgian uses a wide variety of affixes in verbs, nouns, and adjectives; these include both derivational and inflectional affixes, and prefixes, suffixes, and circumfixes. The issues in Section 1 would be best addressed using pairs of words that differ minimally -- pairs that are identical except that one contains an inflectional prefix while the other contains a similar inflectional suffix, together with similar pairs involving derivational affixes. It would be best if both verbs and nouns were included.

We found the ideal pair of inflectional affixes in the Georgian verbal prefix *v-* 'first person subject' and the suffix *–s* 'third person singular subject'. The prefix *v-* is used in most verb forms when there is an appropriate first person subject, while the suffix *–s* is used only in certain tense--aspect--mood forms and only with certain verb types (Harris 1981). Paradigm (1) illustrates this.

(1)	*v–**c'er***	'I write'	*v–**c'er**–t*	'we write'
	c'er	'you write'	***c'er**–t*	'you(pl.) write'
	***c'er**–s*	'she/he/it writes'	**c'er**–*en*	'they write'[2]

The affixes in (1) correspond to subject pronouns listed in (2); all are used in the experiment.

(2)	Singular	Plural	
	first person	*me*	*čven*
	second person	*šen*	*tkven*
	third person	*is*	*isini*

There being no productive derivational noun prefixes in Georgian, we focused on two derivational circumfixes (*me—e*, *sa—o*) together with a small number of derivational suffix pairs (*-ob-a, -eb-a, -el-a, -ur-i*). The idea was that each complex affix or affix pair ends with a suffixal vowel. If we assume that these final vowels have equivalent effects, we can compare the remaining prefixal parts (*me-, sa-*) with the remaining suffixal parts (*-ob, -eb, -el, -ur*). The circumfix *me—e* forms agentive nouns from nouns (e.g. *me-**put'k'r**-e* 'bee keeper' from ***put'k'ar**-i* 'bee'), whereas *sa—o* forms nouns or adjectives expressing location or intention from nouns (e.g. *sa-**st'umr**-o* 'hotel' from ***st'umar**-i* 'guest'). The suffix *–i* is the nominative case marker and is part of citation forms but is not used in the base in derivation. The suffixes *–ob-a* and *–eb-a* form abstract nouns from nouns and adjectives (e.g. ***zeim**-ob-a* 'celebration' from ***zeim-**i* 'feast'). The suffixes *–el-a* form a diminutive (e.g. ***top**-el-a* 'small toy gun' from ***top**-i* 'gun'), whereas *–ur-i* forms characterizing adjectives from nouns (e.g. ***k'ameč**-ur-i* 'strong as a buffalo' from ***k'ameč**-i* 'buffalo').

Georgian has a wide variety of verb forms, including ones with multiple prefixes and ones with multiple suffixes. However, those with no affix other than the one being tested offer the best minimally different pairs and the simplest experiment. Here we refer to bases as 'simplex', if they have a monomorphemic stem, so that the critical affix (the first person subject prefix or the third person singular subject suffix) is the only affix in the experimental item. Each inflected verb represents a complete sentence, as unemphatic pronominal arguments are typically dropped; examples are in (3).

[2] For Georgian, we adopt the convention of bolding the root. Note that for the simplex verbs we use in Experiments 2–5, the root is the same as the stem.

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(3) *v*–***ban*** 'I bathe s.o.' ***ban***–*s* 'he/she/it bathes s.o.'[3]

Complex verbs in our experiments have one prefix and one suffix in the present tense, in addition to the critical subject affix. The derivational prefix is a single vowel, whereas the suffix is a -VC sequence. An example is given in (4) in Section 7.3.

7. The first set of Georgian experiments

We ran a first set of experiments to compare the ease of processing and producing words with prefixes versus those with suffixes. The experiments included a lexical decision task, a verification task with real words and one with nonce words, and a generation task with real words and one with nonce words. At least one component of each experiment is oral, as this represents more natural use of language. Informed consent was obtained before the set of experiments, conforming to the requirements of the University of Massachusetts Amherst.

7.1. Orientation to the first set of Georgian experiments

Experiments 2--5 were conducted as a set during a data-collection visit to Georgia. After we completed the experiments, we assessed issues encountered during the data collection and in the preliminary analyses we conducted. We identified four concerns:

- A number of the simplex verb forms used in Experiments 2, 3, and 5 are not used by some speakers. We had checked these in dictionaries and with a native-speaker linguist. Nevertheless, there is an ongoing tendency for verbs of this type to add the suffix *–av*, and for some speakers this is the only form. For example, in Experiment 3 we used the form *zel-s* 'kneads', but some speakers now use only *zel-av-s* for this meaning.
- The prefix *v-* is much more clearly audible before a vowel than before a consonant. Because almost all Georgian verb roots begin with consonants, the first-person simplex forms called for *v* immediately before a consonant. This made the prefixes difficult to hear with simplex verbs but not with complex verbs. (The suffix *-s* does not have the same problem.)
- The results of comparing noun circumfixes with noun suffixes were not clear and therefore did not give us a good answer to the question of whether derivational morphology behaved like inflectional morphology.

In light of these issues, we consider the results of these experiments useful but still preliminary in measuring the relative impact of prefixes and suffixes on processing. To keep our paper to a readable length, we have shortened our descriptions of these experiments in the published version of this paper.

7.2. Experiment 2: Auditory lexical decision task with verbs of two types

The first Georgian experiment involved a standard lexical decision task in which participants hear real words and nonce words and decide for each whether it is a real word (Yes) or not (No). The goal was to determine whether participants recognize words with one kind of affix

[3] The abbreviations *s.o.* 'someone' and *s.t.* 'something' are used occasionally in our translations.

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more easily than words with the other. Evidence for this would be faster and/or more accurate responses for one kind of affix than for the other.

Response time can be affected by differences between derivational and inflectional morphology, the productivity of an affix, and both root and whole-word frequencies (e.g. Kuperman et al. 2010). To accommodate these factors, we have used both derivational (circumfixes and suffixes in the noun) and inflectional (subject agreement in the verb) morphology.

Work on understudied languages (e.g. Kgolo & Eisenbeiss 2015) has shown that speakers' estimates of frequency are reasonably accurate. We randomly selected five of our participants and gave each a list of the real-word stimuli (in a set that included additional words) after they had completed all of the experiments. We asked these participants to rate the frequency of these items on a scale of 1--5, from very infrequent to very frequent. For each participant we separately randomized the order of the items. We had to eliminate the ratings of one participant because she had apparently reversed the scale. The averages of the remaining four participants are listed for each item in relevant appendices.

7.2.1. Materials

To compare the cognitive processing costs of prefixes and suffixes in the verb, we used simplex stimuli, sharing a base and differing only in having a prefix or a suffix. All examples were in the present tense, the simplest one from a morphological point of view. The 24 real verbs in this experiment are used as in (3), once with a first person singular subject and once with a third person singular subject. These 48 items are given in Appendix D.

Real-word stimuli were paired with 24 nonce words, again with prefixed and suffixed forms. Nonce verbs had nothing that could be identified as an inflectional or derivational affix, apart from the critical subject affixes. These items are listed in Appendix E.

For nouns, we matched 24 words derived by one of the circumfixes discussed previously with a word having the same base but with a derivational suffix. For example, *me-**put'k'r**-e* 'bee keeper' is matched by ***put'k'r**-ob-a* 'industriousness', with the same root. These test items are listed in Appendix F.

Each real noun is paired with a nonce word with related morphology, mostly using real affixes.[4] The 48 nonce words for this set are listed in Appendix G, together with a number representing the location of the decision point (the point at which the listener can determine whether this is a real or nonce word), counting sound segments from the onset.[5]

To the 192 experimental items we added 48 complex inflected verbs and 48 corresponding nonce words as distractors.

All critical items and distractors were recorded by a native speaker of Georgian at the University of Massachusetts using a Tascam DR-40 recorder and a Shure SM10A-CM head-mounted microphone in a sound booth. Individual tokens were extracted from the recordings, cutting at zero crossings near the actual onset and offset of each item (so that reaction time measures will be accurate). Any pops or clicks were edited out, and between-item amplitude differences were approximately normalized.

[4] Due to an investigator error, one of the nonce words with a circumfix is an archaic real word.

[5] The authority for determining the decision point was the online Georgian-English dictionary at https://www.translate.ge/.

7.2.2. Method

Experiments were carried out in a quiet space loaned to us for this purpose by the Georgian Language Institute of Tbilisi State University.

We worked with 56 native speakers, most of them university students. Twelve participants appeared to be male, and 44 female. Participants were prescreened for having normal hearing, being native speakers, and being over 18 years of age. Participants were each paid $5 or 12.5 Georgian Lari.

Participants indicated Yes (real word) or No (nonce word) by pressing one of two labeled keys on the keyboard. Presentation of the 288 experimental items was randomized for each participant. Labels and oral instructions were in Georgian.

7.2.3. Results and discussion

Data for five of the 56 participants were lost due to technical issues. Data from three other participants were not included in the analyses due to excessive error rates (i.e. less than chance performance on items that required a No response), leaving 48 usable data sets. For each of the four cases tested (real verbs, real nouns, nonce verbs, and nonce nouns), we conducted a pair of single-factor repeated-measures ANOVAs. One analysis in each pair examined error rates, and the second examined response times. In all of the ANOVAs, the question was whether performance differed as a function of affix type: prefix versus suffix for the verbs, and circumfix versus suffix for the nouns. The Cutler--Hawkins hypothesis predicts better performance for the suffix condition.

Real verbs Figure 2 presents the accuracy and reaction-time data for the real Georgian simplex verbs. As shown, we did not find an advantage for simplex verbs with suffixes compared to those with prefixes. In fact, there was actually a small advantage for verbs with prefixes: Participants made significantly fewer errors on such items ($F(1, 47) = 9.930$; $p < .005$), and responses were not significantly faster for them ($F(1,47) = 3.578$; $p < .07$).

Real nouns Figure 3 presents the results for the real nouns. Recall that the comparison here is between words with circumfixes and those with suffixes.

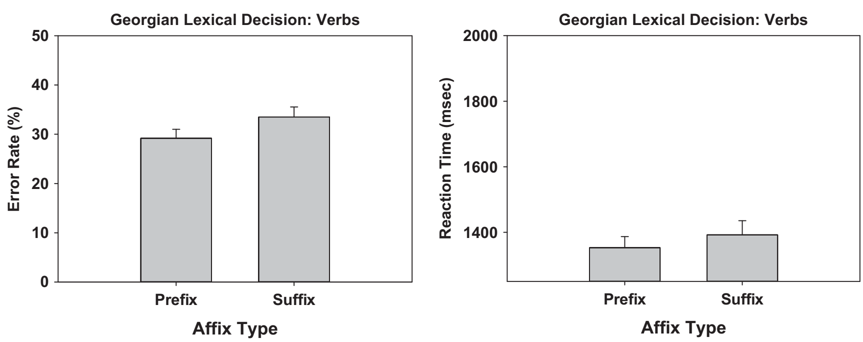

Figure 2. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian simplex verbs. Error bars represent standard errors.

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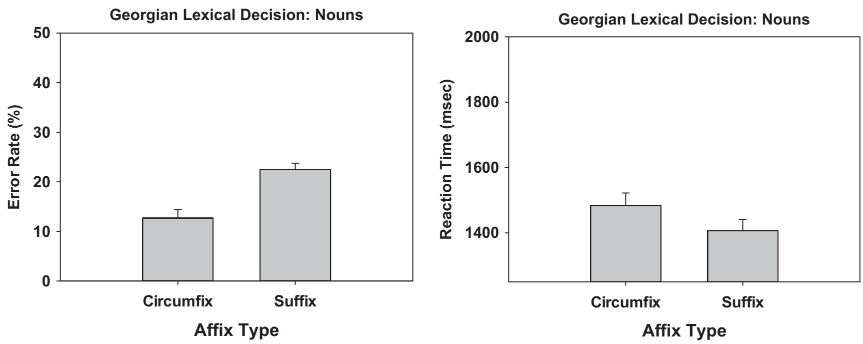

Figure 3. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian nouns. Error bars represent standard errors.

The results for nouns are mixed for the Cutler--Hawkins hypothesis. The accuracy data show the same significant result in the direction opposite to that predicted by the hypothesis that we found for the verbs, with error rates actually being higher for the suffixed items than for those with a circumfix ($F(1,47) = 73.067$; $p < .001$). However, the reaction times were significantly faster for items with a suffix than for those with a circumfix ($F(1,47) = 12.236$; $p = .001$).

Nonce verbs Figure 4 presents the accuracy and reaction time data for the Georgian nonce simplex verbs.

As is clear on the left side of Figure 4, the error rates for nonce verbs with prefixes were essentially the same as those for nonce verbs with suffixes ($F(1,47) = 1.829$; $p = .183$, n.s.). There was, however, a significant difference in the response times, favoring the suffixed items ($F(1,47) = 19.111$; $p < .001$). (Recall from Section 7.1 that we discovered that speakers have a problem distinguishing the prefix *v-* before a consonant, and this problem compromises our stimuli in this experiment.)

Nonce nouns Figure 5 presents the accuracy and reaction time data for the Georgian nonce nouns.

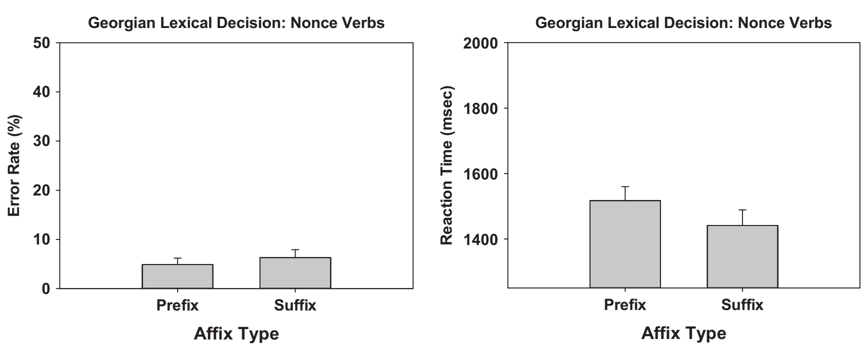

Figure 4. Error rates (left panel) and response times (right panel) for lexical decision judgments for Georgian nonce simplex verbs. Error bars represent standard errors.

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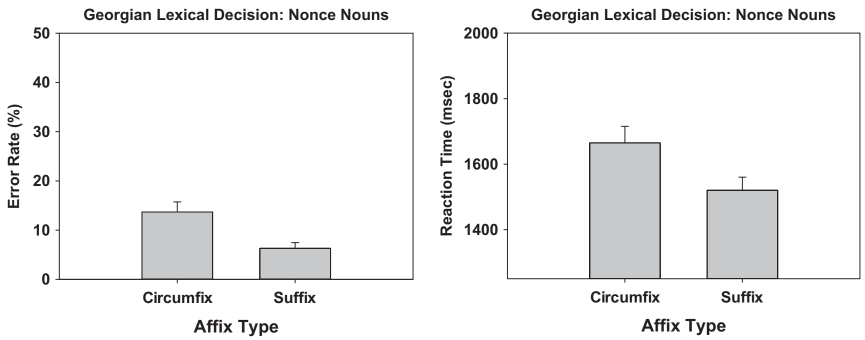

Figure 5. Error rates (left panel) and response times (right panel) for lexical decision judgments for Georgian nonce nouns. Error bars represent standard errors.

The results for the nonce nouns are the most supportive lexical decision data for the suffixing preference. For both the error rates ($F(1,47) = 21.486$; $p < .001$) and for the response times ($F(1,47) = 52.659$, $p < .001$), there is an advantage for the items with a suffix compared to those with a circumfix.

Summary: Lexical decision On balance, although there were a few significant advantages for suffixed items, there were a similar number of significant disadvantages for them.

7.3. Experiment 3: Mixed-modality verification task with real words

The second Georgian experiment uses a verification task in which participants were asked to verify whether the combination of a root and a pronoun (presented visually) matches an inflected form (presented auditorily). This task can be seen as a variation on experiments using cross-modal priming (e.g. Marslen-Wilson, Tyler, Waksler & Older 1994). See the end of Section 2 on the advantages of a cross-modal approach.

7.3.1. Materials

We constructed sets consisting of an inflected form, the citation form of a real verb, and a pronoun. The inflected forms were recorded by a native speaker for aural presentation through earphones. The two other parts were presented in Georgian script on a laptop screen. For example, the participant might hear *v-**zel*** 'I knead' and see the array in Figure 6 on the screen.

The array in Figure 6 consists of ***zel**-a*, the citation form of 'knead', and *me*, the pronoun 'I, me'. In this example, the visual combination matches the spoken word. However, the participant might instead hear *v-**zel*** 'I knead' and see Figure 7 or Figure 8.

In Figure 7, the citation form ***zel**-a* matches the spoken word, but the subject, *is* 'he, she, it', does not. In Figure 8, the subject, *me* 'I, me', matches what the participant would hear but the citation form, ***t'rial**-eb-a* 'spin', does not. Both require No responses.

All finite items were in the present tense. Critical items included 20 simplex and 20 complex verbs, each in a first-person form and a third-person form. Examples of each type are given in (4).

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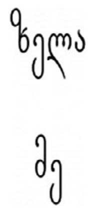

Figure 6. Matching sample screen array.

Figure 7. Non-matching sample screen array, wrong subject pronoun.

Figure 8. Non-matching sample screen array, wrong stem.

(4)	Simplex	*v–**k'vet*** 'I cut off'	***k'vet**–s* 'he/she/it cuts off'
	Complex	*v–a–**ʒlier**–eb* 'I strengthen'	*a–**ʒlier**–eb–s* 'he/she/it strengthens'

There were 40 fillers, verbs of types not represented by critical items, sometimes with many affixes. They were inflected for subjects of person--number combinations not used in critical items: first person plural (*v--t*), second person plural (*-t*), third person plural (*-en* or *-ian*, depending on the verb), or second person singular (no affix).

Critical items and fillers are listed in Appendix H, showing the inflected forms heard and the written citation forms and pronouns. The simplified meaning given corresponds to the lemma of the inflected verb. For example, if a participant heard *v-zel* 'I knead' and saw Figure 8, the meaning 'knead' would be listed in the appendix, not 'spin', which corresponds to the verb in the figure.

7.3.2. Method

Design As shown in Appendix H, the 20 verbs of each type were divided into four sets of five simplex (S) or complex (C) verbs. These were arranged so that participants in two groups heard complementary forms. For example, participants in Group A heard *v-**bɣleʒ*** 'I shred' in one block of stimuli, with ***bɣleʒ**-s* 'he/she shreds' in the other block. Participants in

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Group B would have received a different item in the first person in one block, with the corresponding third person form in the other block.

All 56 participants completed Experiment 3, but five participants' records were lost due to technical problems, and 9 more were excluded for poor performance, leaving 42 participants. Error rates were over 50% in about half of the conditions for all of the excluded participants, whereas error rates for the included participants were on average approximately 10%.

Procedure Participants were arbitrarily assigned to one of two groups, A or B. They were presented aurally with an inflected form of a verb and visually with the citation form of a verb and a pronoun. The question for the participants was 'Do the three forms correspond?' Participants were given oral instruction with oral examples. A brief practice was included before the experiment.

As noted above, each participant received two blocks of trials that were used to counterbalance when the first-person and the third-person versions of the test items were presented. Trials within a block were randomly ordered for each participant.

7.3.3. Results and discussion

As before, error rates, and response times were submitted to ANOVAs, in which performance was compared for items with prefixes versus suffixes.

As shown in Figure 9, the verification results are a mix of ones consistent with the Cutler--Hawkins hypothesis and ones that are not. The error rates for the simplex verbs that matched the root/pronoun combination were consistent with the hypothesis – more errors were made for prefixed verbs than for suffixed verbs ($F(1,41) = 14.318$; $p < .001$). The reaction times for this case did not differ as a function of prefix versus suffix ($F(1,41) = 0.621$; $p = .435$, n.s.). For the complex verbs, no support was found for the hypothesis: Error rates were the same for the two cases ($F(1,41) = 0.029$; $p = .866$, n.s.), and reaction times showed a marginally significant advantage for prefixed items (counter to the hypothesis) ($F(1,41) = 3.831$; $p = .057$).

As summarized in Figure 10, the results for the mismatching verification trials – ones in which the inflected form would not be formed by a combination of the given pronoun and root – provide only weak support for the Cutler--Hawkins hypothesis. There were no differences in error rates for either the simplex verbs ($F(1,41) = 0.009$; $p = .924$, n.s.) or

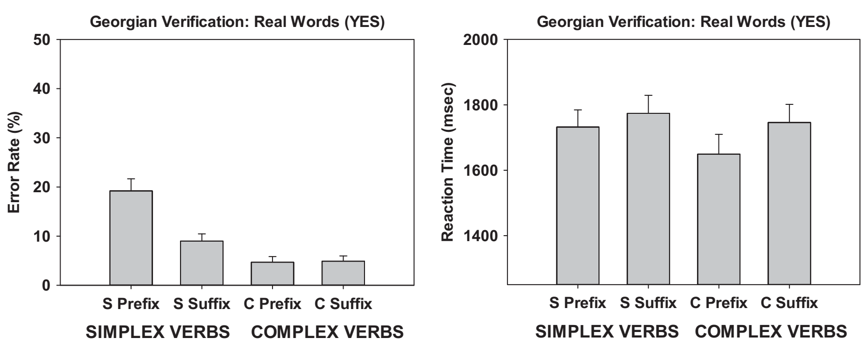

Figure 9. Error rates (left panel) and response times (right panel) for verification judgments for real Georgian verbs that required a Yes response. Error bars represent standard errors.

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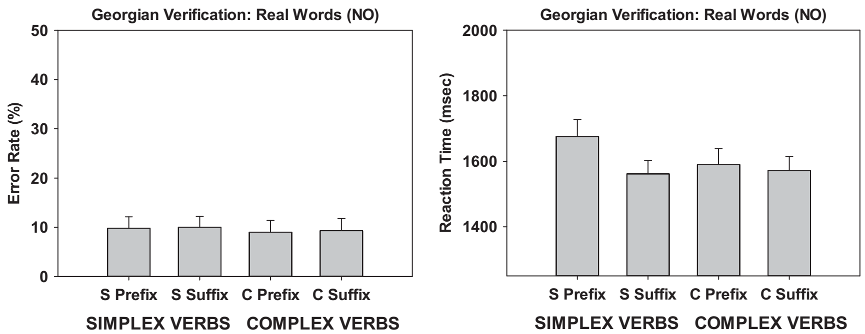

Figure 10. Error rates (left panel) and response times (right panel) for verification judgments for real Georgian verbs that required a No response. Error bars represent standard errors.

for the complex ones ($F(1,41) = 0.043$; $p = .836$, n.s.). The reaction time results are a bit more supportive, with a significant disadvantage for prefixed simplex verbs versus suffixed ones ($F(1,41) = 6.687$; $p = .013$). However, no difference was found for the complex verbs ($F(1,41) = 0.417$; $p = .522$, n.s.).

Across the eight comparisons (simplex/complex x Yes/No x errors/response times), two produced a significant difference consistent with the Cutler--Hawkins hypothesis; one produced a marginally significant reversal; and five showed no difference between prefixed and suffixed stimuli. Thus, the verification task with real Georgian verbs did not yield reliable support for the Cutler--Hawkins hypothesis.

7.4. Experiment 4: Mixed-modality verification task with nonce words

7.4.1. Materials and methods

Sets of stimuli were constructed as for Experiment 3, except that the stem was not Georgian. Sets consisted of an inflected form of a nonce verb recorded by a native speaker for aural presentation, and the citation form of a nonce verb and a pronoun (corresponding or not) written in Georgian script for visual presentation. Mismatching paralleled that in Experiment 3. No separate practice was used.

Both simplex and complex verbs were used. All affixes were real affixes of Georgian, and the pronouns were real pronouns of Georgian. Roots were nonce roots, and this was true also of the fillers. Other aspects of the experiment matched Experiment 3. Nonce forms, both critical items and fillers, are listed in Appendix I.

Three sets of results were not usable due to experimenter error. One was lost to equipment failure, and three more were unused due to participants failure to follow instructions. Three sets of results were not used in the analyses because of high error rates (i.e. chance or below-chance levels on either positive trials, negative trials, or both). This left us with 46 sets of results in the analyses.

7.4.2. Results and discussion

The results for the nonce stimuli were analyzed following the same procedures as in Experiment 3.

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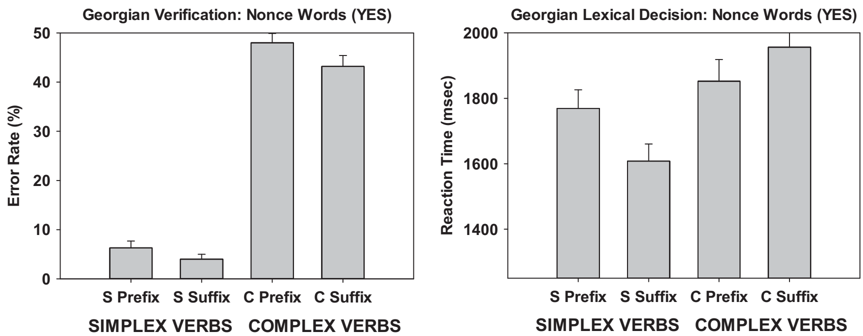

Figure 11. Error rates (left panel) and response times (right panel) for verification judgments for nonce Georgian verbs that required a Yes response. Error bars represent standard errors.

As the left side of Figure 11 shows, for both simplex and complex nonce verbs, error rates were a bit higher for the prefix case than the suffix case. For simplex verbs, the difference was not significant (F(1,45) = 2.474; p =.123, n.s.); for the complex verbs, the difference was marginally significant (F(1,45) = 3.262; p =.078). What is more striking is the huge error rate for complex nonce words, reflecting a strong tendency to accept the match between the root/pronoun combination and the inflected nonce form. We believe that the presence of real derivational morphology made it difficult for participants to judge the correctness of nonce words. For example, the complex nonce word *v-a-**pšet**-eb* contains the real derivational prefix *a-* and the real derivational suffix *-eb*. In contrast, the simple nonce verb *v-bɣlem* contains no real morphology except *v-*, which the complex example also contains. In Experiment 6, we test the hypothesis that real morphology makes nonce tasks more difficult.

The reaction-time results were consistent with the Cutler--Hawkins hypothesis for the simplex nonce verbs, with slower responses to prefixed forms (F(1,45) = 15.084; p <.001). However, the pattern reversed for the complex verbs, with prefixed items yielding marginally faster responses than suffixed ones (F(1,45) = 3.890; p =.055).

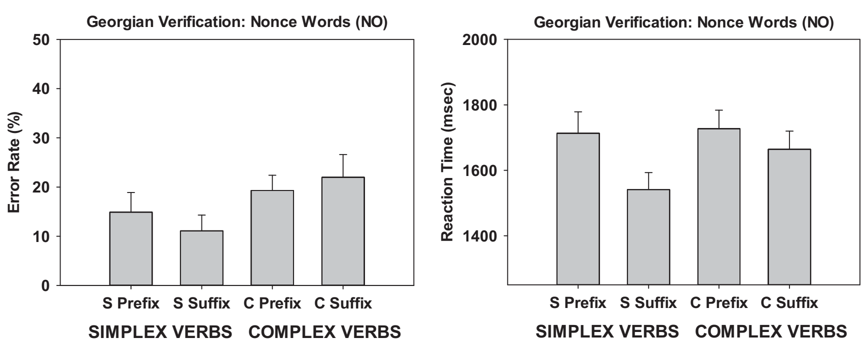

Figure 12. Error rates (left panel) and response times (right panel) for verification judgments for nonce Georgian verbs that required a 'no' response. Error bars represent standard errors.

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As shown in Figure 12, the results for nonce verbs requiring a No response were relatively supportive of the Cutler--Hawkins hypothesis, with prefixed items tending to be more difficult than suffixed ones. For the simplex nonce verbs, this tendency was reliable in both the accuracy measure (F(1,45) = 4.087; p =.049) and in the response time measure (F(1,45) = 11.455; p =.001). For the complex nonce verbs, the slight advantage in accuracy for prefixed forms was not significant (F(1,45) = 1.127; n.s.), nor was the disadvantage in response time for those forms (F(1,45) = 2.006; p =.164, n.s.).

Overall, the results for the nonce verification task were somewhat more supportive of the Cutler--Hawkins hypothesis than the results in the first two Georgian experiments, but the evidence is relatively weak.

7.5. Experiment 5: Production of Georgian words

Collectively, the results of the first four experiments have provided at most weak evidence that prefixes are disruptive of processing spoken words. In Experiment 5, we look at an alternative potential impact of prefixing: Perhaps placing an affix before the root is disruptive during the production of spoken words. To test this idea, participants were asked to produce inflected Georgian words.

7.5.1. Materials

In each trial, the participant heard the citation form of a real verb, together with the visual presentation of a pronoun. The task was to produce the inflected form of the citation form, based on the pronoun on the screen. For the critical items, 24 simplex verbs and 24 complex verbs were used, together with the pronouns *me* 'I, me' or *is* 'he/she/it', each triggering a single prefix or suffix. For 24 fillers, other pronouns were used. The citation forms were recorded by a native speaker. As an example, if *is* 'he/she/it' was shown on the screen, and the participant heard the citation form ***ksov**-a* 'weave', she was expected to reply ***ksov**-s* 'he/she/it weaves'. All experimental sets for this experiment are given in Appendix J. To minimize any effects of order, we created two different pseudo-randomizations of the stimuli.

7.5.2. Methods

43 participants completed Experiment 5. The somewhat smaller sample stemmed from several technical issues, coupled with the need to avoid participants overhearing each other in these production tests.

Participants were instructed to say the form appropriate for the stimuli, and we modeled making the pronoun the subject of the verb. They were given the following oral example: If *is* 'he/she/it' is on the screen, and you hear *ga-**p'ars**-v-a* through the earphones, you would say ***p'ars**-av-s* 'he/she/it shaves'. They were not explicitly instructed to use the present tense, but this, too, was modeled in the instructions and in the practice session.

The training session included both real and nonce words.

7.5.3. Results and discussion

A native speaker of Georgian assessed the match between each actual production and our expectation. A response was considered incorrect if there was no response, if there was self-

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Table 1. Errors in production of real Georgian verbs, Groups A and B combined.

	Prefix	Suffix
Simplex	86	71
Complex	47	37
Total	133	108

correction, if the response was not a real word of Georgian, or if the response had a verb stem, tense, or person--number combination that did not correspond to the prompt. In reviewing the responses, we discovered that *v-* prefixes are often not clearly audible before consonants (see Section 7.1). Therefore, we counted inaudible *v-* prefixed responses as correct; in these instances, the correctness of the rest of the form is consistent with it being a first-person singular response. We also counted as correct forms with an *-av* suffix (see Section 7.1 and subsequent discussion).

Table 1 presents the total number of errors, broken down by the type of verb and whether the trial involved a prefix or a suffix. An ANOVA with these two factors showed that there were more errors on simplex verbs than complex verbs ($F(1,42) = 20.091$; $p < .001$) and more errors on prefix trials than on suffix trials ($F(1,42) = 4.752$; $p = .035$); the interaction of the two factors was not significant ($F(1,42) = 0.154$; n.s.).

We believe that simplex verbs were more difficult than complex verbs because they are less frequent and because of a diachronic change in which some are being replaced by forms with the suffix *-av* (see Section 7.1). The total frequency estimate for the 24 simplex verbs is 67.25, whereas the comparable number for the 24 complex verbs is 111.25. Note that this does not affect the prefix--suffix comparison that is the focus of this paper, as both prefixes and suffixes were used with simplex verbs. The frequency estimate for the 12 simplex verbs presented with first-person pronouns (eliciting a prefixed form) is 32, whereas the comparable estimate for the 12 simplex verbs presented with third-person singular pronouns (eliciting a suffixed form) is 35.25. Verbs that are preferred with *-av* are preferred with that suffix regardless of the subject.

At the end of the session, participants did a nonce production task, but that task proved too hard for people to produce any interpretable patterns.

8. Second set of Georgian experiments: Experiment 6

As we noted in Section 7.1, after assessing the results of the first set of experiments, we decided to return to Georgia to collect data intended to overcome issues we had identified, running an omnibus lexical decision experiment. For this new experiment, we describe three issues and their targeted materials here as ‘Question A’, ‘Question B’, and ‘Question C’.

8.1. Methods

The data collection was carried out in the same space used before. We recruited 41 participants; two additional volunteers came with a friend and were asked to do the word-frequency estimation task instead of the experiments; 28 appeared to be women, 13 men. Most appeared to be in their 20s or 30s, but one appeared to be about 55. All had been prescreened for not having participated in the previous experiments, being a native speaker, having normal hearing, being at least 18 years of age, and not being a linguist. Four of the participants produced below-chance performance in multiple conditions, leaving 37 data sets in the statistical analyses. Informed consent was obtained before the set of experiments. Participants were paid 10 GEL, about $5.

Presentation of the 528 experimental items (264 words, 264 nonwords) was randomized for each participant. Each participant received instructions in Georgian on how to press the Yes and No keys, and each completed a short practice session. The experiment was divided into two parts with a break available between the parts.

8.2. Question A and the materials to test it

The goal for Question A is to compare the first person prefix *v-* with the third person singular suffix –*s* to test whether one of these inflectional affixes is easier to process than the other. Thus, it is the same as the verb-oriented goal of Experiment 2, with stimuli chosen to overcome the observed limitations of that experiment.

To avoid the first and second problems listed in Section 7.1, we used verb forms with a vowel prefix (either *a-* or *i-*) and a suffix of the form –VC (*-eb, -ob, -am, -av,* or *-ev*). We used 24 verbs, each with *v-* in one form and *-s* in another; these 48 experimental items are provided in Appendix K. Twenty of these are complex verbs used previously in Experiment 3, but these items were re-recorded and re-cut. The frequency listed in Appendix K is the surface (form) frequency. Examples are given in (5).

(5) *v–a–**k'et**–eb* 'I do, make' *a–**k'et**–eb–s* 'does, makes'
*v–a–**cx**–ob* 'I bake' *a–**cx**–ob–s* 'bakes'

We used 24 complex nonce verbs consisting of a real vowel prefix (either *a-* or *i-*), a nonce root, and a real –VC suffix (*-eb, -ob, -am, -av,* or *-ev*). Twenty of these are the same complex nonce verbs used previously in Experiment 4, but re-recorded and re-cut. They were used in first-person singular and third-person singular, and each participant heard both forms. These 48 items are listed in Appendix L; examples are shown in (6).

(6) *v–a–**bran**–eb* *a–**bran**–eb–s*
*v–a–**brtol**–eb* *a–**brtol**–eb–s*

An equal number of real words and nonce words were created, comprising a total of 96 experimental items.

8.3. Question B and the materials to test it

The goal for Question B is to compare a pair of minimally different derivational affixes to test whether one type of affix is easier to process than the other. Thus, the goal is the same as that of the noun portion of Experiment 2.

All verbs for Question B were in third-person singular subject form; all ended in *-eb-a*, where *-a* is a suffix for third-person singular subjects of the verb type used in these items. In one condition, verbs had the prefix *i-*; in the other, verbs had the suffix –*d* (which occurs before –*eb-a*). Twenty-four pairs of items were matched for the length of the root.[6] The roots

[6] Due to experimenter error, 2 of the 24 mismatched in length by one segment. The same error was made in 2 of the 24 matched nonce words described subsequently.

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were of the form -CC-, -CVC-, -CVCC-, or -CCVC-. An example of matched root length (-CC-) is given in (7); the roots are in bold.

(7) *i–**sm**–eb–a* 'is drinkable' ***xv**–d–eb–a* 'meets s.o.'

Twenty-four additional pairs of items were matched for the total length of the word in syllables. Roots in the prefix condition were of the form -C-, -CC-, -CCC-, -CCVC-, or -CVCC-; roots in the suffix condition were of the form -C(((C)C)C)VC-, -CVC(C)-, or -CCVVC-. The examples in (8) are both three syllables in length. (In Georgian, the number of vowels corresponds exactly to the number of syllables.)

(8) *i–**nt**–eb–a* 'lights' ***mcir**–d–eb–a* 'is reconciled, sorted out'

Both sets of matched pairs (with their surface frequencies) are listed in Appendix M, for a total of 96 real experimental items.

The real items were matched with 24 pairs of nonce items matched for length of root, and 24 pairs of nonce items were matched for total length of the nonce word in syllables. These are listed in Appendix N. An equal number of real words and nonce words were created to address Question B, contributing a total of 192 experimental items.

8.4. Question C and the materials to test it

Generally speaking, if a nonce item appears more word-like, it will generate lower accuracy and slower response times: If the item seems more word-like, it is harder for the participant to say No. The goal of Question C is to determine whether nonce words with real morphology, such as those used in many of our experiments, are more difficult to recognize as nonce words than ones with no real morphology. Taking this one step further, we also ask whether nonce words with more real morphology are harder to recognize than words with only a little real morphology. Here the nonce words are the focus, and real words are included so that there will be an actual choice for the participants. The results will help us to interpret the previous experiments, especially Experiment 4.

Our stimuli were of three types: 1. Simplex verbs with only a subject prefix or suffix; 2. Complex verbs, having a prefix and a suffix, in addition to a subject prefix or suffix; and 3. highly complex verbs, having four or more affixes. For each of these, we created a set of nonce words with real affixes, a set of real words, and a set of length-matched nonce words without morphological structure.

Simplex verbs: There were 24 simplex nonce verbs having only roots and either the first person subject prefix *v-* or the third person singular subject suffix *–s*, with no other morphology. Of these, 12 were presented in first-person singular and 12 in third-person singular, with the real prefix or suffix. Examples are presented in (9).

(9) *v–**bam*** ***p'ret**–s*

Matching the nonce words were 24 real words. Many of these were also used in Experiment 2, but they were re-recorded and re-cut. In the current experiment, no root was used twice. Many of these words are infrequent, and some speakers prefer to use some of the verbs with

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an additional suffix *-av*, but these are the simplest forms that exist and thus they form the most basic comparison for more complex forms.[7] The items are listed in Appendix O.

We added 24 length-matched nonce words with no real Georgian morphology as controls. These are based on the nonce words with real morphology, matching C for C and V for V. Examples corresponding to the words in (9) are given in (10).

(10) *plam p'rotx*

There were 72 experimental items for this condition, consisting of 24 nonce words with real morphology, 24 real words, and 24 length-matched nonce words.

Complex verbs: There were 24 nonce verbs of medium complexity, each having one real prefix (*a-* or *i-*) and one real suffix (*-eb, -ob, -am, -av,* or *-ev*), in addition to a subject prefix (*v-*) or suffix (*–s*). These were the complex nonce verbs from Question A. Recall that we used first-person singular or third-person singular, for a total of 24 experimental items. Examples are given in (11).

(11) *v–a–**pšet**–eb*
*a–**cr**–ob–s*

These 24 items are listed again in Appendix P, although they were presented only once in the experiment (i.e. we did not repeat the items from Question A; we simply used them to address both Question A and Question C).

To provide participants with a choice, we included 24 real words of medium complexity. These were the real complex words from Question A, using 12 real complex first-person forms and 12 real third-person forms. Thus, no additional experimental items were required. Examples are given in (12).

(12) *v–a–**k'et**–eb*
*a–**cx**–ob–s*

Appendix O lists the words again, although they occurred only once in the experiment.

We generated 24 length-matched nonce words of medium complexity. Of these, 12 match first-person forms and 12 match third-person forms, for a total of 24 additional experimental items. These have no Georgian morphemes; they are listed with the other nonce words in Appendix P.

High Complexity verbs: We included 24 nonce verbs of high complexity, each having four or more affixes. Together, the real affixes add at least three syllables to the root, which consists of a single syllable (bolded). Examples are given in (13).

(13) *še–mo–i–**rač'**–e*
***pxuč**–d–eb–od–a*

In addition, 24 real verbs with the same characteristics were included. Eight of these had been used in a previous experiment. Examples are given in (14).

[7] It is true that forms with second person singular subject are even simpler, as this person-number combination is unmarked (e.g. *ban* 'you bathe'). We judged that a set of experimental items in which each has a second person singular subject was extremely unnatural.

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(14) *še–mo–i–**xed**–e* 'look in here!'
*a–**c'er**–in–eb–s* 'he/she makes s.o. write'

As controls, 24 length-matched nonce words with no Georgian morphology were included. Examples are found in (15).

(15) *beluosedu*
blumlonega

There were 72 experimental items for this condition.

Finally, 72 real-word fillers were added to balance the number of experimental nonce words. They included a variety of tense--aspect--mood categories, with subjects of all kinds, some with agreeing objects; some had dative subjects. Examples are given in (16).

(16) *i–**cod**–i* 'you knew' *v–**nax**–e* 'I saw'
*m–**kon–d**–a* 'I had' *ga–v–i–**tval–is–c'in**–eb–t* 'we take s.t. into account'

These fillers are listed in Appendix Q. Altogether, 168 critical items and 72 fillers were added for Question C; this does not include items already used for another question. Together with the 96 items from Question A and the 196 items from Question B, Experiment 6 had a total of 528 items (half real words, half nonce words). All materials were recorded by a native speaker.

8.5. Question A results and discussion

Our first question involves another comparison of items with the prefix *v-* versus the suffix *–s*, this time using stimuli chosen to make the initial *v-* more audible by having it precede a vowel rather than a consonant. Figure 13 presents the error rates and response times for this comparison for real Georgian verbs, with the corresponding data for the nonce verbs shown in Figure 14.

There is a small but significant accuracy disadvantage for the prefixed real verbs ($F(1,36) = 10.171$; $p = .003$). The two types of stimuli yielded equivalent reaction times ($F(1,36) = 1.733$; $p = .196$, n.s.). For the nonce verbs, accuracy did not differ for the prefixed and suffixed cases ($F(1,36) = 2.681$; $p = .110$, n.s.). The reaction times for the nonce verbs produced a significant reversal, with faster responses for the prefixed items ($F(1,36) = 20.180$; $p < .001$). Collectively, the results for Question A do not provide support for the Cutler--Hawkins hypothesis.

8.6. Question B results and discussion

Our second question involved a contrast between verbs that take the prefix *i-* versus ones that take the suffix *–d*. Because of the properties of these verbs, we used two different methods of matching items. They were either matched in the length of the root, or they were matched in terms of the number of syllables. As with Question A, we tested performance for both real Georgian verbs and for nonce verbs with the relevant affixes. Figure 15 shows the error rates and response times for the real verbs that were matched on the length of their roots. Figure 16 shows the corresponding results for the nonce versions.

As Figure 15 shows, there was no difference between the prefixed and suffixed items, for accuracy ($F(1,36) = 1.049$; $p = .313$, n.s.) or for reaction times ($F(1,36) =$

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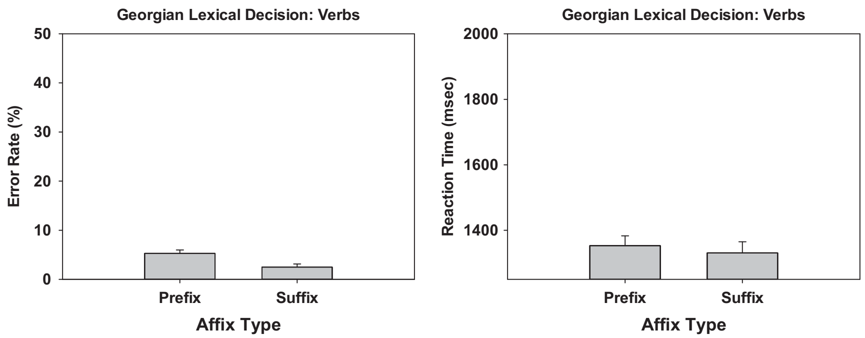

Figure 13. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian verbs. Error bars represent standard errors.

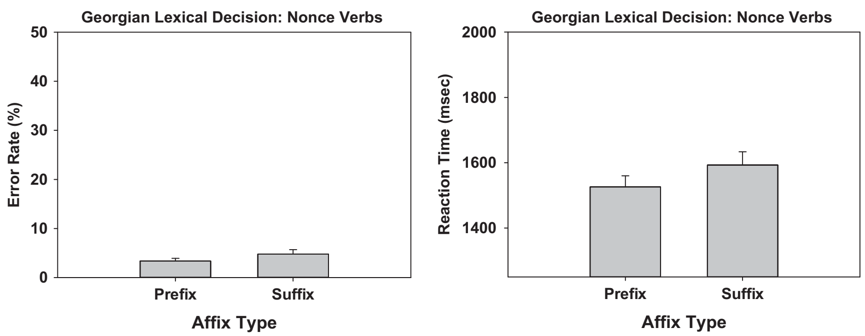

Figure 14. Error rates (left panel) and response times (right panel) for lexical decision judgments for nonce Georgian verbs. Error bars represent standard errors.

1.632; p =.210, n.s.). This was also the case for the error rates for the nonce versions shown in Figure 16 (F(1,36) = 0.730; p =.399, n.s.). The response time data for the nonce versions produced a reversal, with faster responses for the prefixed items (F(1,36) = 19.433; p <.001).

The results were similar for the stimuli that were matched for the number of syllables, rather than the length of the roots. Figure 17 shows the data for the real verbs, and Figure 18 shows the results for the nonce verbs. For the real verbs, there was no difference in the error rates (F(1,36) = 1.214; p = 0.278, n.s.). The reaction times again showed a reversal, with faster responses to items with a prefix (F(1,36) = 18.541; p <.001). The nonce stimuli also produced a reversal, significant for both the error rates (F1,36) = 11.724; p =.002) and for the reaction times (F(1,36) = 22.257; p <.001).

The results for Question B are clearly not supportive of the Cutler-Hawkins hypothesis.

8.7. Question C results and discussion

The third question is rather different from the issues examined in all of the preceding experiments. Those experiments focused on whether performance is better for stimuli with suffixes than for stimuli with prefixes. The issue we examine here arose in the experiments

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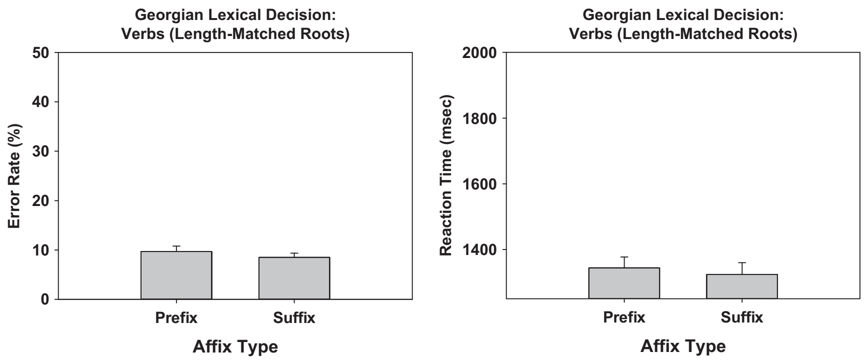

Figure 15. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian verbs matched for length of the roots. Error bars represent standard errors.

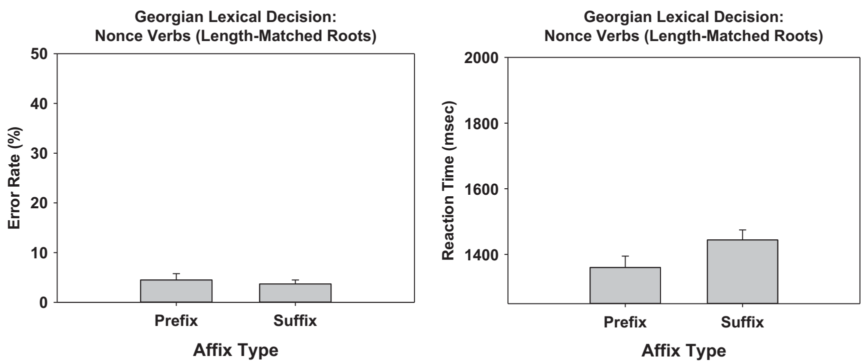

Figure 16. Error rates (left panel) and response times (right panel) for lexical decision judgments for nonce Georgian verbs matched for length of the roots. Error bars represent standard errors.

involving nonce stimuli: Are nonce stimuli harder to classify as nonwords when they include legitimate Georgian affixes? To address this question, we constructed nonwords that had three levels of morphological complexity – simplex, complex, and highly complex. Of course, as we used more morphemes, the nonwords got longer, so we constructed nonwords that matched these three cases in length, but without the morphological structure. We also selected real words with the three levels of complexity; real words should not be more difficult to accept as real with increasing morphological complexity.

We first report the results for the real words, to confirm that they do not become systematically more difficult to recognize as words as the morphological complexity increases. Figure 19 shows the error rates and reaction times for the real words, for the three levels of morphological complexity. As the left panel shows, it is actually the simplest items that are most difficult to accept – words with additional real morphemes are easier to recognize ($F(2,72) = 104.562$; $p < .001$). For the reaction times, the middle level of complexity led to somewhat faster responses than the simpler or more complex cases

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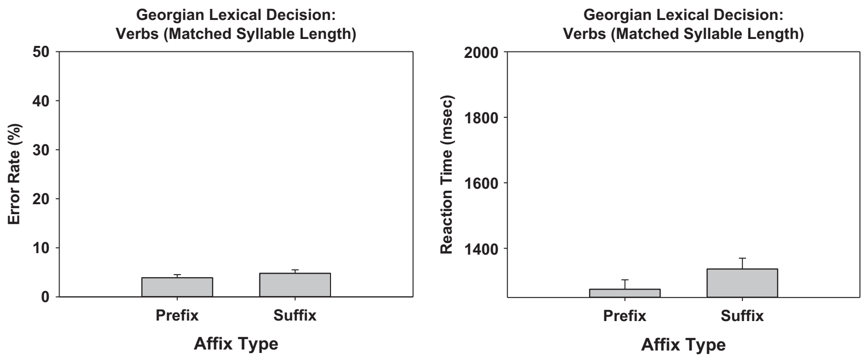

Figure 17. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian verbs matched for number of syllables. Error bars represent standard errors.

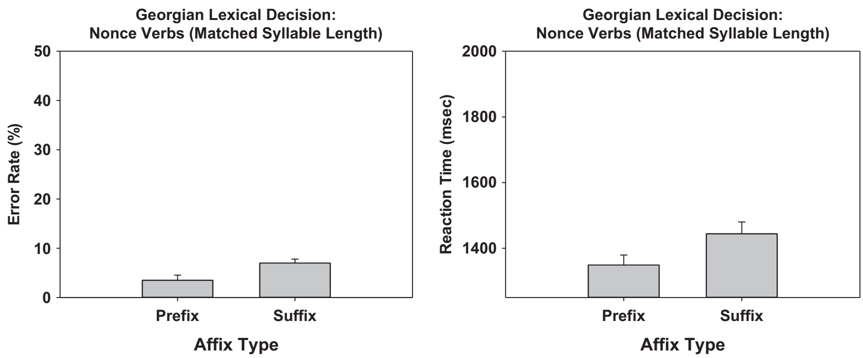

Figure 18. Error rates (left panel) and response times (right panel) for lexical decision judgments for nonce Georgian verbs matched for number of syllables. Error bars represent standard errors.

($F(2,72) = 20.675$; $p < .001$). This may reflect a mix of more morphological evidence being helpful, but longer words taking more time to process.

The critical items for Question C are the nonce words that have different levels of morphological complexity. The hypothesis is that the more a nonce word shows evidence of being a real word, by virtue of including real affixes, the more difficult it should be to reject the item. Figure 20 shows that in fact the simplex items were the easiest and fastest to reject, with the complex and highly complex nonce words producing more errors ($F(2,72) = 8.166$; $p = .001$) and slower response times ($F(2,72) = 66.414$; $p < .001$).

One complication in interpreting the nonce word results is the confounding of item length with morphological complexity – the more complex items are also longer, and the length of a nonword might in and of itself affect performance. To control for this, we included a set of nonce words that were matched in length to the critical nonce words, but without a corresponding increase in morphological complexity for the longer items. Figure 21 shows the error rates and response times for these items (in the figure, the

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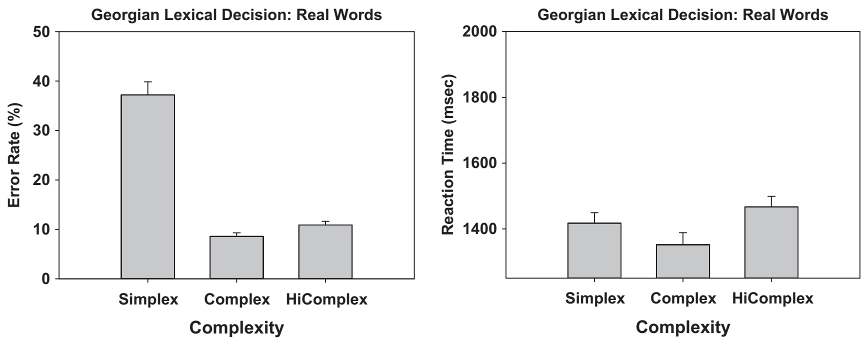

Figure 19. Error rates (left panel) and response times (right panel) for lexical decision judgments for real Georgian words as a function of morphological complexity. Error bars represent standard errors.

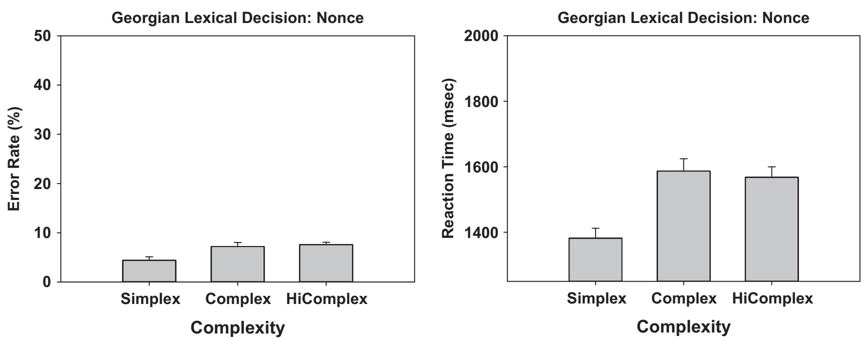

Figure 20. Error rates (left panel) and response times (right panel) for lexical decision judgments for Georgian nonce words as a function of morphological complexity. Error bars represent standard errors.

Complexity axis refers to what the items were matched to – they did not themselves vary in morphological complexity).

As Figure 21 shows, our concern about the simple effect of item length was well-founded: Performance does in fact get worse as a function of nonce word length, even in the absence of increasing morphological complexity. This was true for accuracy ($F(2,72) = 57.489$; $p < .001$) and for reaction times ($F(2,72) = 37.113$; $p < .001$). The critical question is whether the nonce words with morphological structure show an effect of that structure over and above the simple effect of item length. We can answer this question by comparing the patterns for the two different types of nonwords – those with morphological structure and those without it. To test this, we conducted a two-factor analysis of variance for the error rates, and a comparable ANOVA for the reaction times. One factor was item complexity (or length), and the second factor was the stimulus set – the items with morphological structure versus those without it.

The results of the analyses support the conclusion that the presence of morphological structure made it more difficult to reject these items, over and above simple length effects. For errors, this difference manifests as both a main effect of stimulus set, with more errors for

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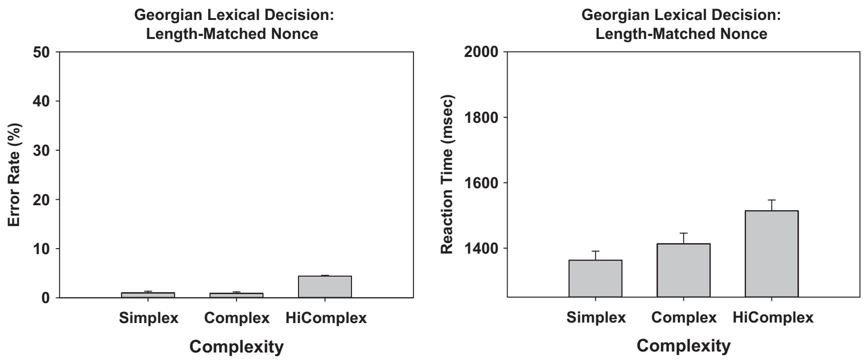

Figure 21. Error rates (left panel) and response times (right panel) for lexical decision judgments for Georgian nonce words that varied in length, matched to the lengths of the critical items that varied in morphological complexity. Error bars represent standard errors.

the morphologically-rich items ($F(1,36) = 76.234$; $p < .001$) and as an interaction between the two factors ($F(2,72) = 8.193$; $p = .001$). The main effect of length/complexity was of course also significant ($F(2,72) = 21.702$; $p < .001$). The same results were found in the reaction time analyses: Morphologically rich nonce words produced longer response times overall ($F(1,36) = 56.735$; $p < .001$), and this difference was more pronounced for complex and highly complex items ($F(2,72) = 17.395$; $p < .001$). Again, the longer/complex items were responded to more slowly ($F(2,72) = 93.782$; $p < .001$).

The results provide a clear affirmative answer to Question C: The presence of real Georgian morphology in a nonword makes it more difficult to reject that item as a real word.

8.8. Summary of answers to Questions A, B, and C

Experiment 6 was conducted after we had assessed the results of the data from the first set of Georgian experiments. That assessment motivated us to undertake additional data collection to address three questions. The first two questions focused on tests of the sort originally conducted in Experiment 2 but with stimuli designed to overcome limitations in the previous tests. The third question was new, stimulated by our observation that it appeared more difficult for the listeners to reject nonce Georgian words if those items included real Georgian affixes. The data provided evidence that such affixes do tend to make nonce words more 'word-like', and thus more difficult to reject as words.

Questions A and B were designed to see if our generally negative findings regarding the Cutler--Hawkins hypothesis in Experiment 2 might have been due to limitations of the stimuli. With the new stimuli, chosen to overcome these concerns, the results remain generally unsupportive of the hypothesis. For Question A (using verbs that take the prefix *v-* versus the suffix *–s)*, there was one supportive result, one significant reversal (i.e. an advantage for prefixes, rather than a disadvantage), and two non-effects. Question B used a new contrast between verbs that take the derivational prefix *i-* versus ones that take the derivational suffix *–d.* Again, the results were not generally consistent with the Cutler--Hawkins hypothesis, with more reversals than results that would be predicted, and a preponderance of cases showing no difference.

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To interpret our results, we need to take into consideration whether Georgian is primarily suffixing, like English, or primarily prefixing, like Kîîtharak. Dryer (2013) provides a way of calculating this for inflectional morphology. The method we applied is shown in Appendix R. According to Dryer's method, Georgian is a language with a 'moderate preference for suffixing'. As far as we are aware, there is no comparable published method for determining preferences for derivational affixes. We believe that the language is roughly balanced with respect to preferences for derivational prefixing and suffixing, as discussed in Appendix R. As a result, it is possible that the mixed results for all experiments, and especially the portions that suggest that processing of prefixes is more accurate or faster than that of suffixes, might be due to the mixed preferences of the language.

Question C was independent of the Cutler--Hawkins hypothesis. We found that nonce words with real Georgian morphology were harder to reject than nonce words with no real morphology, and nonce words with more real morphology were harder to reject than those with less. Although this is an important finding on its own, it does not affect the interpretation of Experiments 2--5 or of Questions A or B in Experiment 6. In each of these we were comparing prefixed words with suffixed words, and the difficulty of this task (due to the presence of real morphology) was matched between the two.

9. General discussion

This project was motivated by two facts and one hypothesis. The facts are that (1) more languages have suffixes than prefixes and (2) languages that have both use suffixes more (Greenberg 1957, 1963). The hypothesis, offered by Cutler, Hawkins, and their colleagues (Cutler et al. 1985; Hawkins & Cutler 1988; Hawkins & Gilligan 1988), is that this 'suffixing preference' stems in part from the greater importance of word onsets than other parts of words during spoken word recognition. This processing asymmetry could make it advantageous to have no prefix, as a prefix alters the hypothetically critical word onset. Most of the research that underlies the idea that onsets are particularly important comes from studies using English or Dutch, a very narrow empirical base to account for facts that apply to thousands of languages from around the world.

We began with an experiment conducted in English – a test that stays close to the original literature that prompted the Cutler--Hawkins hypothesis. We used an auditory lexical decision test because this task has been the most widely used method to measure lexical access. The logic is that factors that support lexical access will lead to faster and more accurate lexical decisions, and factors that impair lexical access will lead to slower and less accurate lexical decisions. Even in a language (English) that had been a primary source of evidence to motivate the Cutler--Hawkins hypothesis, our results were not supportive. The reaction time results did pattern as the hypothesis would predict, with slower lexical decisions for English words with prefixes than for matched words with suffixes. However, the error pattern significantly mismatched the predictions of the hypothesis, with more accurate performance for prefixed words than for suffixed words. This speed--accuracy trade-off cannot be taken as supporting the hypothesis.

The remainder of our experiments were conducted in Georgia, because Georgian morphology provides a rich set of test cases for the Cutler--Hawkins hypothesis, in a language that is outside the Germanic group that includes Dutch and English. Experiment 2 followed

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the approach we took in English, using the well-established lexical decision task to test whether words with prefixes yield less effective lexical access than words with suffixes, the core idea of the Cutler--Hawkins hypothesis. Experiment 6, for both Question A and Question B, used the same task, with additional and refined materials. In this quite broad experimental effort, with multiple types of stimuli and with two separate groups of listeners, we again failed to find evidence to support the hypothesis: Across reaction times and error rates, two of the results were consistent with the hypothesis; four actually significantly contradicted it; and four others showed no differences between prefixed and suffixed items.

To provide a thorough test of the hypothesis, we also included experiments with two additional tasks, as well as tests using nonce words. The additional tasks allow us to see whether the conclusions from lexical decision might be misleading because of some unknown limitation of that task, and the nonce word tests allow us to see whether effects might emerge under especially challenging conditions. One of the additional tasks was the verification test used in Experiment 3 – a task that required listeners to put together information that affects the need for a prefix versus a suffix. This more complex task produced a pattern similar to that found with lexical decision: one supportive result, one significant reversal, and two cases in which there was no difference between prefixed and suffixed items.

The two situations that produced slightly more support for the hypothesis are actually ones that are relatively far-removed from where one might expect an effect to express itself. The nonce stimuli tested in Experiment 2 (lexical decision) and Experiment 4 (verification) collectively yielded four significant outcomes favoring the hypothesis, two significant reversals, and three cases with no differences. This is not strong positive evidence, but it is more positive than what was found with real words. In addition, the production task in Experiment 5 showed that generating words with a prefix was more error-prone than generating words with a suffix. The production test and the nonce cases are not as directly related to predictions of the Cutler--Hawkins hypothesis as the real-word lexical decision and verification tests, but they do offer a small bit of positive evidence.

Although it does not affect our results in these experiments, we discovered that speakers find it harder to reject nonce words with real morphology. Similarly, we found that the more real morphology there is, the harder the nonce word is to reject.

We recently completed a set of experiments that test an extension of the Cutler--Hawkins hypothesis (Harris & Samuel 2025). Just as prefixes and suffixes are small pieces that get positioned before or after a root, some languages use clitics to accomplish similar functions. For example, in Spanish, the clitic *me* ‘me’ can be added to the end of the expression *puedes llamar* ‘you can call’, changing it to *puedes llamarme* ‘you can call me’. In this example, the clitic *me* is similar to a suffix, and in fact, historically, suffixes and prefixes can evolve from clitics. Our experiments with clitics used Udi (a language spoken in Azerbaijan) and European Portuguese because both of these languages have a rich set of clitics; clitics can be used in front of words (like a prefix) and after words (like a suffix), as well as within words. Our extension of the Cutler--Hawkins hypothesis to clitics involved testing whether a clitic positioned before a word is like a prefix in interfering with the hypothetically-critical onset, versus a clitic after a word (like a suffix). The Udi and Portuguese experiments included lexical decision, verification, and production tasks like those used in the current study. As in the current study, the results overall were not especially consistent with the Cutler--Hawkins hypothesis. There was a somewhat more consistent tendency to find support for the hypothesis in the reaction-time data for lexical decision and verification, but this was offset by the error patterns not showing a disadvantage for clitics that preceded a word. In addition, the processing-interruption idea

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underlying the Cutler--Hawkins hypothesis would predict that clitics placed within a root should be particularly disruptive, but that was not the case.

Taken together with the current study, we have data from English, Georgian, Udi, and European Portuguese that bear on whether the suffixing preference is a consequence of a particular processing asymmetry: Early parts of spoken words are especially important, and therefore prefixes could be more disruptive than suffixes. This would provide pressure to disfavor prefixes relative to suffixes, the pattern observed across the languages of the world (Greenberg 1957, 1963). On balance, across the different tasks, different measures, and different languages, there is not good evidence to support the hypothesis.

Given this, it appears prudent to consider alternative explanations of the suffixing preference. As we noted previously, there are several quite different accounts that have been offered. For example, Hupp et al. (2009) have argued that there may be a domain-general preference for onsets versus offsets that cuts across both language and non-linguistic stimuli. Asao (2015) has suggested that the preference may be a consequence of general factors that affect segmentation of morphemes, including prefixes, roots, and suffixes. The suffixing preference itself is well-established, but our results suggest that the basis for this preference does not lie in processing. In fact, our results demonstrate that it should not be assumed (without specific testing) that suffixes are easier to process than prefixes.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S0022226724000033.

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Competing interest. The authors declare none.

References

Asao, Yoshihiko. 2015. Left-right asymmetries in words: aprocessing-based account. Dissertation. University at Buffalo, SUNY.

Beauvillain, Cécile. 1996. The integration of morphological and whole-word form information during eye fixations on prefixed and suffixed words. *Journal of Memory and Language* 35, 801–820.

Bertram, Raymond, Matti Laine, and Katja Karvinen. 1999. The interplay of word formation type, affixal homonomy, and productivity in lexical processing: Evidence from a morphologically rich language. *Journal of Psycholinguistic Research* 28(3), 213–226.

Beyersmann, Elisabeth, Johannes C. Ziegler & Jonathan Grainger. 2015. *Differences in the processing of prefixes and suffixes revealed by a letter-search task*. Scientific Studies of Reading, 360–373. doi: 10.1080/10888438.2015.1057824.

Bridgers, Franca Ferrari & Natalie Kacinik. 2017. How linearity and structural complexity interact and affect the recognition of Italian derived words. *Journal of Psycholinguistic Research* 46, 175–200.

Broerse, A.C. & E.J. Zwaan. 1966. The information value of initial letters in the identification of words. *Journal of Verbal Learning and Verbal Behavior* 5, 441–446.

Browman, Catherine P. 1978. *Tip of the tongue and slip of the ear: Implications for language processing*. UCLA Working Papers in Phonetics 42.

Brown, Roger & David McNeill. 1966. The 'tip of the tongue' phenomenon. *Journal of Verbal Learning and Verbal Behavior* 5, 325–337.

Cutler, Anne & David M. Carter. 1987. The predominance of strong initial syllables in the English vocabulary. *Computer Speech and Language* 2, 133–142.

Cutler, Anne, John A. Hawkins & Gary Gilligan. 1985. The suffixing preference: A processing explanation. *Linguistics* 23, 723–758.

Cutler, Anne & Dennis Norris. 1988. The role of strong syllables in segmentation for lexical access. *Journal of Experimental Psychology: Human Perception and Performance* 14, 113–121.

Deutsch, Avital, Ram Frost & Kenneth I. Forster. 1998. Verbs and nouns are organized and accessed differently in the mental lexicon: Evidence from Hebrew. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 24, 1238–1255.

Domínguez, Alberto, Maira Alija, Javier Rodríguez-Ferreiro, Fernanado Cuetos. 2010. The contribution of prefixes to morphological processing of Spanish words. *European Journal of Cognitive Psychology* 22, 569–595.

Dryer, Matthew S. 2013, Prefixing vs. suffixing in inflectional morphology. In Matthew S. Dryer & Martin Haspelmath (eds.), *World Atlas of Language Structures*, Ch. 26. https://wals.info/chapter/26, (accessed 21 July 2019).

Enrique-Arias, Andrés. 2000. Spanish object agreement markers and the typology of object agreement morphology. In Steven N. Dworkin & Dieter Wanner (eds.), *New approaches to old problems: Issues in Romance historical linguistics*, 149–164. Amsterdam: Benjamins.

Enrique-Arias, Andrés. 2002. Accounting for the position of verbal agreement morphology with psycholinguistic and diachronic explanatory factors. *Studies in Language* 26, 1–31.

Feldman, Laurie Beth & Jacqueline Larabee. 2001. Morphological facilitation following prefixed but not suffixed primes: Lexical architecture or modality-specific processes? *Journal of Experimental Psychology: Human Perception and Performance* 27, 680–691.

Friederici, Angela D., Anja Hahne & Axel Mecklinger. 1996. Temporal structure of syntactic parsing: Early and late event-related brain potential effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 22, 1219–1248.

Frost, Ram, Avital Deutsch, Orna Gilboa, Michal Tannenbaum & William Marslen-Wilson. 2000. Morphological priming: Dissociation of phonological, semantic, and morphological factors. *Memory and Cognition* 28, 1277–1288.

Frost, Ram, Kenneth I. Forster & Avital Deutsch. 1997. What can we learn from the morphology of Hebrew: A masked-priming investigation of morphological representation. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23; 829–856,

Giraudo, Hélène & Jonathan Grainger. 2003. On the role of derivational affixes in recognizing complex words: Evidence from masked priming. In R. Harald Baayen & Robert Schreuder (eds.), *Morphological structure in language processing*, 209–232. Berlin: Mouton de Gruyter.

Grainger, Jonathan, Pascale Colé & Juan Segui. 1991. Masked morphological priming in visual word recognition. *Journal of Memory and Language* 30, 370–384.

Greenberg, Joseph H. 1957. Order of affixing: A study in general linguistics. *Essays in linguistics*, by J.H. Greenberg. Chicago: University of Chicago Press.

Greenberg, Joseph H. 1963. Some universals of grammar with particular reference to the order of meaningful elements. In Joseph H. Greenberg (ed.), *Universals of language*, 73–113. Cambridge, Mass: MIT Press.

Grojean, François. 1980. Spoken word recognition processes and the gating paradigm. *Perception and Psychophysics* 28, 267–283.

Harris, Alice C. 1981. *Georgian syntax: A study in relational grammar*. Cambridge: Cambridge University Press.

Harris, Alice C. & Arthur G. Samuel. 2025. Processing and production of clitics in Udi and European Portuguese: Testing a processing account of an extension of the suffixing preference. *The Journal of Linguistics*, this issue.

Hawkins, John A. & Anne Cutler. 1988. Psycholinguistic factors in morphological asymmetry. In John A. Hawkins (ed.), *Explaining language universals*, 280–317. Oxford: Blackwell.

Hawkins, John A. & Gary Gilligan. 1988. Prefixing and suffixing universals in relation to basic word order. *Lingua* 74, 219–259.

Horowitz, Leonard M., Margaret A. White, & Douglas W. Atwood. 1968. Word fragments as aids to recall:The organization of a word. *Journal of Experimental Psychology* 76, 219–226.

Horowitz, Leonard M., Peter C. Chilian & Kenneth P. Dunnigan. 1969. Word fragments and their redintegrative powers. *Journal of Experimental Psychology* 80, 392–394.

Hupp, Julie M., Vladimir M. Sloutsky & Peter W. Culicover. 2009. Evidence for a domain-general mechanism underlying the suffixation preference in language. *Language and Cognitive Processes* 24, 876–909.

Kgolo, Naledi & Sonja Eisenbeiss. 2015. The role of morphological structure in the processing of complex forms: Evidence from Setswana deverbative nouns. In Alice C. Harris, T. Florian Jaeger & Elisabeth Norcliffe (eds.), *Laboratory in the field: Advances in cross-linguistic psycholinguistics*, special issue of *Language, Cognition and Neuroscience* 30, 1116–1133.

Kim, Say Young, Min Wang & Marcus Taft. 2015. Morphological decomposition in the recognition of prefixed and suffixed words: Evidence from Korean. *Scientific Studies of Reading* 00, 1–21.

Kuperman, Victor, Raymond Bertram & R. Harald Baayen. 2010. Processing trade-offs in the reading of Dutch derived words. *Journal of Memory and Language* 62, 83–97.

Marslen-Wilson, William D. 1980. Speech understanding as a psychological process. In J.C. Simon (ed.), *Spoken language generation and understanding*, 39–67. Dordrecht: Reidel.

Marslen-Wilson, William, Lorraine Komisarjevsky Tyler, Rachelle Waksler & Lianne Older. 1994. Morphology and meaning in the English mental lexicon. *Psychological Review* 101, 3–33.

Martin, Alexander & Jennifer Culbertson. 2020. Revisiting the suffixing preference: Native-language affixation patterns influence perception of sequences. *Psychological Science* 31, 1107–1116.

Nooteboom, Sieb G. 1981. Lexical retrieval from fragments of spoken words: Beginnings versus endings. *Journal of Phonetics* 9, 407–424.

Pounder, Amanda. 2000. *Processes and paradigms in word-formation morphology*. Berlin: Mouton de Gruyter.

Siewierska, Anna & Dik Bakker. 1996. The distribution of subject and object agreement and word order type. *Studies in Language* 20, 115–161.

SUBTLEXus. https://www.ugent.be/pp/experimentele-psychologie/en/research/documents/subtlexus, Ghent University (accessed 13 December 2021).

Taft, Marcus & Kenneth I. Forster. 1975. Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior* 14, 638–647.

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