



ASYMMETRIES IN THE PROCESSING OF AFFIXED WORDS IN BENGALI

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Prefixes and suffixes display distinctive linguistic behaviors. Not only does a crosslinguistic asymmetry exist between them in terms of structural properties, combinatorial constraints, and frequency, but there is also extensive evidence that prefixes and suffixes are processed differently. To further investigate the differences in how prefixes and suffixes are processed, we conducted five crossmodal priming experiments in Bengali, a language rich in derivational morphology. Although all combinations of stems, prefixes, and suffixes provided facilitation, we found that stems primed related prefixed forms to a greater degree than they primed related suffixed forms. Furthermore, morphologically related prefixed forms primed other prefixed forms more than suffixed forms primed related suffixed forms. On the basis of these findings, we propose that the asymmetry in how prefixes and suffixes are processed is due not only to differences in perception, reading, and inhibition from the phonological cohort, but also to the salience of the morpheme boundaries in affixed word representations during recognition.*

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1. INTRODUCTION. The term ‘affix’ refers to several categories, including (minimally) prefixes, suffixes, circumfixes, and infixes, all of which at first glance appear to have much in common: they are bound morphemes anchoring to a stem/root. However, derivational prefixes and suffixes display distinctive linguistic behaviors beyond merely the difference in where they attach to the stem. Conspicuously, they are not crosslinguistic equals: suffixation is more common than prefixation, an assertion that has been made repeatedly and evidence for which is well attested (see Sapir 1921, Jespersen 1942, Greenberg 1957, 1963, Plank 1981, 1988, Hall 1988, Hawkins & Gilligan 1988, Bybee et al. 1990, Haspelmath 1995, Hyman 2008). But that does not mean this applies universally: although rare, some language families, such as Athabaskan (Rice 1993, Berez & Gries 2010), show a marked prefixing preference. This general tendency toward suffixation seems linked to the fact that diachronic processes converting independent words into affixes invariably proceed via cliticization, and encliticization is far more prevalent than procliticization, leading to the development of more suffixes than prefixes (Lahiri & Plank 2010).

Furthermore, although there is evidence that morphological decomposition involving derivational affixes plays a role in language comprehension, the precise mechanisms are not yet well understood. The asymmetric behavior of prefixes and suffixes has been examined at length not only in the typological literature, but also in the psycholinguistic literature, where numerous experimental studies have shown that prefixed and suffixed words are processed differently (see e.g. Taft & Forster 1975, Bergman et al. 1988,

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Grainger et al. 1991, Marslen-Wilson et al. 1994, Beauvillain 1996, Feldman & Soltano 1999, Reid & Marslen-Wilson 2000, Feldman & Larabee 2001).

These results have had significant implications for theories concerning the storage and decomposition of morphologically complex words (see e.g. Taft & Forster 1975, Butterworth 1983, Schreuder & Baayen 1995, and Grainger & Beyersmann 2017). While there is mounting evidence that the internal structure of words plays a role in language comprehension, some crucial questions remain about how the relationship between affixes and stems affects processing. This study presents a comprehensive investigation into the relationship between affixed words and their stems in a language rich in derivational morphology: Bengali. We argue in support of an inherent suffix/prefix asymmetry that is reflected in processing. As background, we begin with a description of the crosslinguistic evidence for the suffix/prefix asymmetry from the phonological (diachronic and synchronic) and psycholinguistic perspectives.

The crosslinguistic suffixation preference has been attributed to two main causes: diachronic effects and processing factors. First, from a historical perspective, the grammaticalization cline gives rise to more suffixes than prefixes (Haspelmath 1989, Bybee et al. 1990, Hopper & Traugott 1993). Second, within the psycholinguistic literature, it has been suggested that there is a processing advantage for stem-initial words, since in these items the stem's semantic and phonological information is perceived first (Cutler et al. 1985, Hawkins & Cutler 1988). We discuss each explanation in turn. In §§1.1 and 1.2 below, we reflect on the diachronic aspects of affixation, with a focus on the phonological processes that apply to stems and their affixes, particularly for Bengali. In §1.3, we outline findings from experimental studies designed to investigate the processing of affixes. We are primarily interested in whether the prefix/suffix asymmetry is reflected in processing, and if so, how.

1.1. EVIDENCE FOR THE PREFIX/SUFFIX ASYMMETRY. The grammaticalization literature argues that full words first gradually become weak words, then affixes (e.g. Traugott & Heine 1991). Thus, grammaticalization acts essentially as a form of phonological encliticization that eventually allows full prosodic words to become affixes, as in the Old Norse enclitic form *-sk*, which developed from the reflexive pronoun *sik*: *falla sik* > *fallask* 'he lay'. A further claim is that this articulatory weakness is more likely to affect the end than the beginning of phonological units (Hall 1988). A preference for encliticization (rather than procliticization) is directly connected to prosodic phrasing (Kim 2010, Lahiri & Plank 2010, Himmelmann 2014, Lahiri & Sytsema 2018), given that a prosodic boundary is typically found between a lexical word and a preceding function word (e.g. between *to* and *bed* in *going to bed*) rather than between a lexical word and a following function word (e.g. between *going* and *to* in *going to bed*).¹ This relationship between syntax and phonology leading to encliticization is attested in several languages: for example, the contractions of phrases such as *have to go* > *hafta go* or *fish and chips* > *fish 'n chips* in English.

While no single explanation for the asymmetrical behavior of prefixes and suffixes has been accepted, it is clear that the relationship between stems and suffixes is different from that between stems and prefixes. This asymmetry has been the subject of discussion for centuries, particularly in regard to changes a stem undergoes once an affix attaches (e.g.

¹ See experimental research in language production where in sequences such as *X the Y*, the boundary between *X* and *the* is so weak that this two-word sequence is treated as one prosodic unit (Wheeldon & Lahiri 1997, Wynne et al. 2018).

von Schlegel 1808, von Humboldt 1822, Haldeman 1871). Indeed, nowhere is the difference between prefixes and suffixes more apparent than in how phonological processes apply differently across prefix-stem and stem-suffix boundaries. Two processes that exhibit this asymmetry are resyllabification and assimilation, which we discuss in turn.

Resyllabification is less frequent across prefix-stem boundaries than across stem-suffix boundaries. Thus, it is more common for morphological and syllabic boundaries to be misaligned in stem-suffix than in prefix-stem configurations. In English *sanity*, for instance, the stem-final consonant [n] is syllabified together with the suffix-initial vowel [ɪ], resulting in a form where the morpheme ([sæn-ɪti]) and syllable ([sæ.nɪ.ti]) boundaries are misaligned. This contrasts with prefix-stem words such as *unable*, where the morpheme ([ʌn-eɪbəl]) and syllable ([ʌn.eɪbəl]) boundaries are aligned.

Similar evidence is provided from epenthesis, which is far less common at suffix boundaries than it is at prefix boundaries, where it prevents the boundary between a prefix and a stem from occurring syllable-internally. In German, for instance, vowel-initial syllables are dispreferred, and a glottal stop is inserted at the beginning of vowel-initial words in order to avoid such syllables, as in *Arbeit* [ʔa:bart] 'work'. A glottal stop is similarly inserted at a prefix (but not at a suffix) boundary; see example 1. Crucially, stress plays no role in this epenthesis; regardless of whether a prefix is stressed, it requires a glottal stop before a vowel-initial stem to keep it phonologically separate from the stem. No such glottal stop is required between a stem and suffix in order to preserve the alignment between syllable and stem edges; the stem-final consonant is free to be resyllabified with the suffix, as can also be seen in 1.

(1) German epenthesis

- a. ver-*arbeit*-en [fɛ:.'ʔa:baɪ.tən] 'to process'
- b. vór-*arbeit*-en ['fɔ:.'ʔa:baɪ.tən] 'to do groundwork'

It is also the case that suffixes are often found in the same stress domain as the stem (or root, depending on the language), while prefixes are more likely to form a stress domain independent from the stem (see Cohn 1989 and Cohn & McCarthy 1998). In Indonesian, for example, main stress typically falls on the penultimate syllable, but prefixes are ignored when stress is assigned, as in *cát* 'print' > *di-cát* 'PASS-print', not **dí-cat* (cf. *cári* 'look for' > *mən-carí-kan* 'search for').

Phonological assimilation, or spreading of features, is common across stem-affix boundaries, but here too we see asymmetries. Two types of assimilation bind adjacent segments by feature sharing: regressive and progressive. Typologically, regressive assimilation (where a sound is affected by properties of a following sound) is more prevalent than progressive assimilation (where a sound is affected by properties of a preceding sound). Consequently, an immediate asymmetry emerges when we consider linear sequences of morphological units (see 2 below): frequent regressive assimilation entails that phonological features of suffixes are more likely to AFFECT the stem, while phonological features of prefixes are more likely to BE AFFECTED BY material in the stem. This asymmetry is even more pronounced if we consider the domains of affixation: assimilation between stems and suffixes can be either regressive or progressive, but for prefixes and stems only regressive assimilation is generally found.

Examples of regressive assimilation between suffix and stem show the effect of the bond between the two. Germanic umlaut is a classic case of regressive assimilation, in which the high front vowel of the suffix fronts the vowel of the stem. In both 2a and 2b, the stem vowel changes when a suffix attaches to the stem.

(2) Germanic umlaut (stem to suffix; regressive)

a. Old English

fōt 'foot.sg'
 fōt-i > fēt-i > fēt 'foot-PL'; the plural suffix -i [i] fronts the stem vowel,
 cf. Mod. Eng. *foot-~~feet~~*

b. German

Tag 'day.sg'
 täglich 'daily'; the vowel [i] in -lich fronts the vowel of the
 stem

Progressive assimilation involving vowels is most commonly found in agglutinating languages (which are predominantly suffixing), and here it is the stems that affect the suffixes. In 3, we give a typical example of vowel harmony in Turkish.

(3) Turkish vowel harmony (stem to suffix; progressive)

	NOM SG	NOM PL	
a.	ip	ip-ler	'rope'
	el	el-ler	'hand'
b.	pul	pul-lar	'stamp'
	son	son-lar	'end'

When the stem has a front vowel [i, e], the plural suffix similarly surfaces with a front vowel, -*ler*, as in 3a. By contrast, back stem vowels [u, o] cause the suffix to surface with a back vowel, -*lar*, as in 3b.

Progressive assimilation between stems and suffixes can involve not only vowels, but also consonants. A well-known example is voicing assimilation in English, where the plural and past-tense suffixes are affected by the form of the stem. Note that in both the Turkish and the English examples, the stem remains unchanged.

(4) English voicing assimilation (stem to suffix; progressive)

a.	leg – legs	[lɛgz]
	stick – sticks	[stɪks]
b.	beg – begged	[bɛgd]
	pick – picked	[pɪkt]

Examples of assimilation between prefixes and stems are rarer and typically occur only in one direction, viz. prefix to stem. Thus, assimilation between prefixes and stems is generally regressive: the material in the prefix changes, rather than the stem. For example, in English, the final nasal in the Latinate negative prefix *in-* undergoes complete assimilation with a stem-initial sonorant (*illegal*, *irrelevant*) and takes on the place of articulation of a stem-initial obstruent (*impossible*, *i[ŋ]congruent*; Clements 1985). Progressive assimilation across the prefix-stem boundary, while possible, is much less frequent.²

Thus, not only does an inherent asymmetry exist in the diachronic pattern of affix formation (encliticization leading to suffixation more often than to prefixation), but there is also a striking difference in the phonological effects that occur between the affix and the stem depending on whether a prefix or a suffix is involved. In the following section, we consider these asymmetries in Bengali, the language in which our study was conducted.

² For example, Chamorro has a progressive vowel fronting rule whereby a preceding particle affects the stem, for example, *tómu* 'knee' > *i tému* 'the knee' (see Topping 1968). However, it is unclear what the status of the particle is.

1.2. BENGALI. The Bengali language lends itself well to an experimental study of the processing of affixed words for a number of reasons. First, Bengali provides a set of affixes that can be strictly controlled in terms of history and synchronic behavior: for instance, unlike the Germanic languages, where a large number of affixes are not inherited but borrowed, most derivational affixes in Bengali have the same provenance, having originated within the history of Bengali itself (see Chatterji 1975 [1926]). Second, stress in Bengali is overwhelmingly word-initial and applies on the word level after affixation. Third, a number of phonological processes (e.g. resyllabification and assimilation) apply across both prefix-stem boundaries and stem-suffix boundaries. Unlike in the examples from German and English discussed in §1.1, in Bengali both suffixes and prefixes can create domains with their stems in which resyllabification and assimilation can apply. Nevertheless, the affects of these phonological processes on the stem are asymmetric and contingent on whether the rule domain includes a prefix or a suffix. We discuss each in turn.

First, resyllabification entails that the coda of a syllable becomes the onset of the following syllable if the latter begins with a vowel. Thus, the very nature of phonological resyllabification implies that the syllabic structure of a morpheme will change.

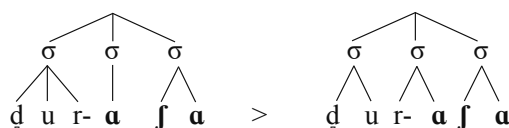


FIGURE 1. Resyllabification in a Bengali prefixed form ([d̪ur-aɹ̥] ‘bad desire; unreachable wish’).

In the example in Figure 1, resyllabification has led to the prefix-final consonant /r/ becoming a part of the first syllable of the stem. Consequently, the syllabic structure of the stem, which was /V.CV/, has changed to /CV.CV/. Resyllabification can also result in a change to the stem at a suffix edge, as indicated in the example in Figure 2, where the final coda consonant of the stem becomes the onset of the following suffix. Here, the CVC syllabic structure of the stem changes to CV after suffixation.



FIGURE 2. Resyllabification in a Bengali suffixed form ([pe-t-uk] ‘glutton’).

Thus, resyllabification can affect the syllabic structure of the stem for both suffixed and prefixed domains.

Second, assimilation, by definition, implies an alteration of phonological features in context and can lead to asymmetric effects on the stem. As mentioned in §1.1, regressive assimilation is far more common than progressive assimilation: in a two-phoneme sequence, the first phoneme will change based on features of the second phoneme. In Bengali, regressive assimilation applies across both prefix-stem and stem-suffix boundaries. But unlike resyllabification (where the effect on the stem is symmetrical), regressive assimilation has asymmetrical effects on the stem: the shape of the stem can be altered in a suffix domain but not in a prefixed domain.

For instance, in a sequence /r + C/ where C is a [CORONAL] consonant (such as /t̪, d̪, ʈ, dʒ, l, n/), /r/ takes on all of the features of the following consonant, which leads to a geminate (double consonant). That is, /r + C/ becomes a geminate /C:/ (see Figure 3).

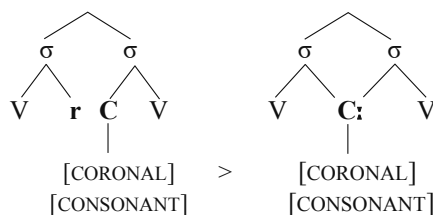


FIGURE 3. Regressive assimilation in Bengali with /r/ and a following [CORONAL] consonant.

In the examples in 5, the consequence of this assimilation is that the final consonant /r/ of the prefix /dur-/ ‘NEG’ disappears, and the initial /d̪/ or /n/ of the stem becomes geminated instead.

- (5) a. /dur-**niṭi**/ > [d̪un:ṭi] NEG-policy ‘corruption’
 b. /dur-**ḍin**/ > [d̪uḍ:in] NEG-day ‘bad days’

As a result, in terms of syllable structure, the geminated [d̪:] or [n:] does double duty as both the coda of the prefix and the onset of the initial syllable of the stem, as seen in Figure 4. Crucially, the segmental makeup of the stem remains unchanged, while the prefix changes from /CVr/ to /Cvḍ/ or /CVn/.

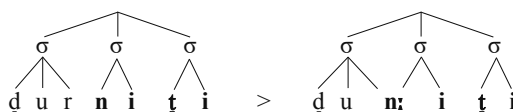


FIGURE 4. Regressive assimilation with the prefix /dur-/.

The assimilation effects are the same in the suffix domain: in the example in 6, the stem-final /r/ disappears and the initial coronal consonant of the suffix is geminated, so that it now does double duty as the coda of the final syllable of the stem and the onset of the suffix syllable (see Figure 5). For this domain, however, it is the segmental makeup of the stem that is affected rather than that of the suffix: the stem-final /r/ has become /dʒ:/, while the suffix is unchanged.³

- (6) /**prəṭfur**-dʒo/ > [prəṭfudʒ:o] abundant-NMLZ ‘abundance’

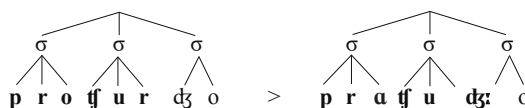


FIGURE 5. Regressive assimilation with the suffix /-dʒo/.

Thus, unlike English and German, Bengali allows resyllabification and assimilation to apply at both edges of the stem; but crucially, the effects of these phonological processes on the shape of the stem differ depending on the affix domain involved. The consequences of resyllabification apply equally to the stem for both affix domains; at

³ The change to the stem vowel in /prəṭfur/ is an independent morphophonological rule.

the left edge the stem acquires an onset consonant, and at the right edge the stem loses a coda consonant. For assimilation, however, the effects on the stem are asymmetric. When the stem is prefixed, regressive assimilation affects the prefix, not the stem, which remains unchanged. But when regressive assimilation applies across a stem-suffix boundary, the final consonant of the stem changes. Thus, where assimilation is concerned, the suffix has a more radical effect on the stem than the prefix does; the segmental makeup of the stem has been altered. The stem morpheme, which is a free morpheme and a lexical word, is considered crucial in lexical access. A change in the shape of the stem under one type of affix but not another could therefore potentially have an effect in processing. In the following section, we consider how such effects may be perceived in existing psycholinguistic evidence.

1.3. PSYCHOLINGUISTIC EVIDENCE FOR POSITIONAL ASYMMETRY. Psycholinguistic studies employing lexical-decision paradigms (both with and without priming) have found evidence that prefixed words and suffixed words are processed differently. One consistent experimental finding is that, while prefixed words (e.g. *misuse*) regularly prime both related prefixed forms (e.g. *reuse*) and suffixed forms (e.g. *useful*) as well as stems (e.g. *use*), suffixed words (e.g. *useful*, *useless*) reveal less evidence of facilitation for any type of related target (e.g. *misuse*, *use*), particularly in visual paradigms. In fact, while several studies (e.g. Feldman & Larabee 2001) find less facilitation for configurations containing suffixed primes, others (e.g. Grainger et al. 1991, Marslen-Wilson et al. 1994, Reid & Marslen-Wilson 2000, Smolka et al. 2009) find no facilitation at all.

In this section, we present findings from experimental studies that investigate the processing of affixed words and their related unaffixed words (e.g. *impure*, *purity*, *pure*). In order to review how each type of affix affects the processing of related stems, these findings have been organized into sections by the priming configurations employed, for example, stem-prefixed. As we will see below, with the exception of Marslen-Wilson et al. 1994, these studies typically examine only one type of priming configuration, such as priming of a stem by an affixed word (*impure*–*PURE*, *purity*–*PURE*) but not vice versa. In fact, findings from affixed-stem configurations dominate the literature on morphological priming (see Diependaele et al. 2009). As a consequence, these studies often fail to examine the other direction of priming (stem-affixed, e.g. *pure*–*IMPURE*, *pure*–*PURITY*). Furthermore, few studies test more than one or two of the possible morphological relationships between prefixes/suffixes and stems. For example, a study may investigate prefixed words in a particular language, but not suffixed words.

Given the asymmetry of the phonological patterning of prefixed and suffixed words, however, it is detrimental to not examine all possible relationships and configurations between morphologically related forms. As far as we are aware, Marslen-Wilson et al. (1994) is the only study to have examined all priming configurations for affixed words and stems, and even then the degree of priming across experiments was not investigated fully. For example, while Marslen-Wilson et al. found priming for both stem-prefixed forms (e.g. *sincere*–*INSINCERE*) and stem-suffixed forms (e.g. *friend*–*FRIENDLY*), they did not examine whether one configuration primed more than the other, that is, whether one condition elicited stronger priming effects than the other. Such an analysis is crucial if we are to look for signs of asymmetry in the processing of prefixed and suffixed forms.

Studies examining PREFIXED-STEM priming configurations (e.g. *impure*–*PURE*) have generally found strong effects of morphological priming, at least when the semantic relationship between the words is transparent. In crossmodal priming experiments, Marslen-Wilson et al. (1994) found priming for semantically transparent word pairs such as *insincere*–*SINCERE*, but semantically opaque pairs such as *restrain*–*STRAIN* did

not show priming. Meunier and Segui (2002) also found crossmodal priming effects for French prefixed–stem pairs (*incomplet*–*COMPLET* ‘incomplete–complete’), and Giraudo and Voga (2013) replicated this finding in masked priming conditions (*prénom*–*NOM* ‘first name–name’). In the crossmodal studies of Meunier and Segui (2002), prefixed words primed stems even when the phonological relationship between the forms was opaque (e.g. French *imberbe*–*BARBE* ‘beardless–beard’). Kazanina (2011) similarly found priming for semantically transparent Russian noun pairs (e.g. *narost*–*ROST* ‘out-growth–growth’). In the STEM–PREFIXED configuration, semantically transparent word pairs (e.g. *pure*–*IMPURE*) also show significant priming effects (see Grainger et al. 1991, Marslen-Wilson et al. 1994, Giraudo & Grainger 2003, Kazanina 2011), but there exists considerably less evidence for this configuration. Overall, it appears that as long as the semantic relationship between the words is transparent, prefixed words prime morphologically related stems (e.g. *impure*–*PURE*) and vice versa (e.g. *pure*–*IMPURE*).

In SUFFIXED–STEM priming configurations (e.g. *purity*–*PURE*), suffixed words typically prime morphologically related stems (Morris et al. 2011, Beyersmann et al. 2013, Coughlin & Tremblay 2015, Kim et al. 2015, Kraut 2015, Beyersmann et al. 2016). Marslen-Wilson et al. (1994) found crossmodal priming for semantically transparent suffixed–stem word pairs such as *serenity*–*SERENE* and *punishment*–*PUNISH*. Semantically opaque suffixed–stem pairs (e.g. *casualty*–*CASUAL*), however, failed to prime. Gonnerman and Andersen (2000) also found that suffixed–stem combinations primed in crossmodal conditions only when the pairs were closely related both semantically and phonologically, such as *lately*–*LATE* as opposed to *hardly*–*HARD*. Similarly, Meunier and Segui (2002) found priming for suffixed–stem combinations in crossmodal conditions only when the relationship between the words was phonologically transparent (e.g. French *brutal*–*BRUTE* ‘brutal–brute’); phonologically opaque pairs such as *circulaire*–*CERCLE* ‘circular–circle’ did not induce priming. Finally, Russian diminutive suffixed words (e.g. *gorka* ‘little hill’) were found to prime semantically related stems (e.g. *GORA* ‘hill’) in a masked priming study by Kazanina et al. (2008).

Configurations containing STEM–SUFFIXED combinations (e.g. *pure*–*PURITY*) have produced less predictable results. Marslen-Wilson et al. (1994) found that semantically transparent stems primed related suffixed words (e.g. *friend*–*FRIENDLY*), and Feldman and Larabee (2001) showed strong priming effects for English stem–suffixed pairs (e.g. *pay*–*PAYMENT*) across three different modalities (auditory–visual, visual–auditory, and visual–visual). Conversely, Grainger et al. (1991) did not find priming for French stem–suffixed configurations (e.g. *mur*–*MURET* ‘wall–low wall’) in a masked priming experiment, an outcome attributed in part to orthographic effects related to the masked priming environment. However, Marslen-Wilson et al. (2008) found priming for morphologically transparent stem–suffixed pairs in English (e.g. *brave*–*BRAVELY*) in masked priming. Thus it appears that while the suffixed–stem configuration can elicit strong priming effects, findings for this configuration are less concrete.

The AFFIXED–AFFIXED priming configuration has also received considerable attention in the psycholinguistic literature, likely due to the fact that this configuration involves testing for decomposition of both the prime and the target word. In this configuration, PREFIXED–PREFIXED priming (e.g. *reuse*–*MISUSE*) is generally salient across languages and priming paradigms: Meunier and Segui (2002) found that French prefixed–prefixed pairs (*retourner*–*CONTOURNER* ‘to turn over–to bypass’) primed one another in crossmodal conditions, and Grainger et al. (1991), Giraudo and Voga (2013), and Kim et al. (2015) also found strong priming for prefixed–prefixed pairs in masked priming conditions. Likewise, experiments testing priming of words sharing the same

prefix (e.g. *dislike*–*DISOWN*) have found strong priming effects (e.g. Emmorey 1989, Chateau et al. 2002, Giraudo & Grainger 2003).

However, when we turn to the SUFFIXED–SUFFIXED priming configuration (e.g. *pureness*–*PURITY*), we find conflicting results even within the same language and modality (see Marslen-Wilson et al. 1994 and Meunier et al. 2000). Marslen-Wilson et al. (1994) found no facilitation effects for suffixed–suffixed (e.g. *government*–*GOVERNOR*) pairs, which led them to predict that when a sequence of sounds and syllables is heard, all other related words are also activated (i.e. the COHORT MODEL). Thus, in a crossmodal design where the prime is a suffixed form (e.g. *government*), the stem (*govern*) is heard and accessed first. From this point, any other words that share the same base morpheme are also activated (e.g. *governor*, *governmental*, *governed*), resulting in inhibition due to multiple competitors. Such findings were not restricted to English: in a similar crossmodal task, Reid and Marslen-Wilson (2000) found that Polish suffixed pairs (e.g. *rzeźbi-enie*–⁴*rzeźbi-arz* ‘sculpting~sculptor’) also did not prime one another.

Gonnerman et al. (2007) documented similar effects in crossmodal conditions for suffixed–suffixed pairs with low semantic relatedness (e.g. *useful*–*USELESS*) or low phonological relatedness (e.g. *observation*–*OBSERVANT*), but pairs with high semantic and phonological transparency (e.g. *saintly*–*SAINTHOOD*) resulted in significant priming. Likewise, Meunier and Segui (2002) found that French suffixed words (e.g. *respectueux*–*RESPECTABLE* ‘respectful~respectable’) primed one another.

This disparity in results is not restricted to the crossmodal priming environment: Meunier et al. (2000) found strong evidence of suffixed–suffixed priming in French (e.g. *tristement*–*TRISTESSE* ‘sadly~sadness’) in both crossmodal and masked priming paradigms. By contrast, while Feldman and Soltano (1999) and Feldman and Larabee (2001) found priming for suffixed–suffixed pairs in English (e.g. *calculator*–*CALCULATION*) in visual-visual conditions, when the prime was presented visually and the target auditorily, these pairs did not show facilitation.⁵ Similarly, when the standard crossmodal configuration was employed (auditory prime–visual target), suffixed–suffixed pairs failed to prime.

Lastly, priming experiments testing SUFFIXED–PREFIXED (e.g. *trustful*–*MISTRUST*) and PREFIXED–SUFFIXED (e.g. *mistrust*–*TRUSTFUL*) configurations generally find priming for both directions (Grainger et al. 1991, Marslen-Wilson et al. 1994), although Feldman and Larabee (2001) found priming only in the visual-auditory modality (priming for the prefixed–suffixed configuration in the visual-visual modality was marginal, with significance only in the by-subject analysis).

In sum, it appears that across experimental environments, modalities, and languages, prefixed words reliably prime both related stems and other related affixed words—both prefixed and suffixed. Suffixed words, by contrast, show less evidence of priming, particularly when access to semantic information is restricted; see Table 1.

As noted earlier, the crosslinguistic preference for suffixation has been attributed to the position of the stem (e.g. Hawkins & Cutler 1988): simply put, speakers and listeners ‘prefer’ constructions in which the bulk of the word’s information is coded at the beginning of the word. If this is true and stem-initial constructions facilitate access to a word’s crucial information, then this should be reflected in processing accounts. But as seen

⁴ Throughout this article (excluding the reporting of statistical models and the IPA nasal diacritic), the symbol ‘~’ is used to denote priming configurations that test both directions: that is, ‘stem–prefixed’ denotes both ‘stem–PREFIXED’ and ‘prefixed–STEM’ configurations. By contrast, the ‘–’ symbol denotes only one direction: that is, ‘stem–prefixed’ denotes only ‘stem–PREFIXED’.

⁵ In the 1999 study, suffixed–suffixed pairs exhibited inhibition only in the by-subject analysis, while in the 2001 study, these pairs exhibited inhibition only in the by-item analysis.

PRIME		TARGET		PRIMING?
STEM	trust	PREFIXED	mistrust	✓
		SUFFIXED	trusty	?
PREFIXED	mistrust	STEM	trust	✓
		PREFIXED	distrust	✓
		SUFFIXED	trusty	✓
SUFFIXED	trusty	STEM	trust	✓
		PREFIXED	mistrust	✓
		SUFFIXED	trustful	?

TABLE 1. Evidence for priming configurations.

above, across a number of experimental paradigms and modalities, priming configurations containing suffixed words (e.g. *useful*, *useless*) consistently reveal LESS evidence of facilitation than any other. There thus exists an inherent asymmetry not only in the various characteristics of the affix types themselves, but also in the relationships that hold between different types of affixes and their stems. We are chiefly interested in whether this asymmetry is reflected in processing, and if so, how. Specifically, we ask: if suffixes are indeed more closely attached to stems than prefixes are (and vice versa), are these stem-suffix combinations processed differently from prefix-stem combinations?

1.4. PREDICTIONS. Having established the general priming behavior for affixed words and their stems (as well as affixed words with one another), we move on to the predictions for our study. We focus on the processing of derivationally complex, semantically related words in Bengali. We chose a crossmodal (auditory prime-visual target) design for this study. Evidence for priming in crossmodal studies has been used to strengthen the argument that the effect of morphological relatedness in recognition tasks is distinct from that of orthographic, phonological, or semantic relatedness (see e.g. Taft & Forster 1975, Marslen-Wilson et al. 1994).

In order to tease apart not only the internal structure but also the asymmetric behavior of prefix-stem and stem-suffix structures, we examine all combinatorial possibilities (i.e. stem~prefixed form, stem~suffixed form, prefixed form~prefixed form, suffixed form~suffixed form, and prefixed form~suffixed form), as illustrated in Figure 6 with the Bengali stem [bʰaɡ:o] ‘luck’ and various affixes. Since we test priming in all possible configurations, we outline our predictions accordingly.

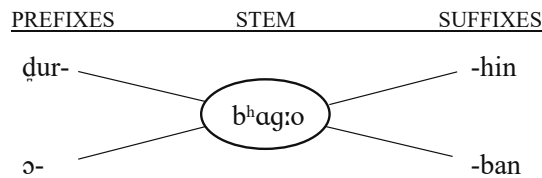


FIGURE 6. Combinatorial possibilities for the Bengali stem word [bʰaɡ:o] ‘luck’ ([dur-bʰaɡ:o] ‘bad luck’, [o-bʰaɡ:o] ‘misfortune’, [bʰaɡ:o-hin] ‘unlucky’, [bʰaɡ:o-ban] ‘lucky’).

Our first set of experiments (experiments 1 and 2) examine the relationship between affixed words and stems—that is, the canonical notion of decomposition. In terms of the availability of information in spoken language, it is inevitable that whatever the order of affixation, a prefix will be heard before the stem. Likewise, with suffixed words, the stem is heard before the suffix. For this reason, it is crucial to examine the effect of access in both configurations (e.g. prefixed words–stems and suffixed words–stems).

As discussed above, across a variety of languages, modalities, and experimental paradigms, morphologically related affixed–stem configurations (both prefixed–stem and

suffixed–stem) generate strong priming results. However, when the configuration is reversed (i.e. stem–prefixed and stem–suffixed), there is some evidence that stem–suffixed configurations may generate less priming (see §1.3). But those studies that test these configurations regularly fail to examine specifically the degree of priming between stem–prefixed and stem–suffixed forms: that is, whether one configuration generates more priming than the other.

Based on the evidence regarding suffixed words as targets, we expect a comparison of priming between these two configurations to reveal an asymmetry. Since suffixed words as targets have been shown to yield inconsistent results, we expect to see less priming for the stem–suffixed configuration than for the stem–prefixed configuration. Thus, within a set of Bengali words such as [lɔɖʒ:a] (stem, ‘shame’), [nir-lɔɖʒ:o] (prefixed, ‘shameless’), and [lɔɖʒ:-iʈo] (suffixed, ‘embarrassed’), we would expect there to be more priming between stem and prefixed form ([lɔɖʒ:a]–[nir-lɔɖʒ:o] ‘shame–shameless’) than between stem and suffixed form ([lɔɖʒ:a]–[lɔɖʒ:-iʈo] ‘shame–embarrassed’).

Our second set of experiments (experiments 3, 4, and 5) examine the relationships between morphologically complex words, using configurations containing affixed words as both primes and targets. We saw above that in previous priming literature, morphologically related prefixed–prefixed word pairs have generated strong priming results, while a number of studies have found that suffixed–suffixed configurations (e.g. *government–GOVERNOR* in Marslen-Wilson et al. 1994) fail to prime, which Marslen-Wilson et al. (1994) ascribe to competition by words that share the same base morpheme within the same cohort. But if morphological decomposition is indeed a fundamental part of language comprehension, then suffixed–suffixed word pairs should still prime one another. Within these experiments, we thus expect all morphologically related prime–target configurations to prime successfully.

The question that remains is whether facilitation can be expected to be equal across different configurations. The nature of the attachment between stem and affix and the general issue of asymmetries in affixed words discussed above are expected to play a role in the processing signatures we observe. Recall that the theoretical literature provides a range of explanations for the asymmetric patterns of behavior in both the phonological and the morphological systems that govern stems and affixes. Therefore, it could well be that the relationship between the stem and affix constrains decomposition in suffixed forms more than it does in prefixed forms. Furthermore, while affixes are also represented in the lexicon by their individual properties, the identification of a prefix can take place almost immediately due to its position at the beginning of a word, while the identification of a suffix is delayed. Consequently, the activation of the stem and its involvement in the ultimate processing of an affixed form can well be expected to be asymmetric in nature. However, this assumption is for now merely hypothetical and must be tested.

2. METHODS AND DESIGN. We report on a series of crossmodal lexical-decision tasks with priming, which cover a full range of morphologically complex Bengali words differing in the type of affixation they display. The experiments are organized into two groups: configurations examining the relationship between affixed words and stems (experiments 1 and 2), and configurations with affixed words as both primes and targets (experiments 3, 4, and 5). Factors under investigation are affix position and combination (e.g. suffixed or prefixed) and direction of priming (e.g. stem–affixed item or affixed item–stem).

Experiment 1 tests the relationship between morphologically related stems and prefixed words (stem–prefixed), and experiment 2 tests the relationship between stems and

suffixed words (stem~suffixed). We also examine whether one configuration has a greater priming effect by comparing the degree of priming in experiment 1 to that in experiment 2. Experiment 3 examines morphological priming for prefixed forms as both prime and target, and experiment 4 does the same for suffixed words. Similar to the first two experiments, we also investigated whether prefixed words primed prefixed words (experiment 3) more than suffixed words primed suffixed words (experiment 4) by comparing the degree of priming. Finally, experiment 5 tests priming between suffixed and prefixed words. The following section presents the experimental design in detail.

2.1. STIMULI. Experiments 1 (stem~prefixed), 2 (stem~suffixed), and 5 (prefixed~suffixed) consisted of thirty-two prime-target pairs, each with a set of control primes, and a set of thirty-two phonotactically nonword targets with real-word primes that were matched for complexity. In these experiments, each item served both as the prime and the target in different blocks, resulting in four separate lists (and sixty-four combinations of prime and target in total, that is, thirty-two stem~prefixed and thirty-two prefixed~stem). The stimuli were divided into four lists to allow for both directions of presentation as well as control/test prime manipulations while avoiding the repetition of stimuli. As there were four lists, the same eight control primes were used for each condition.

In experiments 3 (prefixed~prefixed) and 4 (suffixed~suffixed), the stimuli were divided into two lists to ensure that each participant saw each target only once. As in the other experiments, there were thirty-two prime-target pairs in each experiment, but they were presented only in one order since both members of each pair were of the same type (i.e. both prefixed or suffixed). In each experiment, sixteen control primes were used in both lists. Example stimuli for each experiment can be seen in Table 2, and details of the recording of the auditory primes can be found in §2.2. For comprehensive lists of test stimuli, see the appendix.

	EXP 1:	EXP 2:	EXP 3:	EXP 4:	EXP 5:
	STEM ~	STEM ~	PREFIXED ~	SUFFIXED ~	PREFIXED ~
	PREFIXED	SUFFIXED	PREFIXED	SUFFIXED	SUFFIXED
	<i>n</i> = 32	<i>n</i> = 32	<i>n</i> = 32	<i>n</i> = 32	<i>n</i> = 32
PRIME	[aɔr] 'respect' আদর	[rupo] 'silver' রূপো	[duʃ-kriti] 'miscreant' দুষ্কৃতি	[bʰag:o-ban] 'lucky' ভাগ্যবান	[nir-lodʒ:o] 'shameless' নির্লজ্জ
TARGET	[ɔn-aɔr] 'disrespect' অনাদর	[rupo-li] 'silvery' রূপালি	[ʃu-kriti] 'goodness' সুকৃতি	[bʰag:o-hin] 'unlucky' ভাগ্যহীন	[lodʒ:-ito] 'embarrassed' লজ্জিত

TABLE 2. Sample experimental stimuli.

2.2. STIMULUS RECORDING. All auditory stimuli were recorded by a female native speaker of Bengali in a sound-attenuated room at a sampling rate of 44.1 kHz using a high-quality USB microphone (Roland R-26 WAV) and the recording software Audacity (Version 2.0.6). The recorded sound files were then cut to the exact length of the word and equalized for intensity using Praat (Boersma & Weenink 2011), but were not manipulated further.

2.3. DESIGN. All lexical-decision tasks followed the same design. Participants heard a beep followed by a 200 ms pause before every trial. This was followed by the auditory prime, which was immediately followed by the visual target (displayed for 1000 ms). The intertrial interval was 1500 ms, and after every sixteen items participants heard three beeps, which served as a short break.

In experiments 1, 2, and 5, each test stimulus served as both target and prime, and as noted above, the experiment was thus divided into four separate lists, to avoid participants being exposed to any repetition of the target stems. Each list consisted of 192 trials. For example, in the prefixed~stem condition of experiment 1, [aḍor] ‘respect’ served as the prime in list 1, with [ɔn-aḍor] ‘disrespect’ as the target, while in list 2, the same target [ɔn-aḍor] was preceded by a stem control [ḍirgʰo] ‘large’ as prime. In list 3, [aḍor] was the prime, with [aḍor] as the target, while in list 4 the target [aḍor] was preceded by a prefixed control [atʃʃala] ‘thatched house with eight walls’ as prime. See Table 3.

	LIST 1	LIST 2	LIST 3	LIST 4
CONDITION	TEST	CONTROL	TEST	CONTROL
AUDITORY PRIME	[aḍor] ‘respect’	[ḍirgʰo] ‘large’	[ɔn-aḍor] ‘disrespect’	[atʃʃala] ‘thatched house with eight walls’
VISUAL TARGET	[ɔn-aḍor] ‘disrespect’ অনাদর		[aḍor] ‘respect’ আদর	

TABLE 3. Design of experiment 1.

Experiments 3 and 4 (prefixed~prefixed and suffixed~suffixed) consisted of primes and targets of the same degree of complexity, thus removing the need for each item to serve as both prime and target. This resulted in two lists of sixty-four trials each for experiments 3 and 4.

2.4. PROCEDURE. Experiments were conducted in quiet and darkened classrooms at Jadavpur University and Bethune College, Kolkata. Participants were tested in groups of sixteen and provided their responses via individual custom-made two-button serial response boxes. Responses and reaction times were collected with multiparticipant experimental hardware and software (Reetz & Kleinmann 2003). Subjects were instructed to use their thumbs to press the button and to ensure that they were responding ‘yes’ with their dominant hand. The targets were projected on a screen in font size 96 using a MacBook Pro, and auditory primes were played through individual headphones (Sony MDR110 LP).

At the beginning of each testing session, participants were provided with oral instructions in Bengali and were given the opportunity to ask clarification questions before a ten-item practice task was conducted. The practice task was repeated until the experimenters were satisfied that all subjects understood the task. Each testing session lasted approximately forty-five minutes.

2.5. PARTICIPANTS. All participants were native speakers and fluent readers of Bengali. The experiments were conducted with ninety-six undergraduate students (average age nineteen) from Jadavpur University, Kolkata, and Bethune College, University of Calcutta. In total, sixty-four participants took part in experiments 1, 2, and 5 (sixteen per list), while thirty-two different students were recruited for experiments 3 and 4, since some of the same stimuli were used in both sets of experiments. Subjects had normal or corrected-to-normal vision and no hearing impairments, and they were compensated appropriately for their time and received a certificate of participation.

2.6. ANALYSES. Responses were coded for CONDITION (related/unrelated) and, when applicable, DIRECTION (e.g. stem~prefixed or prefixed~stem). Reaction time was measured from the onset of stimulus display. All data points beyond two standard deviations from the subject mean were counted as outliers and removed. Statistical analyses were performed in R by fitting a linear mixed-effects model to reaction times using the

‘lme4’ package (Bates et al. 2012). Subjects and items were treated as random factors. We are aware of the suggestion that the random-effect structure should be kept maximal (Barr et al. 2013) and chose to follow the recommendations made in Matuschek et al. 2017 for determining the random-effect structure—that is, to select the model where the complexity of the random-effect structure is supported by the data set (Bates et al. 2015, Matuschek et al. 2017). Beginning with the full random-effect structure, a stepwise reduction approach was used. A likelihood ratio test (LRT) was used to test whether reducing the random effect harmed the model fit. $\alpha_{LRT} = 0.2$ was used, which gives more weight to more complex models (Matuschek et al. 2017). Goodness of fit was established by model comparison and normality of residuals. Following Baayen et al. 2008, all *t*-values greater than 2 or less than -2 were treated as significant.

3. RESULTS.

3.1. EXPERIMENT 1: STEM~PREFIXED PRIMING. Experiment 1 tested morphological priming for stems and prefixed forms. Responses were coded for Condition (related/unrelated) and Direction (e.g. stem–prefixed or prefixed–stem). Outlier removal resulted in a loss of 3.6% of the data ($N = 1,637$). The optimal model (i.e. that which best fit the data) to converge contained the fixed effects Condition and Direction, and random by-subject and by-item slopes and intercepts for Condition and Direction.⁶ This model appeared homoscedastic when inspected visually and showed a significant effect (est. = -44.12, $SE = 7.3$, $t = -6.04$) of Condition: reaction times to the related condition were faster than to the unrelated (control) condition (Table 4). A comparison between the model containing the fixed effect Condition and a model that does not contain Condition resulted in a significant difference ($\chi^2(1) = 30.4$, $p < 0.0001$).

DIRECTION	RELATED		CONTROL		EFFECT
	RT	SE	RT	SE	
STEM~PREFIXED	616	(13.2)	662	(13.3)	46*
PREFIXED~STEM	535	(13.2)	566	(13.1)	31*

TABLE 4. Experiment 1: reaction times (RT) in ms for stem~prefixed configurations (* denotes priming).

There was also an effect of Direction (est. = 87.46, $SE = 13.1$, $t = 6.70$), confirmed by comparison to a model excluding Direction ($\chi^2(1) = 33.01$, $p < 0.0001$). The prefixed–stem configuration (e.g. [ɔn-ɑdɔr]–[ɑdɔr] ‘disrespect–respect’) generated significantly faster response times than the stem–prefixed configuration (e.g. [ɑdɔr]–[ɔn-ɑdɔr] ‘respect–disrespect’). There was no interaction between the two main effects: introducing an interaction in the fixed-effect structure did not result in a significant difference between the two models ($\chi^2(1) = 1.8$, $p = 0.18$).

3.2. EXPERIMENT 2: STEM~SUFFIXED PRIMING. Experiment 2 tested morphological priming for stems and suffixed forms in both directions. Responses were coded for Condition (related/unrelated) and Direction (e.g. stem–suffixed or suffixed–stem). Outlier removal resulted in a loss of 3.5% of the data ($N = 1,715$). The optimal model to converge contained Condition and Direction as fixed effects and random by-subject and by-item slopes and intercepts for Condition.⁷ It also contained log-transformed values for reaction times:⁸ profile log-likelihoods of reaction times were generated via a Box-Cox (Box

⁶ RT ~ Condition + Direction + (1 + Condition + Direction | Subject) + (1 + Condition | Item)

⁷ logRT ~ Condition + Direction + (1 + Condition | Subject) + (1 + Condition | Item)

⁸ RT was log-transformed in this analysis due to distinct skewing in the visual inspection of residuals. Although optimum $\lambda = -0.87$, the lower confidence limit exceeded -1. Furthermore, a nontransformed analysis of the reaction time data in this experiment did not change the outcome.

& Cox 1964) transformation ($\lambda = -0.87$) using the ‘boxcox’ function from the R package ‘car’ (Fox et al. 2021). This model appeared homoscedastic when inspected visually. The model showed a significant effect (est. = -0.06 , $SE = 0.01$, $t = -5.51$) of Condition: reaction times to the related condition were faster than to the unrelated condition (Table 5). A comparison between the model containing the fixed effect Condition and a model excluding Condition resulted in a significant difference ($\chi^2(1) = 25.2$, $p < 0.0001$).

DIRECTION	RELATED		CONTROL		EFFECT
	RT	SE	RT	SE	
STEM-SUFFIXED	593	(11.6)	620	(11.6)	27*
SUFFIXED-STEM	532	(11.4)	573	(11.5)	41*

TABLE 5. Experiment 2: reaction times in ms for stem~suffixed configurations (* denotes priming).

There was also an effect of Direction (est. = 0.09 , $SE = 0.02$, $t = 5.36$) in this experiment: the suffixed–stem configuration (e.g. [rupo-li]–[rupo] ‘silvery–silver’) generated faster response times than the stem–suffixed configuration (e.g. [rupo]–[rupo-li] ‘silver–silvery’). This was also confirmed by comparison to a model excluding Direction ($\chi^2(1) = 22.3$, $p < 0.0001$). There was no interaction between the two main effects: introducing an interaction in the fixed-effect structure did not result in a significant difference between the two models ($\chi^2(1) = 1.78$, $p = 0.18$).

3.3. COMPARISON OF PREFIXED AND SUFFIXED WORDS WITH THEIR STEMS (EXPERIMENTS 1 AND 2 COMBINED). In experiments 1 and 2, we found that morphologically related stems and affixes reliably primed one another. Moreover, there was a significant difference in reaction times for both experiments in terms of Direction of priming: reaction times were overall faster when participants heard an affixed word and saw a stem than when they were primed with a stem and saw an affixed word. Neither experiment showed an interaction between Condition and Direction: that is, prefixed words did not prime stems any more or less than stems primed prefixed forms. Likewise, suffixed words did not prime stems any more or less than stems primed suffixed forms.

However, these results do not indicate whether prefixed words primed stems MORE than suffixed words primed stems (and vice versa), or if the priming within one experiment was stronger than the other. Therefore, we ran a second analysis on experiments 1 and 2 in order to examine degree of priming across the experiments. For this analysis, reaction times were modeled as a function of the fixed-effect factors Condition (related/unrelated), Target type (stem/affixed), and Configuration (stem~prefixed/stem~suffixed). The optimal model to converge contained a three-way interaction between Condition, Target type, and Configuration and random by-subject and by-item slopes and intercepts.⁹ It also contained log-transformed values for reaction times:¹⁰ profile log-likelihoods for reaction times were via a Box-Cox transformation ($\lambda = -0.79$). This model appeared homoscedastic when inspected visually.

The model showed a significant effect (est. = -0.07 , $SE = 0.01$, $t = -7.18$) of Target type: reaction times to the related conditions were faster than to the unrelated conditions. A model in which the fixed effect Condition was removed from the three-way interaction resulted in a significant difference ($\chi^2(4) = 67.27$, $p < 0.0001$),¹¹ and comparison of a

⁹ $\log\text{ReacTime} \sim \text{Condition} * \text{TargetType} * \text{Configuration} + (1 \mid \text{Subject}) + (1 \mid \text{Item})$

¹⁰ RT was log-transformed in this analysis due to distinct skewing in the visual inspection of residuals. Log-transforming did not change the outcome of the analysis: in fact, the effect of the three-way interaction was stronger (est. = -28.0 , $SE = 12.2$, $t = -2.303$) in the nontransformed model.

¹¹ $\log\text{ReacTime} \sim \text{TargetType} * \text{Configuration} + (1 \mid \text{Subject}) + (1 \mid \text{Item})$

model containing Condition¹² as a fixed effect to a model without Condition¹³ also showed a significant difference between the two models ($\chi^2(1) = 161.6, p < 0.0001$).

There was an effect of Target type (est. = 0.16, $SE = 0.02, t = -7.48$) on reaction times. Removal of the effect from the three-way interaction in the fixed-effects structure resulted in a significant difference between the two models ($\chi^2(4) = 67.6, p < 0.0001$), and comparison of a model containing Target type¹⁴ to a model excluding the factor elicited a significant difference ($\chi^2(1) = 55.3, p < 0.0001$). Reaction times were overall slower when affixed forms were the targets than when stems were the targets; see Table 6.

DIRECTION	RT					DIRECTION	RT				
	REL	SE	CTL	SE	EFFECT		REL	SE	CTL	SE	EFFECT
STEM-AFFIXED						AFFIXED-STEM					
stem-prefixed	615	(12.5)	661	(12.5)	46**	prefixed-stem	534	(12.4)	565	(12.4)	31*
stem-suffixed	595	(12.2)	620	(12.3)	25*	suffixed-stem	526	(12.1)	566	(12.2)	40*

TABLE 6. Reaction times in ms for stem-affixed configurations
(* denotes priming, ** denotes stronger priming).

Although there was an effect of Configuration (est. = $-0.08, SE = 0.02, t = -3.64$), comparison of a model containing Configuration¹⁵ to a model without Configuration did not result in a significant difference ($\chi^2(1) = 2.9, p = 0.09$). This suggests that Configuration alone did not have an effect on reaction times; there was, however, a significant two-way interaction between Configuration and Target type (est. = 0.08, $SE = 0.02, t = 3.00$) on reaction times, and comparison with a model in which Configuration was removed from the three-way interaction resulted in a significant difference ($\chi^2(4) = 167.3, p < 0.0001$). Thus, the configurations in experiment 1 (prefixed forms~stems) generated significantly longer overall reaction times than the configurations in experiment 2 (suffixed forms~stems).

As reported above, there was a three-way interaction (est. = $-0.04, SE = 0.02, t = -2.17$) between Condition, Target type, and Configuration. This was confirmed in model comparison, where reducing the interaction between the three fixed-effect factors¹⁶ impaired model fit ($\chi^2(4) = 10.95, p = 0.03$). The interaction between Condition, Target type, and Configuration was followed up in a post hoc test (Tukey adjustment) using the ‘emmeans’ package (Lenth 2021) in R. When the target was a stem, prefixed (est. = 0.05, $SE = 0.01, t = 6.05$) and suffixed forms (est. = 0.07, $SE = 0.01, t = 7.80$) primed similarly, with similar effect sizes for both configurations: prefixed-stem configurations ($M = 550, SD = 105.8$, Hedges’s $g_s = 0.30$ with 95% CI [0.16, 0.43]) and suffixed-stem configurations ($M = 547, SD = 101.8$, Hedges’s $g_s = 0.38$ with 95% CI [0.25, 0.52]). When the target was an affixed form, however, a stem primed a prefixed form (est. = 0.07, $SE = 0.01, t = 7.17$) MORE than a stem primed a suffixed form (est. = 0.04, $SE = 0.01, t = 4.81$). This finding is supported by a comparison of the effect sizes between the stem-prefixed configurations ($M = 637, SD = 135.9$, Hedges’s $g_s = 0.35$ with 95% CI [0.19, 0.48]) and the stem-suffixed configurations ($M = 607, SD = 121.6$, Hedges’s $g_s = 0.18$ with 95% CI [0.06, 0.34]).

¹² logReacTime ~ Condition + (1 | Subject) + (1 | Item)
¹³ logReacTime ~ 1 + (1 | Subject) + (1 | Item)
¹⁴ logReacTime ~ TargetType + (1 | Subject) + (1 | Item)
¹⁵ logReacTime ~ Configuration + (1 | Subject) + (1 | Item)
¹⁶ logReacTime ~ (Condition + TargetType + Configuration)² + (1 | Subject) + (1 | Item)

As predicted, all prime-target combinations containing stems showed priming: this confirms decomposition of the affixed form and identification of the stem. In an evaluation of reaction times, stem-affixed combinations (e.g. [lɔɖʒ:a]–[lɔɖʒ:i-to] ‘shame–embarrassed’) took longer to process; priming a stem with a related affixed word (e.g. [nir-lɔɖʒ:o]–[lɔɖʒ:a] ‘shameless–shame’) resulted in significantly shorter reaction times. Moreover, we found an asymmetry in degree of priming between prefixed and suffixed words: stem–prefixed forms primed MORE than stem–suffixed forms. It is important to note that this asymmetry is present only when the stem is presented as the prime (recall that this configuration is rarely investigated).

These findings suggest that the relationship between a suffixed form and a stem is not analogous to that between a prefixed form and a stem. Since the stem–affixed configuration involves a process of composition rather than decomposition, an investigation of affixed words as both prime and target is the next logical step. In such configurations, we assume that activation will proceed via the stem, and thus that the process of decomposition and activation will also show an asymmetry.

3.4. EXPERIMENT 3: PREFIXED–PREFIXED PRIMING. Experiment 3 tested morphological priming for Bengali prefixed words (e.g. [ɖuʃ-kriʃi]–[ʃu-kriʃi] ‘miscreant–goodness’). Since prefixed forms served as both prime and target, responses were coded only for Condition (related/unrelated). Outlier removal resulted in a loss of 2.4% of the data ($N = 1,623$). The optimal model contained the fixed effect of Condition and random by-subject and by-item slopes and intercepts for Condition.¹⁷ This model, which appeared homoscedastic when inspected visually, showed a significant effect (est. = -39.36 , $SE = 7.77$, $t = -5.29$) of Condition: reaction times to the related condition were faster than to the unrelated condition (Table 7). A comparison of this model to a model without Condition¹⁸ yielded a significant difference ($\chi^2(1) = 21.7$, $p < 0.0001$), suggesting that Condition had an effect on reaction times.

	RELATED		CONTROL		EFFECT
	RT	SE	RT	SE	
PREFIXED–PREFIXED	609	(13.8)	693	(13.8)	84*

TABLE 7. Experiment 3: reaction times in ms for prefixed–prefixed configurations (* denotes priming).

3.5. EXPERIMENT 4: SUFFIXED–SUFFIXED PRIMING. Experiment 4 tested morphological priming for suffixed forms (e.g. [bʰaɡ:o-ban]–[bʰaɡ:o-hin] ‘lucky–unlucky’) as both prime and target. Since suffixed forms served as both prime and target, responses were coded only for Condition (related/unrelated). Outlier removal resulted in a loss of 4.4% of the data ($N = 1,292$). The optimal model contained a fixed effect of Condition and random by-subject and by-item slopes and intercepts.¹⁹ This model appeared homoscedastic when inspected visually, and the model showed a significant effect (est. = -22.01 , $SE = 8.40$, $t = -2.62$) of Condition: reaction times to the related condition were faster than to the unrelated condition (Table 8). Comparison to a model without Condition²⁰ yielded a significant difference ($\chi^2(1) = 1$, $p = 0.01$).

3.6. COMPARISON OF SUFFIXED–SUFFIXED AND PREFIXED–PREFIXED PRIMING. To examine the difference in priming between experiments 3 (prefixed–prefixed) and 4 (suf-

¹⁷ $RT \sim \text{Condition} + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

¹⁸ $RT \sim 1 + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

¹⁹ $RT \sim \text{Condition} + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

²⁰ $RT \sim 1 + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

	RELATED		CONTROL		EFFECT
	RT	SE	RT	SE	
SUFFIXED–SUFFIXED	635	(11.3)	656	(11.5)	21*

TABLE 8. Experiment 4: reaction times in ms for suffixed–suffixed configurations (* denotes priming).

fixed–suffixed), we ran a cross-experiment analysis (similar to that for experiments 1 and 2). For this experiment, reaction times were modeled as a function of the fixed-effect factors Condition (related/unrelated) and Configuration (prefixed–prefixed/suffixed–suffixed).

The optimal model to converge contained an interaction between Condition and Configuration, and random by-subject and by-item slopes and intercepts.²¹ This model appeared homoscedastic when inspected visually and indicated a significant effect of Condition on reaction times (est. = −38.13, *SE* = 5.13, *t* = −7.43): overall, reaction times to the related conditions were faster than to the unrelated conditions (Table 9). This was confirmed by model comparison, in which a model containing Condition significantly differed ($\chi^2(1) = 64.4$, *p* < 0.0001) from a model not containing Condition.²² There was no effect of Configuration on reaction times: that is, reaction times between the two experiments did not differ significantly (est. = 8.89, *SE* = 7.79, *t* = 0.41), and a model in which Configuration was removed from the fixed-effect structure showed no significant difference ($\chi^2(1) = 0.67$, *p* = 0.41).

CONFIGURATION	RELATED	SE	RT		EFFECT
			CONTROL	SE	
prefixed–prefixed	609	(12.1)	693	(12.5)	84**
suffixed–suffixed	635	(12.1)	656	(12.4)	21*

TABLE 9. Comparison of reaction times for prefixed–prefixed and suffixed–suffixed configurations (* denotes priming, ** denotes stronger priming).

There was, however, a weak interaction between Condition and Configuration (est. = 15.90, *SE* = 7.79, *t* = 2.04), and removing the interaction from the model²³ resulted in a significant difference between the two models ($\chi^2(1) = 4.16$, *p* = 0.04). This interaction between Condition and Configuration was followed up in a post hoc test using the ‘lsmeans’ package. Both conditions primed, but priming effects were stronger (est. = 38.13, *SE* = 5.13, *t* = 7.43) for the prefixed–prefixed configuration than for the suffixed–suffixed configuration (est. = 22.23, *SE* = 5.87, *t* = 3.79). Effect sizes reflected the difference in priming between prefixed–prefixed pairs (*M* = 622, *SD* = 149.1, Hedges’s *g*_s = 0.56 with 95% CI [0.35, 0.74]) and suffixed–suffixed pairs (*M* = 644, *SD* = 140, Hedges’s *g*_s = 0.13 with 95% CI [0.03, 0.24]).

Since we observed an asymmetry in the degree of priming between prefixed–prefixed and suffixed–suffixed forms, with greater facilitation in the prefixed–prefixed configuration (similar to experiments 1 and 2, where stem–prefixed pairs showed more facilitation than stem–suffixed pairs), one conclusion could be that priming is reduced when the visual target is a suffixed word. This is indeed one of the hypotheses that was entertained when suffixed–suffixed priming was not observed in earlier studies (Grainger et al. 1991, Marslen-Wilson et al. 1994, Feldman & Soltano 1999, Reid & Marslen-Wilson 2000). To ensure that it is not the suffixed target itself that is driving

²¹ RT ~ Condition * Configuration + (1 | Subject) + (1 | Item)

²² RT ~ Configuration + (1 | Subject) + (1 | Item)

²³ RT ~ Condition + Configuration + (1 | Subject) + (1 | Item)

the effect, in the next experiment we investigated the opposing configuration, in which prefixed and suffixed forms are paired as primes and targets (i.e. prefixed–suffixed and suffixed–prefixed).

3.7. EXPERIMENT 5: SUFFIXED~PREFIXED PRIMING. Experiment 5 consisted of a crossmodal lexical-decision task testing priming between two different types of Bengali affixed words: suffixed–prefixed (e.g. [lodʒ:-ito]–[nir-lodʒ:o] ‘embarrassed–shameless’) and prefixed–suffixed (e.g. [ɔ-biʃar]–[biʃar-ok] ‘injustice–judge’). Responses were coded for Condition (related/unrelated) and Direction (e.g. prefixed–suffixed or suffixed–prefixed). Outlier removal resulted in a loss of 3.4% of the data ($N = 1,628$).

Reaction times were modeled as a function of the main fixed-effect factors, Condition and Direction. The optimal model contained Condition as a fixed effect, and random by-subject and by-item slopes and intercepts for Condition.²⁴ There was a main effect of Condition on reaction times (est. = -19.95 , $SE = 5.79$, $t = 3.26$), and removing Condition from the fixed-effect structure resulted in a significant difference²⁵ ($\chi^2(1) = 10.8$, $p = 0.001$). Thus, reaction times to the related condition were faster than to the unrelated condition; see Table 10.

DIRECTION	RELATED		CONTROL		EFFECT
	RT	SE	RT	SE	
prefixed–suffixed	576	(12.6)	591	(12.6)	15*
suffixed–prefixed	593	(12.4)	612	(12.4)	19*

TABLE 10. Experiment 5: reaction times in ms for suffixed–prefixed configurations (* denotes priming).

There was no effect of Direction on reaction times (est. = 22.78 , $SE = 12.89$, $t = 1.76$); a model containing Direction²⁶ in the fixed-effects structure did not significantly differ from one without ($\chi^2(1) = 3.08$, $p = 0.07$). Thus, reaction times for the prefixed–suffixed configuration were no faster than those for the suffixed–prefixed configuration. Consequently, comparison of a model containing an interaction²⁷ showed no significant difference from one without an interaction ($\chi^2(1) = 0.39$, $p = 0.53$).

In experiment 5 (suffixed–prefixed), we found that prefixed Bengali words primed suffixed words and suffixed words primed prefixed words. These findings are similar to those presented in Grainger et al. 1991, Marslen-Wilson et al. 1994, Feldman & Larabee 2001, Giraudo & Grainger 2003, and Smolka et al. 2009. Unlike these earlier studies, however, we also compared degree of priming across the conditions (prefixed–suffixed, suffixed–prefixed) and found no difference. This suggests that when there is a bidirectional competition in affixation, the advantage of a prefix disappears. We discuss this in greater detail below.

4. GENERAL DISCUSSION. The asymmetric nature of affixation has had significant implications for theories of the storage and decomposition of morphologically complex words, such as the full listing of complex words (Butterworth 1983), affix stripping (Taft & Forster 1975), the dual route model (Schreuder & Baayen 1995), and edge-alignment theory (Grainger & Beyersmann 2017). Across experimental paradigms and modalities, there has been robust evidence that prefixed words reliably prime morphologically related affixed forms (both prefixed and suffixed) as well as stems. Suffixed

²⁴ $RT \sim \text{Condition} + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

²⁵ $RT \sim 1 + (1 \mid \text{Subject}) + (1 \mid \text{Item})$

²⁶ $RT \sim \text{Condition} + \text{Direction} + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

²⁷ $RT \sim \text{Condition} * \text{Direction} + (1 + \text{Condition} \mid \text{Subject}) + (1 + \text{Condition} \mid \text{Item})$

words, by contrast, have revealed less evidence of facilitation, particularly in priming configurations where the suffixed word appears as a visual target (see e.g. Grainger et al. 1991, Marslen-Wilson et al. 1994). This has variously been attributed to listener preference for the position of the stem (Cutler et al. 1985, Hawkins & Cutler 1988), dissimilar grammaticalization processes (Greenberg 1957, Bybee et al. 1990), and phonological grouping (Nespor & Vogel 1986, Lahiri & Plank 2010); however, no single cause has been definitively identified. Rather than simply being an issue of access inhibition, we believe that such findings reflect the nature of the bond between stem and suffix versus that between prefix and stem. That is, stems and suffixes are morphologically more closely related than are prefixes and stems. This has multiple effects, including the propensity for phonological processes to apply more across stem-suffix boundaries than across prefix-stem boundaries. Likewise, in processing, suffixes are less detachable, resulting in an asymmetry in the degree of priming for experiments containing suffixes and prefixes (see §1.3).

To investigate this, we conducted five crossmodal priming experiments on semantically transparent, morphologically related Bengali stems and affixes. Bengali lends itself to this line of investigation for several reasons. First, unlike English, Bengali has a large selection of derivational prefixes and suffixes, and morphophonological rules apply equally across both. Second, the affixes are more generally comparable with each other since there is little influence from borrowed affixes. Third, both suffixes and prefixes can be subject to resyllabification and assimilation processes. Fourth, and perhaps most importantly, Bengali allows us to test all configurations (stem~prefixed, stem~suffixed, prefixed~prefixed, suffixed~suffixed, suffixed~prefixed), which we did with the same subject population.

Overall, the data provide substantial evidence for morphological decomposition. Table 11 gives a summary of the priming effects observed across all configurations.

CONDITION		CONDITION	
prefixed–stem	=	suffixed–stem	
stem–prefixed	>	stem–suffixed	
prefixed–suffixed	=	suffixed–prefixed	
prefixed–prefixed	>	suffixed–suffixed	

TABLE 11. Summary of priming effects observed.

To summarize, we found an asymmetry in the degree of priming between the stem~prefixed and stem~suffixed configurations, and an asymmetry in the degree of priming between prefixed~prefixed and suffixed~suffixed word pairs. Furthermore, we found priming for the suffixed~suffixed configuration, an effect that varies in the experimental literature. We discuss these findings in greater detail below.

In experiments 1 and 2, we investigated whether accessing the stem via decomposition of prefixes and suffixes is equally efficient in Bengali. Across a variety of priming paradigms (masked, crossmodal) and modalities (visual, auditory), semantically transparent affixed words have shown salient priming effects when paired with morphologically related stem targets (Marslen-Wilson et al. 1994, Drews & Zwitserlood 1995, Meunier & Segui 2002, Marslen-Wilson et al. 2008, Smolka et al. 2009, Kazanina 2011, Beyersmann et al. 2013, Giraudo & Voga 2013, Kim et al. 2015, Schuster & Lahiri 2018). Our findings for these constructions were analogous: we found that when the target was a stem, prefixed and suffixed words primed similarly.

When the target was an affixed form, however, a stem primed a prefixed word more than a stem primed a suffixed word. This can be explained as follows: in affixed~stem

configurations in a crossmodal environment, the morphologically complex word is heard first. If morphological decomposition is occurring, then affixed auditory prime words must be decomposed into stem + affix: for example, for *impure*, *im-* and *pure*, and for *purity*, *pure* and *-ity*. Therefore, for affixed *impure* and *purity* as primes, the stem *pure* is activated through decomposition. No decomposition is required for the target (see Table 12).

CONFIGURATION	PRIME	TARGET
prefixed–stem	impure [im.pjʊər]	PURE
suffixed–stem	purity [pjʊər.i.ti]	PURE

TABLE 12. Affixed–stem configurations.

In the stem–affixed word configurations, by contrast, the stem is activated immediately as the prime, but the visual target must be decomposed. If the target is a prefixed item, the prefix must be stripped (and activated), and then the stem is accessed. Prefixed target words provide the necessary information (i.e. which prefix is used) early, giving prefixed words a processing advantage. In suffixed words, the information about the stem and suffix is delayed (to a later uniqueness point; see Marslen-Wilson et al. 1994). For instance, upon hearing the [pjʊər] of *purity*, the participant experiences competition among *pure*, *purity*, *purify*, and so forth, and even monomorphemic words such as *puritan*. This competition leads to a processing disadvantage for suffixed words—or in other words, it leads to an advantage for prefixed forms and therefore more priming by a stem for a prefixed target word than is seen for suffixed targets.

Experiments 3, 4, and 5 tested priming of affixed words. In experiment 3 (prefixed–prefixed), we found that prefixed words reliably primed other morphologically related prefixed words. In experiment 4 (suffixed–suffixed), the findings also suggest that morphologically related suffixed items prime each other readily in Bengali, contrary to the lack of priming found for suffixed words in Marslen-Wilson et al. 1994, Feldman & Soltano 1999, Gonnerman & Andersen 2000, Reid & Marslen-Wilson 2000, Feldman & Larabee 2001, and Comstock 2018.

In comparing the degree of priming between prefixed–prefixed and suffixed–suffixed configurations, however, we found a substantial difference. While the prefixed–prefixed configuration exhibited a priming effect size of 84 ms, the suffixed word pairs exhibited a priming effect size of only 21 ms. The difference between these two configurations was confirmed by statistical analysis: prefixed words that shared the same stem (e.g. [ɖur-bʰaɡ:o]–[ɔ-bʰaɡ:o] ‘bad luck–misfortune’) primed one another MORE than suffixed words that shared a stem (e.g. [bʰaɡ:o-hin]–[bʰaɡ:o-ban] ‘unlucky–lucky’) primed one another. While differences in perception, reading, or inhibition from the phonological cohort may contribute to this asymmetry, we believe that it is also a result of the salience of the morpheme boundaries in affixed word representations during recognition. Given the asymmetry in processing observed between prefixed–prefixed and suffixed–suffixed forms, one could argue that a suffixed target leads to a slower activation, reflected in the reaction time latencies. However, when prefixed words and suffixed words were presented in a multidirectional configuration (experiment 5, e.g. [bʰaɡ:o-hin]~[ɖur-bʰaɡ:o] ‘unlucky~bad luck’), the asymmetry disappeared. Thus, it appears that having a suffixed form as the target is not what leads to the asymmetry observed above; rather, it is the way in which the stem participates in structural attachment with prefixes and suffixes that determines the observed priming patterns.

Our account of the asymmetry critically depends on our assumptions about lexical representations: not only are stems stored in the mental lexicon, but affixes are also

stored with information relating to their selection restrictions (e.g. which stems they can combine with; what, if any, the resulting word class will be). Recall in this context that when the stem was presented as the prime and affixed forms as targets, asymmetries were observed due to rapid segmentation of the prefixed form into its constituents. The same situation was observed when prefixed–prefixed forms were compared to suffixed–suffixed forms: in a direct comparison between the two configurations, segmentation was again facilitated for prefixed forms.

The experiments reported above suggest that processing derived words is by no means straightforward. Our experimental evidence is in line with prefix–suffix asymmetries observed in linguistic structures and word-formation constraints across the languages of the world. These asymmetries include facts such as suffixes cohering more to stems, suffix stacking being more prevalent than prefix stacking, and differences in the way suffixes and prefixes develop in the course of language change. Our experiments suggest that such asymmetric properties have an effect in processing. For instance, stems priming affixed words show a prefixing advantage: that is, stems prime prefixed words more than they prime suffixed words. Comparing prefixed and suffixed words directly, again we find an advantage of prefixation: prefixed–prefixed word pairs primed each other more than suffixed–suffixed pairs. This advantage disappears when the prime–target configuration is bidirectional: facilitation for suffixed–prefixed pairs does not differ significantly from that seen for prefixed–suffixed pairs.

The effect of morphological cohesion between stem and affix is unmistakable in our results: in two comparisons (stem–prefixed vs. stem–suffixed, and prefixed–prefixed vs. suffixed–suffixed), word pairs containing suffixed forms generated significantly less priming than their prefixed counterparts did. This suggests that the ‘glue’ that attaches suffixes to stems is stronger than that which binds prefixes to stems, and that prefixed words consequently have a priming advantage. This raises the possibility that these asymmetrical priming results are attributable not only to morphological processes, but also to phonological processes operating between stem and affix: morphological processes attach affixes to stems, while phonological processes help to bind these elements together.

Overall, these results reflect the historical difference regarding affixation while also supporting the hypothesis that suffixed words are more difficult to decompose due to a lack of salience of the morpheme boundary between stem and suffix. As we have seen above, multiple phonological processes (e.g. resyllabification) reflect an asymmetry in the relationship between stems and suffixes versus that between stems and prefixes. Hawkins and Cutler (1988) credited the position of the stem with motivating the crosslinguistic preference for suffixation: simply put, they claimed that speakers and listeners prefer stem-initial constructions, in which the bulk of the word’s information is presented at the beginning. If the stem-initial construction facilitates access to a greater degree, this should be reflected in processing. However, across experimental paradigms and modalities, priming configurations containing suffixed words (e.g. *useful*, *useless*) consistently reveal LESS evidence of facilitation, particularly when the suffixed word is a visual target (Crepaldi et al. 2016). Marslen-Wilson et al. (1994) attribute this finding to the fact that suffixed forms (e.g. *government* and *governor*) share the same base morpheme (*govern*), resulting in competition for the stem and thus inhibition. We believe that such findings (including the ones presented in this study) are motivated by more than simply stem/affix position: they also reflect the effect of the phonological processes that occur between stem and affix.

There is still much to be learned about the phonological relationships between stems and affixes and the consequences these relationships may have for both representation

and processing. Bengali morphology permitted us to investigate all directions of affixation without the influence of additional structural asymmetries: for instance, morphophonological rules apply to both suffixes and prefixes such that surface prefixed and suffixed forms may deviate equally from their underlying strings. Nevertheless, as in most languages, further complexities exist that should be investigated, and similar effects in other languages should be examined in future research.

APPENDIX: STIMULI

STEM ITEMS			PREFIXED ITEMS		
1. [aɔɔr]	আদর	'respect'	[ɔn-aɔɔr]	অনাদর	'disrespect'
2. [ain]	আইন	'law'	[be-ain]	বেআইন	'lawlessness'
3. [gɔndʰo]	গন্ধ	'smell'	[ɔur-gɔndʰo]	দুর্গন্ধ	'bad odor'
4. [ʃena]	চেনা	'familiar'	[ɔ-ʃena]	অচেনা	'unfamiliar'
5. [nɔɔɔɔr]	নজর	'view, sight'	[ʃu-nɔɔɔɔr]	সুনজর	'favorable view'
6. [gʰɔɔna]	ঘটনা	'event'	[ɔur-gʰɔɔna]	দুর্ঘটনা	'misadventure'
7. [kɔtʰa]	কথা	'speech, story'	[ku-kɔtʰa]	কুকথা	'scandal, bad words'
8. [kʰɔɔɔr]	খবর	'news'	[ʃu-kʰɔɔɔr]	সুখবর	'good news'
9. [ʃabʰabik]	স্বাভাবিক	'natural'	[ɔ-ʃabʰabik]	অস্বাভাবিক	'unnatural'
10. [ɔɔɔɔ]	জয়	'victory'	[pɔɔɔ-ɔɔɔɔ]	পরাজয়	'defeat'
11. [iʃʰe]	ইচ্ছে	'willingness'	[ɔn-iʃʰe]	অনিচ্ছে	'unwillingness'
12. [obʰe]	অভ্যাস	'practice, habit'	[ɔn-obʰe]	অনভ্যাস	'state of being unused to something'
13. [ʃabɔɔ]	শব্দ	'sound'	[ni-ʃabɔɔ]	নিঃশব্দ	'silence'
14. [aʃa]	আশা	'hope, wish'	[ɔur-aʃa]	দুরাশা	'bad desire; unreachable wish'
15. [proɔip]	প্রদীপ	'limited'	[ɔ-proɔip]	অপ্রদীপ	'unrestricted'
16. [ʃɔɔɔɔɔ]	চরিত্র	'character'	[ku-ʃɔɔɔɔɔ]	কুচরিত্র	'bad character'
17. [proʃur]	প্রচুর	'large quantity'	[ɔ-proʃur]	অপ্রচুর	'inadequate amount'
18. [purno]	পূর্ণ	'complete'	[ɔ-purno]	অপূর্ণ	'incomplete'
19. [ɔɔɔɔɔɔɔ]	ধৈর্য	'patience'	[ɔ-ɔɔɔɔɔɔɔ]	অধৈর্য	'impatience'
20. [āt:a]	আত্মা	'soul, life'	[ɔur-āt:a]	দুরাত্মা	'villain; wicked at heart'
21. [ɔɔɔɔɔ]	জীবন	'life'	[a-ɔɔɔɔɔ]	আজীবন	'until death, lifelong'
22. [ʃoʃɔna]	শোচনা	'immediate'	[anu-ʃoʃɔna]	অনুশোচনা	'immediately'
23. [kɔɔmo]	কর্ম	'deed'	[ɔpo-kɔɔmo]	অপকর্ম	'misdeed'
24. [prap:ɔ]	প্রাপ্য	'something that is available'	[ɔur-prap:ɔ]	দুপ্রাপ্য	'rare'
25. [bʰabna]	অবনাম	'anxiety, thought'	[nir-bʰabna]	নির্ভাবনাম	'absence of anxiety'
26. [uɔɔɔ]	উত্তর	'answer'	[nir-uɔɔɔ]	নিরুত্তর	'silent, cannot be answered'
27. [stɔɔɔɔɔ]	স্তব্ধ	'still'	[nis-tɔɔɔɔɔ]	নিস্তব্ধ	'stock-still'
28. [ɔɔɔɔɔ]	দর্শন	'view'	[ʃu-ɔɔɔɔɔ]	সুদর্শন	'presentable view'
29. [biʃar]	বিচার	'judgment'	[ʃu-biʃar]	সুবিচার	'correct judgment'
30. [ʃur]	সুর	'tune'	[be-ʃur]	বেসুর	'out of tune'
31. [hiʃab]	হিসাব	'account, calculation'	[be-hiʃab]	বেহিসাব	'incorrect calculation'
32. [hūʃ]	হুঁশ	'sense'	[be-hūʃ]	বেহুঁশ	'senseless'

TABLE A1. Experiment 1: test items for the stem-prefixed configuration.

STEM ITEMS			SUFFIXED ITEMS		
1. [ʃɔɔɔr]	শহর	'city'	[ʃɔɔɔr-e]	শহুরে	'municipality'
2. [rupo]	রূপো	'silver'	[rupo-li]	রূপালি	'silvery'
3. [gombʰir]	গম্ভীর	'serious'	[gʰambir-ɔɔɔ]	গাম্ভীর্থ	'seriousness'
4. [mukʰ]	মুখ	'mouth'	[moukʰ-ik]	মৌখিক	'speaker'
5. [dam]	দাম	'cost'	[dam-i]	দামী	'costly'
6. [ɔukʰ:ɔ]	দুঃখ	'sorrow'	[ɔukʰ:-iɔ]	দুঃখিত	'sorrowful'
7. [ɔɔɔɔɔɔ]	বগড়া	'quarrel'	[ɔɔɔɔɔɔ-ɔ]	বগড়াটে	'brawl'
8. [ɔɔɔa]	দয়ালু	'kind'	[ɔɔɔa-lu]	দয়ালু	'fanciful'
9. [gʰum]	ঘুম	'sleep'	[gʰum-ɔɔɔ]	ঘুমন্ত	'sleepy'

(Table A2. *Continues*)

STEM ITEMS			SUFFIXED ITEMS		
10. [lob ^h]	লোভ	'greed'	[lob ^h -onio]	লোভনীয়	'covetable'
11. [ʃik ^h :a]	শিক্ষা	'education'	[ʃik ^h :-ok]	শিক্ষক	'teacher'
12. [ʃorir]	শরীর	'body'	[ʃarir-ik]	শারীরিক	'corporal'
13. [kɔlpona]	কল্পনা	'idea'	[kalpon-ik]	কাল্পনিক	'fantasy'
14. [kali]	কালি	'dark'	[kali-ma]	কালিমা	'darkness'
15. [hiŋʃe]	হিংসে	'envy'	[hiŋʃu-ʃe]	হিংসুটে	'animosity'
16. [lek ^h a]	লেখা	'text'	[lek ^h -ok]	লেখক	'writer'
17. [lɔdʒ:a]	লজ্জা	'shame'	[ladʒ-uk]	লাজুক	'bashful'
18. [uʃa]	উড়া	'soar'	[uʃ-onto]	উড়ন্ত	'flown'
19. [manuʃ]	মানুষ	'mortal'	[manof-ik]	মানসিক	'fanciful'
20. [din]	দিন	'day'	[doin-ik]	দৈনিক	'daily'
21. [ɔnʃol]	অঞ্চল	'multitude'	[anʃol-ik]	আঞ্চলিক	'countless'
22. [upokar]	উপকার	'benefit'	[upokar-i]	উপকারী	'beneficial'
23. [ɔntor]	আন্তরিক	'heart'	[antor-ik]	আন্তরিক	'charity'
24. [iʃʰ:a]	ইচ্ছা	'wish'	[iʃʰ-uk]	ইচ্ছুক	'wishful'
25. [pet]	পেট	'stomach'	[peʃ-uk]	পেটুক	'glutton'
26. [dʒor]	জোড়	'force'	[dʒor-alo]	জোড়ালো	'forceful'
27. [dʒaʃi]	জাতি	'nation'	[dʒaʃ-io]	জাতীয়	'national'
28. [rodʒgar]	রোজগার	'income'	[rodʒ-gare]	রোজগারে	'earning'
29. [naʃok]	নাটক	'drama'	[naʃok-io]	নাটকীয়	'dramatic'
30. [dʒa]	দয়া	'pray'	[dʒa-lu]	দয়ালু	'forgiving'
31. [ɔporad ^h]	অপরাধ	'crime'	[ɔporad ^h -i]	অপরাধী	'criminal'
32. [dʒorkar]	দরকার	'use'	[dʒorkar-i]	দরকারী	'useful'

TABLE A2. Experiment 2: test items for the stem-suffixed configuration.

PREFIXED PRIMES			PREFIXED TARGETS		
1. [dur-din]	'bad days'	[fu-din]	সুদিন	'happy days'	
2. [ku-buʃi]	'confusion'	[dur-buʃi]	দুর্ভিক্ষ	'mischief'	
3. [dur-b ^h abna]	'misery'	[nir-b ^h abna]	নির্ভাবনা	'intrigue'	
4. [ɔ-ʃalok]	'nondriver'	[pori-ʃalok]	পরিচালক	'manager, director'	
5. [ku-ʃoriʃro]	'bad character'	[duʃ-ʃoriʃro]	দুষ্চরিত্র	'wicked'	
6. [ku-ʃiŋʃa]	'evil thought'	[duʃ-ʃiŋʃa]	দুষ্কিন্তা	'bad thoughts, worry'	
7. [duʃ-kriti]	'miscreant'	[fu-kriti]	সুকৃতি	'goodness'	
8. [dur-bak:ɔ]	'abusive language'	[proʃi-bak:ɔ]	প্রতিবাক্য	'synonym'	
9. [ku-puruʃ]	'bad person'	[fu-puruʃ]	সুপুরুষ	'nice person'	
10. [ku-montro]	'bad advice'	[fu-montro]	সুস্ত্র	'good advice'	
11. [ku-lok ^h :on]	'bad omen'	[fu-lok ^h :on]	সুলক্ষণ	'good omen'	
12. [fu-ʃɔŋbad]	'good news'	[duʃ-ʃɔŋbad]	দুঃসংবাদ	'bad news'	
13. [fu-k ^h ad:ɔ]	'delicacy'	[ɔ-k ^h ad:ɔ]	অখাদ্য	'inedible food'	
14. [fu-niti]	'morals'	[dur-niti]	দুর্নীতি	'corruption'	
15. [ɔ-ʃɔmɔe]	'inappropriate time'	[duʃ-ʃɔmɔe]	দুঃসময়	'bad times'	
16. [fu-ʃɔpno]	'good dreams'	[duʃ-ʃɔpno]	দুঃস্বপ্ন	'nightmare'	
17. [ɔ-ʃad ^h :ɔ]	'unbearable'	[duʃ-ʃad ^h :ɔ]	দুঃসাধ্য	'hard to accomplish'	
18. [niʃ-prap:ɔ]	'noteworthy'	[duʃ-prap:ɔ]	দুঃপ্রাপ্য	'rare'	
19. [fu-gɔnd ^h ɔ]	'fragrance'	[dur-gɔnd ^h ɔ]	দুঃগন্ধ	'stench'	
20. [dur-b ^h ag:ɔ]	'bad luck'	[ɔ-b ^h ag:ɔ]	অভাগ্য	'misfortune'	
21. [ɔ-ruʃi]	'repugnance'	[ku-ruʃi]	কুর্গতি	'garbage'	
22. [dur-mul:ɔ]	'high-priced'	[ɔ-mul:ɔ]	অমূল্য	'priceless'	
23. [dur-aʃa]	'groundless hope'	[nir-aʃa]	নিরাশা	'disappointment'	
24. [fu-biʃʃar]	'justice'	[ɔ-biʃʃar]	অবিচার	'injustice'	
25. [fu-gɔʃo]	'avowed'	[onu-gɔʃo]	অনুগত	'devoted'	
26. [ku-kadʒ]	'miscreant'	[ɔ-kadʒ]	অকাজ	'wrongdoing'	
27. [ɔpo-kɔrmo]	'harm'	[ku-kɔrmo]	কুকর্ম	'sin'	
28. [ni-ʃid ^h :ɔ]	'profane'	[pro-ʃid ^h :ɔ]	প্রসিদ্ধ	'reverent'	
29. [fu-paʃro]	'worthy person'	[ku-paʃro]	কুপাত্ত	'unfit person'	
30. [ɔʃ-pɔʃʃo]	'unwanted touch'	[duʃ-pɔʃʃo]	দুঃস্পর্শ	'rejected'	
31. [dur-dʃiʃʃo]	'foresight'	[ɔ-dʃiʃʃo]	অদর্শ	'destiny'	
32. [proʃi-ruʃd ^h :ɔ]	'opposed; besieged'	[ni-ruʃd ^h :ɔ]	নিরুদ্ধ	'obstructed'	

TABLE A3. Experiment 3: test items for the prefixed-prefixed configuration.

SUFFIXED PRIMES			SUFFIXED TARGETS		
1.	[bʰag:o-ban]	'lucky'	[bʰag:o-hin]	ভাগ্যহীন	'unlucky'
2.	[bʰæ:purno]	'fearful'	[bʰæ:fun:o]	ভয়শূন্য	'fearless'
3.	[bʰokʰi-hin]	'godless'	[bʰokʰi-bʰab]	ভক্তিভাব	'reverence'
4.	[ʃʃin-tito]	'worried'	[ʃʃin-tan:ito]	চিন্তান্বিত	'thoughtful'
5.	[dɔja-lu]	'kind'	[dɔja-hin]	দয়ালু	'selfish'
6.	[gæn-i]	'knowledgeable'	[gæ-tob:o]	জ্ঞাতব্য	'fit to be known'
7.	[gun-i]	'capability'	[gun-onio]	গুণনীয়	'quality'
8.	[dɔɔl-onʈo]	'scorched'	[dɔɔl-ɔbʰab]	জলাভাব	'barren'
9.	[lobʰ-i]	'greedy'	[lobʰ-onio]	লোভনীয়	'covetable'
10.	[lodʒ-i-to]	'regretful'	[lodʒ:a-boʈi]	লজ্জাবতী	'shameful'
11.	[mano-nijo]	'honorable'	[mano-fik]	মানসিক	'ethical'
12.	[ʃikʰ-i-to]	'literary'	[ʃikʰ:-ɔk]	শিক্ষক	'teacher'
13.	[triʃ-i-to]	'thirsty'	[triʃ-aʈto]	তৃষার্ত	'parched'
14.	[dʱormo-hin]	'blasphemous'	[dʱarm-ik]	ধার্মিক	'religious'
15.	[dʱaʈu-kʰ:ɔe]	'metal'	[dʱaʈu-gorbʰo]	ধাতুগর্ভ	'metallic'
16.	[orʰo-niti]	'economy'	[orʰo-faʃtro]	অর্থশাস্ত্র	'economics'
17.	[ɔʃa-ŋgo]	'eight parts of the body'	[ɔʃa-dɔʃ]	অষ্টাদশ	'eighteen'
18.	[kaɖa-ɛ]	'dirty'	[kaɖa-moe]	কাদাময়	'muddy'
19.	[guno-ban]	'talented'	[guno-moe]	গুণময়	'endowed with good qualities'
20.	[gupto-ʃʃor]	'spy'	[gupto-bʰab]	গুপ্তভাব	'secretly'
21.	[guru-tɔ]	'importance'	[guru-bʰab]	গুরুভাব	'responsible charge'
22.	[ʃʈotur-gun]	'quadruple'	[ʃʈotur-tʰo]	চতুর্থ	'fourth'
23.	[ʃʈoritro-hin]	'without character'	[ʃʈoritro-dof]	চরিত্রদোষ	'character fault'
24.	[ʃʈokʰ:u-dan]	'eyesight'	[ʃʈakʰ:u-ʃ]	চাক্ষুস	'visual'
25.	[ʃʈaʈ-ano]	'trim'	[ʃʈaʈ-ai]	ছাঁটাই	'clipping'
26.	[dɔɔma-t]	'coagulated'	[dɔɔma-no]	জমানো	'amassed'
27.	[dɔɔti-bʰrɔŋʈo]	'ethnicity'	[dɔɔti-hin]	জাতিহীন	'stateless'
28.	[gæn-funno]	'senseless'	[gæn-i]	জ্ঞানী	'insightful'
29.	[dukʰ:o-mɔe]	'sad'	[dukʰ:-i]	দুঃখী	'distressed'
30.	[dʱorma-ta]	'religious'	[dʱormo-naʃ]	ধর্মশাস্ত্র	'blasphemy'
31.	[pap-iʃʰo]	'sinful'	[pap-i]	পাপী	'sinner'
32.	[pran-onʈo]	'living'	[pran-i]	প্রাণী	'creature'

TABLE A4. Experiment 4: test items for the suffixed-suffixed configuration.

PREFIXED ITEMS			SUFFIXED ITEMS		
1.	[nir-lodʒ:o]	নির্লজ্জ	[lodʒ-i-to]	লজ্জিত	'embarrassed'
2.	[ɔ-kadʒ]	অকাজ	[kadʒ-er]	কাজের	'useful'
3.	[duʃ-ʃomɔe]	দুঃসময়	[ʃamo-ik]	সাময়িক	'temporary'
4.	[dur-nam]	দুর্নাম	[nam-i]	নামী	'well known'
5.	[ɔ-dʒana]	অজানা	[dʒana-no]	জানানো	'to make known'
6.	[ʃu-paʈro]	সুপাত্র	[paʈr-i]	পাত্রী	'prospective bride'
7.	[ku-kormo]	কুকর্ম	[korm-i]	কর্মী	'worker'
8.	[ɔ-biʃaʃ]	অবিশ্বাস	[biʃaʃ-i]	বিশ্বাসী	'dependable'
9.	[ɔ-dʱarmo]	অধর্ম	[dʱarm-ik]	ধার্মিক	'righteous'
10.	[nir-dof]	নির্দোষ	[dof-i]	দোষী	'guilty'
11.	[ɔ-biʃar]	অবিচার	[biʃar-ok]	বিচারক	'judge'
12.	[ɔ-fukʰ]	অসুখ	[ʃukʰ-i]	সুখী	'happy'
13.	[ɔ-niʃʃɔe]	অনিশ্চয়	[niʃʃ-i-to]	নিশ্চিত	'certain'
14.	[dur-bʰag:o]	দুর্ভাগ্য	[bʰag:o-ban]	ভাগ্যবান	'good luck'
15.	[dur-mul:o]	দুর্মূল্য	[mul:o-ban]	মূল্যবান	'valuable'
16.	[duʃ-ʃintʃa]	দুশ্চিন্তা	[ʃintʃ-i-to]	চিন্তিত	'worried'
17.	[ɔ-ʃʈol]	অচল	[ʃʈol-onto]	চলন্ত	'goodness'
18.	[ku-budʱ:i]	কুদ্বুদ্ধি	[budʱ:i-man]	বুদ্ধিমান	'rationality'
19.	[ɔnu-rag]	অনুরাগ	[rag-i]	রাগী	'anger'
20.	[ɔ-ʃikʰ:a]	অশিক্ষা	[ʃikʰ-i-to]	শিক্ষিত	'educated'

(Table A5. *Continues*)

PREFIXED ITEMS			SUFFIXED ITEMS		
21. [nir-b ^h ul]	নির্ভুল	'perfect'	[b ^h ol-a]	ভোলা	'mistaken'
22. [nir-biʃar]	নির্বিচার	'unconcerned'	[biʃar-ək]	বিচারক	'referee'
23. [ʃu-ʃɔŋbad]	সুশংবাদ	'good news'	[ʃaŋbad-ik]	সাংবাদিক	'journalist'
24. [ɔpo-man]	অপমান	'dishonor'	[man-onijo]	মাননীয়	'honorable'
25. [ɔ-g:æn]	অগ্ৰাণ	'lose consciousness'	[gæn-i]	গ্ৰাণী	'knowledgeable'
26. [ɔ-b ^h okti]	অভক্তি	'irreverence'	[b ^h okti-hin]	অভিহীন	'godless'
27. [ɔ-baʃtob]	অবাস্তব	'unreal'	[baʃtob-ɔta]	বাস্তবতা	'realism'
28. [nir-gun]	নিষ্ঠুর	'void of qualities'	[gun-i]	গুণী	'wise person'
29. [nir-lob ^h]	নির্লোভ	'without greed'	[lob ^h -i]	লোভী	'covetous'
30. [ku-ʃaʃon]	কুশাসন	'misrule'	[ʃaʃon-io]	শাসনীয়	'governor'
31. [nir-b ^h ɔe]	নির্ভয়	'without fear'	[b ^h ɔe-purno]	ভয়পূর্ণ	'with fear'
32. [nir-baʃon]	নির্বাসন	'deportation'	[baʃin-dɔ]	বাসিন্দা	'resident'

TABLE A5. Experiment 5: test items for the prefixed-suffixed configuration.

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