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Morphological Decomposition in Heritage Turkish in the U.S.

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Abstract. Heritage Speakers (HSs) of Turkish in the U.S. are unbalanced bilinguals, with Turkish as their morphologically rich, non-dominant language and English as their analytical, dominant language. The present study investigated whether HSs of Turkish process morphologically complex derived words in Turkish and English through decomposition or as whole words. This study also compared HSs' processing patterns with those of baseline Turkish and baseline English speakers to determine whether HSs' processing of morphology in the dominant and non-dominant languages relies on the same fundamental mechanisms as does baseline speakers' morphological processing (Uygun & Clahsen 2021). Two morphological priming experiments were conducted: the Turkish experiment compared HSs to baseline Turkish speakers; the English experiment compared the same HSs tested in their dominant language to baseline English speakers. The findings suggest that HSs patterned with both baseline groups, exhibiting efficient morphological decomposition in both their weaker heritage language and their dominant language. In line with previous work on Heritage Turkish (Uygun & Clahsen 2021; Jacob et al. 2019), these findings suggest that, despite limited exposure to the heritage language, HSs still develop baseline speaker-like morphological decomposition mechanisms for derived words in their heritage language.

Keywords. morphological processing; lexical access; heritage speakers; Turkish

1. Introduction. A fundamental goal of psycholinguistic research is to understand the cognitive mechanisms that underlie the storage, retrieval, and processing of morphologically complex words, thereby providing insight into how the human mind organizes and accesses lexical units in the mental lexicon. Researchers have thus been particularly interested in determining the intricate processes by which complex word forms are represented in the mental lexicon, that is, whether morphologically complex words are accessed as whole word forms or if they are decomposed into their morphological units (ex. Uygun & Clahsen 2021; Jacob et al. 2019; Bybee 2013; Kırkıcı & Clahsen 2013; McCormick et al. 2008; Rastle et al. 2004; Gürel 1999).

Lexical access in agglutinative languages is suggested to involve decomposition rather than whole-word processing (Gürel 1999). Since a typical mental lexicon would be incapable of storing billions of separate lexical entries for each inflected and derived form in an agglutinating language (Hankamer 1989), for storage efficiency, complex words in morphologically rich languages (such as Finnish and Turkish) are suggested to be accessed through a morphological parsing route (Gürel 1999; Frauenfelder & Schreuder 1992). Besides language-specific factors, properties of individual morphemes play a role in the way morphological processing mechanisms function in a given language (Ciaccio et al. 2020), including morpheme frequency, regularity, length, and morpheme type (Kırkıcı & Clahsen 2013). Morphologically complex words with higher frequency, especially those with irregular, inflectional morphemes, are accessed as whole

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words, whereas words with lower frequency, particularly derived words and some regular inflectional morphemes, are decomposed into their morphological units (Ciaccio & Clahsen 2020; Uygun & Gürel 2016; Lehtonen & Laine 2003).

Importantly, some studies have additionally shown differences in the processing of (regular) inflectional vs derivational morphology (Feldman et al. 2002 for Serbian L1; Silva & Clahsen 2008 for English L1 and L2), while other studies do not find such differences (Jacob et al. 2019; Jacob & Kırkıcı 2016 for HSs of Turkish) or find differences only for L2 learners (Kırkıcı & Clahsen 2013 for L2 learners of English). These inconclusive results are interpreted as indicative of the deeper differences between inflection and derivation. Derivational morphology often changes the meaning and/or part of speech of the lexical item with which it combines (ex. *kindness* vs *kind*) whereas inflectional morphology is often the realization of morphosyntactic features such as plurality or tense. Under some accounts, derivation yields a separate entry in the mental lexicon, whereas inflection does not; namely, derived forms are stored as separate lexical entries, whereas the output of inflection is a feature–form pairing, but not an entry (Matthews 1991; Kırkıcı & Clahsen 2013).

1.1. MORPHOLOGY IN HERITAGE LANGUAGES. This study aims to explore how heritage speakers of Turkish process derivational morphology in their heritage language (HL). Heritage speakers (henceforth, HSs) are individuals who acquire a HL at home but live in an environment where a different community language is spoken (Scontras et al. 2018). HSs' language acquisition process is suggested to diverge from that of typical baseline speakers as they experience reduced input to their first (heritage) language compared to baseline speakers, and the community language eventually becomes their dominant language.[1] Hence, existing literature highlights the need to understand the divergences in HSs' language development, which can provide valuable insights into which aspects of linguistic knowledge and mechanisms of HL processing remain stable despite reduced exposure and which ones are less robust and more vulnerable to input conditions (Uygun & Clahsen 2021; Jacob et al. 2019).

A vulnerable linguistic domain commonly noted in the HL literature is morphology (Montrul & Yoon 2019). The limited input that HSs receive to their HL ultimately leads to divergences in adulthood in this domain, such as general tendencies towards reduction, simplification, and overgeneralization of inflectional morphemes (Polinsky 2018; Montrul 2023). Montrul et al. (2015), for example, reveal that HSs of Hindi limit the use of dative case to the indirect object recipient (and lose it with experiencer verbs and non-1SG persons). For Mandarin, Ming and Tao (2008) show that HSs ungrammatically omit or incorrectly use classifiers in nominal phrases. In Arabic, HSs are found to overgeneralize regular plural forms over irregular plurals (Albirini & Benmamoun 2014), and in Turkish, HSs are shown to inconsistently omit differential object marking (Coşkun-Kunduz & Montrul 2022). All these findings point to morphological patterns in HLs that diverge from baseline standards (Putnam et al. 2021).

There is limited research focusing on derivational morphology in HLs (Montrul & Yoon 2019). Cross linguistic research suggests that derivational morphology is acquired later than inflectional morphology (Kuo & Anderson 2006), and that derivational morphemes are the first to depart in language attrition, suggesting they are less stable than inflectional morphology

[1] Language dominance is used variably in the literature to refer to a binary distinction – between a language that one is more proficient or comfortable using versus a language in which one is not – or to a gradable property that tracks along a continuum the "observed asymmetries of skill in or use of one language over the other" (Birdsong, 2014). Here we use the term "dominant language" in the first sense, referring simply to the language the HSs speak more proficiently.

(Gruzdeva 2017). This is consistent with the evidence gained from HLs: findings from Heritage Hungarian indicate that HSs exhibit less productivity in the use of deadjectival and deverbal causatives (Gal 1989) and that HSs of Hebrew reduce derivational templates to one form (by using idiosyncratic templates rather than adopting the templates used by Hebrew baseline standards) (Kaufmann & Aronoff 1991).

The present study investigates adult HSs of Turkish living in the U.S. These speakers have a heritage language with rich morphological structure and a dominant language with comparatively little inflectional and derivational morphology. In Turkish, an agglutinating language, words are formed through productive affixation (predominantly suffixation) of inflectional and derivational morphemes, allowing for extensive morphological productivity and numerous word forms from a single root (Hankamer 1986). During processing (at least by monolingual speakers), this morphological productivity translates to frequent combinatorial processing, where complex word forms are decomposed into their morphological constituents during word recognition (Frauenfelder & Schreuder 1992). English morphology, on the other hand, is characterized by both isolating and inflectional-fusional properties, resulting in a simpler and less rich morphological system than in Turkish (Uygun & Gürel 2016). Accordingly, the combination of Turkish and English raises critical questions regarding morphological processing in bilingual Turkish-English speakers, specifically as to how HSs of Turkish process morphology in their weaker, morphologically rich HL and in their dominant language, which is relatively more analytical than Turkish and than the dominant language of Turkish HSs tested in previous studies.

1.2. Morphological Processing Models. The processing of morphologically complex words is typically investigated via morphological priming studies. Three major theoretical models for morphological processing in a native language have been proposed: the single mechanism associative model (Bybee 1995), the rule-based model (Halle & Mohanan 1985), and the dual mechanism model (Clahsen 1999; Pinker 1991, 1999; Pinker & Ullman 2002). Single mechanism accounts assume that, regardless of morphological complexity, words are stored in the mental lexicon in their full forms, i.e., without decomposition (Bybee & Slobin 1982). Conversely, rule-based accounts claim that lexical access of morphologically complex words primarily involves decomposition (Ling & Marinov 1993). Dual mechanism accounts put forth a hybrid model: while monomorphemic, simple word forms and some high-frequency complex words are stored in the mental lexicon in full form, multimorphemic, complex word forms, and many low frequency words are segmented into their morphological constituents during word recognition (Pinker 1999).

As for the role of these mechanisms in bilingual morphological processing, two primary accounts are the Shallow Structure Hypothesis (SSH) (Clahsen & Felser 2006a) and the Declarative/Procedural Model (Ullman 2005). Both models were originally based on studies on L2 learners, yet the growing body of research on morphological processing in various speaker groups led the SSH to be extended to morphological processing in a non-dominant language by different bilingual populations, including HSs (Clahsen & Felser 2018). The SSH suggests that L2 morphological processing depends more on lexical storage and less on rule-based (decomposition) processing than does L1 processing (Clahsen & Felser 2006a). Empirical evidence supporting the SSH comes from studies that do not find evidence for masked priming effects in L2 speakers (Clahsen et al. 2013), while evidence that advanced L2 learners of English demonstrate native-like priming patterns for productive derived word forms (though not for equally productive inflected forms) goes against the SSH (Kırkıcı & Clahsen 2013).

The Declarative/ Procedural Model involves two distinct mechanisms in the L2 (Ullman 2005): the declarative memory system regulates the way whole word units are stored and retrieved from the mental lexicon, and the procedural system manages the application of rule-based grammar knowledge. L2 learners vary in their use of these systems depending on their proficiency in the L2: the more proficient they are, the more they shift from employing declarative memory to the procedural system. For example, highly-proficiency Spanish-English and Dutch-English L2 speakers have been shown to adopt similar morphological decomposition strategies to baseline English speakers, rather than relying more heavily on whole-word processing in the L2 (Diependaele et al. 2011).[2] Further studies suggest that processing of morphology may be modulated by morpheme type: advanced L2 learners of English show native-like priming patterns for derived words, but not for regularly inflected forms, suggesting differences in L2 processing of inflection and derivation (Kırkıcı & Clahsen 2013; Silva & Clahsen 2008).

Psycholinguistic research on bilingual morphological processing has only recently shifted to HSs. Recent findings suggest HSs may exhibit efficient morphological decomposition mechanisms, while also diverging from baseline speakers with respect to their overall speed of processing (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016). In an auditory priming experiment, HSs of Russian displayed morphological decomposition in processing of both regular and irregular inflectional verbal morphology, similar to baseline Russian speakers (Gor & Cook 2010). Jacob et al. (2019)'s visual morphological priming study on HSs of Turkish with German as their dominant language suggests that HSs, similar to prototypical baseline speakers, exhibit efficient morphological decomposition of not only derivational but also inflectional morphology. This suggests that, even with limited input to their HL, Turkish HSs with German as the dominant language have developed target-like decomposition mechanisms for morphologically complex words in their HL. Uygun & Clahsen (2021) further examined Turkish HSs' morphological processing of regular and irregular inflectional morphology in Turkish aorist. The HS and baseline groups showed similar morphological decomposition patterns, though the processing of the regular aorist resulted in higher variability among HSs than the baseline group. These studies demonstrate that, even in an agglutinating language like Turkish, decomposition mechanisms may be in operation during morphological processing. Still, to date, the studies on Turkish HSs have considered HS populations whose dominant language (German) has rich a morphological system, making the generalizability of these findings inconclusive.[3]

1.3. THE PRESENT STUDY. A main limitation in the heritage bilingualism literature is that most morphological processing research has focused dyads with structurally similar Indo-European languages (notable exceptions are Uygun & Clahsen, 2021; Jacob et al., 2019; Jacob & Kırkıcı 2016), so it is unclear if existing findings apply to L1-L2 pairs that have typologically distinct morphological systems (Kırkıcı & Clahsen 2013). Existing studies investigating morphology in Heritage Turkish tested populations with German as their dominant language (Uygun & Clahsen 2021; Jacob et al. 2019); although German is an Indo-European language while Turkish is not, the generalizability of the findings is unclear given that German also has a relatively rich morphological system. It is not yet known whether similar processing patterns would be observed for

[2] We note, however, that Diependaele et al. (2011) did not test a lower-proficiency group for comparison.

[3] Differently from the present study, the existing literature cited in this paragraph either mentions that the existing models are unable to account for their data (e.g., Jacob & Kırkıcı 2016) or the authors do not commit to a direct relation between the data and the models summarized in our study's introduction section (e.g., Uygun & Clahsen 2021; Jacob et al. 2019).

HSs of Turkish with English as the dominant language – whose morphology is less rich than not only Turkish but also German.

Additionally, while some research has investigated morphological processing in both the L1 and L2 of bilingual populations (Diependaele et al. 2011), no study has examined morphological processing in both languages of HSs, which could provide information about the morphological priming pattern not only in HSs' weaker HL but also in their dominant language. Accordingly, the present study investigated English-dominant adult HSs of Turkish, as well as two baseline populations of comparison (baseline Turkish speakers and baseline English speakers in the U.S.), to address the following research questions:

1. Do baseline Turkish speakers process morphologically complex derived words in Turkish through decomposition or as whole words?
2. Do baseline English speakers process morphologically complex derived words in English through decomposition or as whole words?
3. Do HSs process morphologically complex derived words in their weaker HL, Turkish, and in their dominant language, English, through decomposition or as whole words?

With respect to Research Question 1, based on prior work on morphological processing in baseline Turkish, we expect to find that Turkish speakers do decompose morphologically complex words during language processing (ex. Uygun & Clahsen 2021; Jacob et al. 2019; Kırkıcı & Clahsen 2013). As for Research Question 2, we also expect to find evidence for decomposition during language processing by baseline English speakers, given a wealth of studies on this phenomenon (ex. Silva & Clahsen 2008; McCormick et al. 2008; Rastle et al. 2004). For Research Question 3, drawing on studies of morphological processing in Turkish-German HSs, the findings may vary depending on the influence of English. If the analyticity of English as HSs' dominant language plays a role in processing of morphology in Heritage Turkish, we may not observe evidence for decomposition in HSs. If analyticity of the dominant language does not play a role, we expect to find evidence for decomposition in HSs.

The research questions in this study are pursued via a morphological priming task, in which participants are very briefly presented with a morphologically complex prime word (ex. *sınırsız* 'limitless') and immediately after that with a target word. The brief presentation of the prime (60 ms for this study) prevents its conscious recognition, allowing researchers to observe the early stages of word recognition. Participants are asked to make a lexical decision on the target word, i.e., to indicate whether it is a real or a nonce word. Table 1 shows the three prime conditions used in this study (examples are from the Turkish task; conditions for the English task are designed analogously). In the key test condition, the prime and the target word are morphologically related, ex. Related prime *sınırsız* 'limitless' and target word *SINIR* 'limit' (cf. Table 1). If the parser decomposes the Related prime into its stem *sınır* and suffix *-sız*, then this should lead to the activation of the stem *sınır*, making it easier to recognize the target word *SINIR*. By contrast, if the prime is morphologically unrelated to the target (ex. *çocuk* 'child'), no facilitation of the recognition of the target word is expected (Jacob et al. 2019; Silva & Clahsen 2008). As mentioned earlier, only derivational morphology was tested here. Since derivational and inflectional morphology differ in whether they are thought to yield a separate lexical entry (Matthews 1991), it is best to consider them separately in a study on shallow processing.

	Prime Type	Prime Item	Target Item
a.	Related (Test) Prime	sınırsız 'limitless'	SINIR 'limit'
b.	Identical Prime	sınır 'limit'	SINIR 'limit'
c.	Unrelated Prime	çocuk 'child'	SINIR 'limit'

Table 1. Experimental conditions, with example experimental items from Exp. 1

The speed of making the lexical decision for the target item is measured, and differences in response times (RTs) between the Related and Unrelated Prime conditions are taken as a measure of morphological priming: slower RTs are predicted for the Unrelated prime condition than the Related and Identical prime conditions. The Identical Prime condition is expected to yield the fastest RTs, as it is a repetition prime of the target word in underived form, without any morphological sub-parts as constituents – a commonly used control condition in morphological priming studies. Accordingly, the following predictions are made for each of the studies:

1. If participants morphologically decompose derived words, RTs will be faster for the Related prime than the Unrelated prime condition.
2. If participants access derived words as whole words, RTs will not differ between the Related prime and the Unrelated prime conditions.

2. Experiment 1 (Turkish).

2.1. PARTICIPANTS. 27 Heritage Turkish speakers residing in the U.S. and 28 baseline Turkish speakers (TSs) residing in Turkey completed the Turkish morphological priming experiment. Participants were selected based on their language background and their self-reported language proficiency. Table 2 summarizes the background information for TSs and HSs:

	Heritage Turkish Speakers (HS) (n= 27)	Baseline Turkish Speakers (TS) (n= 28)
Mean Age (SD):	20.3 *(2.6)*	23.2 *(2.1)*
Mean Age of Switch to English	3;7 *(2.2)*	9;8 *(1.9)*
Self-rated Proficiency in English (1-6)	Speaking: 5.8 Comprehension: 6 Reading: 5.8 Writing: 5.9	Speaking: 3.03 Comprehension: 3.4 Reading: 3.5 Writing: 3.2
Self-rated Proficiency in Turkish (1-6)	Speaking: 5.1 Comprehension: 5.6 Reading: 4.6 Writing: 4.1	Speaking: 5.9 Comprehension: 6 Reading: 5.9 Writing: 5.9

Table 2. Background information for participants in Exp. 1

The following criteria were used to select HS participants: they were either born and raised in the U.S. or arrived in the U.S. before or at the start of formal education (average age of onset of exposure to English: 4;5). Their home language was Turkish, and their dominant language was English. Among the 27 participants in the HS group, 17 were born and raised in the U.S.; 6 had arrived at the U.S. before the age of 4, two participants arrived at age 5, and two arrived at age 8. All participants reported being native Turkish speakers.

TS participants reported having learned English as a foreign language at school, and their self-reported proficiency in English ranged from beginner to (upper-)intermediate level.

2.2. MATERIALS. Turkish derived words formed with the denominal adjective marker -*sIz* and the deadjectival nominalizer -*lIk*, were selected as the focus of the experiment. Both -*sIz* and -*lIk* suffixes are phonologically transparent, meaning that they do not cause any changes in the forms of the stems they attach to, and they are both highly frequent and productive, i.e., they can combine with a large number of nouns and adjectives (Jacob et al. 2019; Kırkıcı & Clahsen 2013). Both suffixes also exhibit similar patterns in terms of semantic compositionality, in that knowing the meanings of base forms and the suffixes can result in accurate predictions about the output.

In Turkish, vowel harmony leads to four distinct realizations of suffixes, depending on the frontness and roundedness of the vowel(s) in stems, as shown in (1) for -*sIz* and (2) for -*lIk*:

(1)	a.	*sınır-sız*	'limitless'	(2)	a.	*zayıf-lık*	'thinness'
	b.	*gerek-siz*	'needless'		b.	*sade-lik*	'simplicity'
	c.	*pürüz-süz*	'smooth'		c.	*mutlu-luk*	'happiness'
	d.	*umut-suz*	'hopeless'		d.	*özgür-lük*	'freedom'

2.3. DESIGN. Target stimuli for Exp. 1 consisted of a total of 48 morphologically related prime-target pairs: 24 test primes with deadjectival -*lIk* and 24 test primes with denominal adjectives derived with -*sIz* (e.g., *sınırsız – sınır*; 'limitless – limit') (see Appendix D for stimuli lists). Target words were the simple forms of the morphologically complex primes. In Identical Prime conditions, primes were the same forms as target words, whereas in Unrelated Prime conditions, prime words had no semantic, orthographic, or morphological relation to the target word.

The three conditions (cf. Table 1) were counterbalanced and distributed across three Latin-Squared experimental versions to ensure that no participant saw the same target word more than once. Each condition for each derivational morpheme included 8 prime-target sets, resulting in a total of 48 test items (24 for -*sIz* and 24 for -*lIk*), which were counterbalanced with 30 real-word fillers and 78 non-word fillers (pseudowords). The total number of prime-target pairs in each experiment was 156, and the target stimuli composed 30.7% of all experimental pairs. All prime and target words were selected from the Bogazici University (BOUN) Corpus, controlling for surface frequency per million (see Appendix A for mean frequencies) (Sezer & Sezer 2013). Since target words and Identical primes consisted of the same words, they had the same frequency and word length. High-frequency words from the BOUN Corpus were selected to ensure that HS participants would likely know them. Pseudowords were generated via the Wuggy software's Turkish extension (Keuleers & Brysbaert 2010).

2.4. EXPERIMENTAL PROCEDURE. A masked priming experiment – commonly used in morphological priming experiments – was employed (Figure 1). For each stimulus, participants were first presented with an asterisk on a black screen in Arial size 40 font for 500ms, followed by a blank screen for 500ms. Next, a forward mask consisting of a series of eight hashtags appeared on the screen. Then, the prime word was presented in lowercase letters for 60ms, followed by an uppercase target word presented for 3000ms. Participants were asked to give their lexical decision response as 'yes' or 'no' (by pressing the 'A' or 'L' buttons on the keyboard, respectively). The experiment was implemented in Psytoolkit (Stoet 2010, 2017).

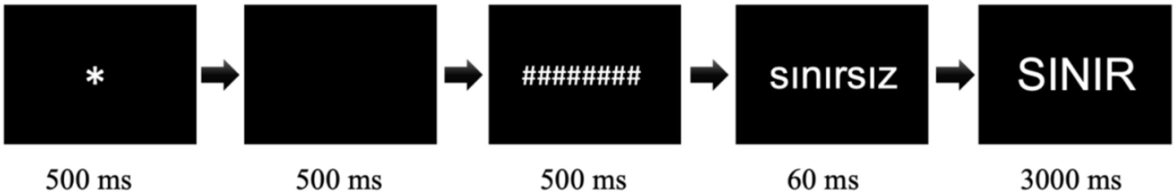

Figure 1. Visual representation of the masked priming experiment used in Exp. 1 (same procedure was used for Exp. 2 but with English stimuli).

2.5. Data Collection. All participants were contacted via social media, class, and email announcements. The researcher scheduled online appointments with each participant to ensure that participants completed the experiment online, in one sitting, and in a silent place. Upon participation, HSs received a gift card worth $10, and TSs received a gift card worth 40₺.

Individual online meetings began with participants giving informed consent, after which they were given a link to practice trials and left the online meeting. Once participants completed the practice trials, they returned to the online meeting and were introduced to the main task. Upon the completion of the main task (approximately 8 min.), participants returned to the meeting to complete a vocabulary task (Appendix F) – consisting of 25 target and prime words used in the Turkish stimuli – in which they were asked to identify the words they were familiar with.

Lastly, participants were given a language background questionnaire. HSs received the questionnaire in English while TSs received the questionnaire in Turkish (Appendix C). In total, the experimental session lasted 30-35 minutes for TSs and 40-45 minutes for HSs.

2.6. Data Analysis. All incorrect responses and timeouts were excluded from analysis (4.58% of the total responses). In addition, RTs exceeding two standard deviations below and above a participant's average RT across all correct trials were removed (4.29% of the remaining total responses). Furthermore, fillers were removed (67.8% of remaining total responses). Since predictions pertain to RTs for the Related and Unrelated Prime condition trials only, Identical prime condition trials were also excluded from analysis (33.7% of remaining total responses). Lastly, one target item was removed due to an error in the experiment (4.2% of the total). To normalize residuals to ensure that errors are normally distributed, and to ensure better interpretation of the RT data, the remaining RTs (n=1595) were log-transformed (Beyersmann et al. 2021). The log-transformed RTs were analyzed using R Version 2022 (R Development Core Team 2017).

2.7. Results. Visual assessment of Figure 2 indicates that overall response times for the Unrelated prime condition were higher than the Related prime conditions for both HSs and TSs. HSs had numerically higher RTs in both Related (Mean=675.7, SD=158.01) and Unrelated (Mean=719.47, SD=154.5) prime conditions than TSs did for the Related (Mean=564.98, SD=36.2) and Unrelated (Mean=588.24, SD=119.9) prime conditions.

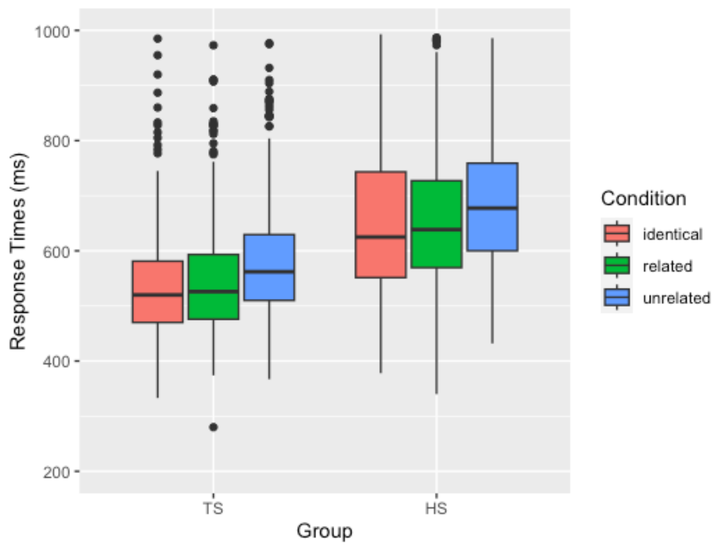

Figure 2. Comparison of RTs for HSs and TSs, split by prime condition

Linear mixed effects regression models were fitted to the RT data. The models included Group (HS vs. TS), Condition (Related vs. Unrelated), and Suffix (-*sIz* vs. -*lIk*) as fixed effects, and Participant and target Item as grouping factors for random effects. Categorical predictors were sum-coded (-0.5, 0.5). Models were fitted parsimoniously using the package *lme4* (Bates, Mächler, Bolker, & Walker 2015). The Satterthwaite method was used for estimating the approximate degrees of freedom for an F-test and to obtain p-values, using the *lmerTest* package (Kuznetsova et al. 2017). The maximum random-effects model was fitted; when the model did not converge, it was gradually simplified until convergence was reached. The best-fit model predicted log-transformed RT with fixed effects of Condition, Group, and Suffix, and with random intercepts grouped by target Item and by Participant (Table 3).

Predictor	$\hat{\beta}$	$SE(\hat{\beta})$	*t*	*df*	*p*
(Intercept)	6.42	0.016	391.9	77.57	<0.001
Group1	-0.204	0.028	-7.21	52.85	<0.001
Condition1	0.066	0.0081	8.11	1510	<0.001
Suffix1	0.035	0.018	1.91	4303	0.063

Number of obs.: 1595, groups: Item(46), Participant(55). *p*-values/ *df* calculated using the Satterthwaite approximation.
Model formula: ResponseTimes ~ Group + Condition + Suffix + (1|Item) + (1|Participant)
Marginal R^2=0.23, Conditional R^2=0.49

Table 3. Fixed effects for the best-fit model for the Turkish results

This model indicated significant main effects of Group ($\hat{\beta}$=-0.204, SE=0.028, t=-7.21, df= 52.85, p<0.001) and Condition ($\hat{\beta}$=0.066, SE=0.0081, t=8.11, df= 1510, p<0.001), whereas Suffix did not show a significant effect ($\hat{\beta}$=0.035, SE=0.018, t=1.91, df= 4303, p=0.063). The HS group had significantly slower RTs compared to the TS group. Moreover, the RTs for the Unrelated prime condition were significantly slower than those for the Related prime condition.

3. Experiment 2 (English).

3.1. PARTICIPANTS. 27 Heritage Turkish speakers and 21 baseline English speakers (ESs) residing in the U.S. completed the English morphological priming experiment. The same HS participants who completed Exp. 1 also completed Exp. 2. Participants were selected using the same criteria sought in Exp. 1. All ES participants self-identified as native speakers of English,[4] and they were all born and raised in the U.S. Table 4 summarizes the background information for ES and HS participants.

	Baseline English Speakers (ES) *(n= 21)*	Heritage Turkish Speakers (HS) *(n= 27)*
Mean Age (SD):	25.8 *(4.3)*	20.3 *(2.6)*
Mean Age of Switch to English	*N/A*	3;7 *(2.2)*
Self-rated Proficiency in English (1-6)	Speaking: 6 Comprehension: 6 Reading: 6 Writing: 6	Speaking: 5.8 Comprehension: 6 Reading: 5.8 Writing: 5.9
Self-rated Proficiency in Turkish (1-6)	*N/A*	Speaking: 5.1 Comprehension: 5.6 Reading: 4.6 Writing: 4.1

Table 4. Background information of the participants in Exp. 2

3.2. MATERIALS. For the stimuli in Exp. 2, the denominal adjectival *-less* and deadjectival nominalizer *-ness* suffixes were selected as the derivational morphemes because these suffixes can be considered to be translational equivalents of the Turkish suffixes *-sIz* and *-lIk* used in Exp. 1. Also, analogous to *-sIz* and *-lIk*, both *-less* and *-ness* suffixes are phonologically transparent, high-frequency, and productive (Kırkıcı & Clahsen 2013):

(3) a. help-less
b. care-less

(4) a. calm-ness
b. bright-ness

3.3. DESIGN. The same experimental design as in Exp. 1 was employed for Exp. 2, with the only difference being the language of instructions and experimental items, which was English in Exp. 2 (see Appendix A for frequency measures and Appendix E for stimuli lists).

3.4. EXPERIMENTAL PROCEDURE. The same experimental procedure as in Exp. 1 was employed for Exp. 2, with the only difference being the language of the task.

3.5. DATA COLLECTION. The same recruitment and data collection procedures as in Exp. 1 were used in Exp. 2. Participants received $10 gift card upon participation.

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[4] As an anonymous reviewer points out, in all likelihood most of the baseline English speakers were not strictly speaking monolingual. However, we do not find this to be a concern, as all baseline English participants reported learning a second language in a classroom setting, with maximally intermediate proficiency and with an age of onset of bilingualism between ages 12-18 (with the exception of one participant who reported age of onset of bilingualism at age 8). It seems safe to assume that the participants were functionally monolingual.

3.6. DATA ANALYSIS. The same data cleaning procedure was implemented as in Exp. 1. All incorrect responses and timeouts were excluded from analysis (3.65% of the total responses). In addition, RTs exceeding two standard deviations below and above a participant's average RT across all correct trials were deemed outliers and removed (4.66% of the remaining total responses). Furthermore, fillers were removed (67% of the remaining total responses), followed by the exclusion of the Identical prime condition (34.02% of the remaining total responses) as in Section 2.6. To ensure that the errors are normally distributed, and to have a better interpretation of the RT data, the remaining data (n=1463) were log-transformed (Beyersmann et al. 2021) and analyzed using R version 2022 (R Development Core Team 2017).

3.7. RESULTS. Visual assessment of Figure 3 indicates that overall RTs for the Unrelated prime condition were numerically higher than the Related prime conditions for both HSs and ESs. HSs had numerically higher RTs in both Related (Mean=597.6, SD=124.8) and Unrelated (Mean=617.4, SD=113.6) prime conditions than ESs' RTs in the Related (Mean=559.92, SD=101.2) and Unrelated (Mean=596.13, SD=101.1) prime conditions.

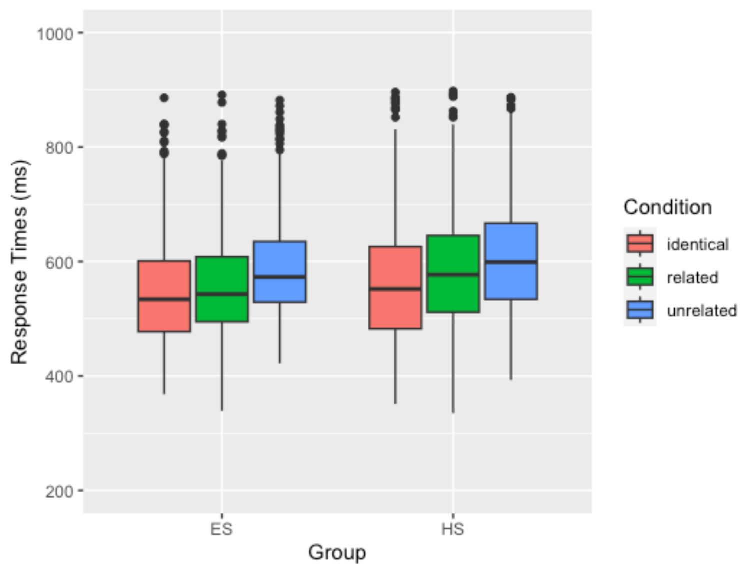

Figure 3. Comparison of RTs for HSs and ESs, split by prime condition

Linear mixed effects regression models were used to analyze the data. The models included Group (HS vs. ES), Condition (Related vs. Unrelated), and Suffix (*-less* vs. *-ness*), as well as their interactions, as fixed effects, and Participant and Item as grouping factors for random effects. Categorical predictors were sum-coded (-0.5, 0.5). Model fitting proceeded as in Section 2.7. The best-fit model is reported in Table 5.

Predictor	$\widehat{\boldsymbol{\beta}}$	$SE\ (\widehat{\boldsymbol{\beta}})$	*t*	*df*	*p*
(Intercept)	6.37	0.016	384.24	54.39	<0.001
Group1	0.048	0.031	1.53	45.83	0.13
Condition1	0.051	0.0074	6.88	1389	<0.001
Suffix1	-0.028	0.012	-2.28	45.42	0.03
Condition1: Suffix1	-0.029	0.015	-1.97	1386	0.04

Number of obs.: 1463, groups: Item(48), Participant(48). *p*-values/ *df* calculated using the Satterthwaite approximation.

Model formula: ResponseTimes ~ Group + Condition + Suffix + Condition:Suffix + (1|Item) + (1|Participant)
Marginal R^2=0.043, Conditional R^2=0.41

Table 5. Fixed effects for the results of Exp. 2

This model indicated significant main effects of Condition ($\hat{\beta}$=0.051, SE=0.0074, t=6.88, df=1389, p<0.001) and Suffix ($\hat{\beta}$=-0.028, SE=0.012, t=-2.28, df=45.42, p=0.03), as well as the interaction of Condition and Suffix ($\hat{\beta}$=-0.029, SE=0.015, t=-1.97, df=1386, p=0.04) whereas Group did not show a significant effect ($\hat{\beta}$=0.048, SE=0.031, t=1.53, df=45.83, p=0.13). The log-transformed RTs for the Unrelated prime condition were significantly slower than for the Related prime condition. In addition, the RTs for the *-ness* suffix was significantly faster than the RTs for the *-less* suffix. While the HS group had numerically slower RTs compared to the RTs of the ES group, this difference was not statistically significant. Follow-up models fit to unpack the interaction effect between Condition and Suffix show that there is a significant positive effect of Condition on log-transformed RTs for both levels of Suffix (*-less*: $\hat{\beta}$=0.066, SE=0.012, df=671.76, t=6.05, p<0.001; *-ness*: $\hat{\beta}$=0.035, SE=0.009, df=669.1, t=3.56, p<0.001), showing that the related condition was faster than the unrelated condition for both levels of Suffix.

4. Discussion.

The first research question addressed in this study was whether TSs process morphologically complex derived Turkish words through decomposition or as whole words. The results showed that the TS group had significantly slower RTs for the Unrelated prime than the Related prime condition. Consistent with the predictions (Section 1.3), this finding indicates morphological priming effects, suggesting decomposition in early lexical access in TSs. In line with the literature (Uygun & Clahsen 2021; Jacob et al. 2019; Kırkıcı & Clahsen 2013), this finding suggests that baseline Turkish speakers exhibit efficient morphological decomposition.

The second research question asked whether ESs access derived English words through decomposition or as whole words. As shown in the results, ESs had significantly slower RTs for the Unrelated prime condition than the Related prime condition. This morphological priming effect observed in ESs is in line with the predictions for morphological decomposition (Section 1.3) and is also consistent with findings from previous studies on baseline English speakers (ex. Diependaele et al. 2011; Silva & Clahsen 2008; McCormick et al. 2008; Rastle et al. 2004).

The third research question asked whether HSs of Turkish process morphologically complex derived words in their weaker HL, Turkish, and in their dominant language, English, through decomposition or as whole words. The results of Exp. 1 showed that Turkish HSs were significantly faster in the Related prime condition than the Unrelated prime condition in Turkish. Likewise, findings gained from Exp. 2 showed that HSs' average RTs for the Related prime condition were significantly faster than the Unrelated prime condition in English, as well. Taken together, the results indicate significant morphological priming effects in both languages. This suggests that Turkish HSs exhibit morphological decomposition in both their HL (Exp. 1) and their dominant language (Exp. 2). The finding that HSs demonstrated morphological decomposition in their HL provides additional evidence in support of claims made in prior work on morphological decomposition in HLs (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016; Gor & Cook 2010).

HSs' self-rated proficiency reports indicate they are weaker in their HL than in their dominant language (Table 2 and Table 4); still, they patterned with the TSs in Exp. 1, showing similar morphological priming effects. This suggests that the limited input that Turkish HSs received in the HL during childhood still allowed them to develop target-like morphological decomposition mechanisms for word recognition in the HL in adulthood. This informs our understanding of the robustness of derivational morphology to decreased input in acquisition. Cross-linguistically, derivational morphology is thought to be acquired later than inflectional morphology (Kuo & Anderson 2006), and in fact, inflectional morphology in agglutinating languages (i.e., Turkish) is suggested to be acquired especially early – as early as at 15 months – relative to non-agglutinating languages (Bohnacker 2020; Aksu-Koç & Slobin 2013). Relatedly, as discussed in Section 1.1, derivational morphology is thought to be particularly vulnerable to language attrition (Gruzdeva 2017), and in production HSs do consistently show divergent patterns of use of derivational morphology (ex. Gal 1989; Kaufman & Aronoff 1991). As a reminder, we only tested derivational morphology in the present study, and it is possible that morphological decomposition of inflectional morphology may differ for HSs relative to baseline speakers. Still, the findings in the present study, as well as related studies on morphological processing in Heritage Turkish (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016), suggest that, at least during real-time visual word recognition, derivational morphology demonstrates resilience to reduced input conditions characteristic of the HL acquisition. Namely, while the impact of limited input conditions in HSs' language acquisition is commonly evidenced in morphological production studies, where HSs often exhibit divergent performance compared to monolinguals, in the present study's online morphological processing task, such differences between the baseline and HS groups are notably absent.

Besides priming effects, the results also indicated a significant main effect of Group in the RTs in Exp. 1 (Turkish) but not in Exp. 2 (English): HSs had slower RTs than TSs but were not significantly different from ESs in their overall RTs. These findings may point to HSs' lower dominance in Turkish compared to TSs, which may have resulted in the overall slower speed of lexical retrieval for HSs in the Turkish task (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016). In their dominant language, HSs did not experience this delay. These results are consistent with the heritage bilingualism literature in morphology that commonly indicate slower RTs in the HL even when HSs exhibit efficient morphological priming (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016).

In addition, comparisons across the two suffixes (*-sIz*, *-lIk*) in Turkish showed no significant effect on the response variable, so the processing speed for derived words formed with *-sIz* and *-lIk* was not significantly different. On the other hand, the English suffixes (*-less*, *-ness*) indicated a different pattern in terms of RTs. This might be related to the processing differences associated with specific properties of these suffixes, such as frequency or orthographic and phonological neighborhood size of the words derived with them. However, this matter is outside the scope of this study, so we leave it for future work. Future work with a larger sample size may also investigate individual variation, in the vein of Uygun & Clahsen (2021).

5. Conclusions.

We present findings from two morphological priming studies that indicate that HSs of Turkish with English as their dominant language exhibit morphological priming effects in both their weaker HL and their dominant language, patterning with baseline speakers of both languages. Following previous findings regarding HSs of Turkish whose dominant language is German (Uygun & Clahsen 2021; Jacob et al. 2019; Jacob & Kırkıcı 2016), the findings provide additional evidence that HSs of Turkish develop baseline-speaker like morphological decomposition mechanisms for derived words in the HL, even though the quantity and quality of input to their acquisition differs substantially from that of TSs. The present study's findings provide further insight into this claim, suggesting that this target-like morphological decomposition is evident for HSs of Turkish even when the dominant language is not morphologically rich. In the present study, HSs were tested not only in their HL but also in their dominant language (English) – testing bilinguals in both their languages is increasingly recognized as crucial. In their dominant language, the HSs of Turkish tested in this study also exhibited priming patterns similar to the relevant baseline group.

6. Supplementary materials. For supplementary material accompanying this paper, visit here, or contact the authors.

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