

# MORPHOLOGICAL PROCESSING OF TURKISH DERIVED WORDS: DOES BILINGUALISM AFFECT THE PROCESSING ROUTE?<sup>1</sup>

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Taşan, M. & Uygun, S. (2025). Morphological processing of Turkish derived words: Does bilingualism affect the processing route? In O. Çınar, F. Başbuğ & H. Aydemir (Eds.), *Contemporary studies in linguistics 1: IMU Linguistics 15th anniversary commemorative volume* (pp. 311–334). Artsürem. <https://doi.org/10.7816/imuling-15-2025-01X017>

## ABSTRACT

It has been suggested that native speakers may develop different processing patterns in their first language as they become proficient second language users. While most of the studies are conducted with heritage speakers whose first language is the minority language in the society they live in, the number of studies that investigate first language as the majority language remains scarce. These studies have shown that high proficiency in a second language can influence first language processing even in the majority language context (van Hell & Dijkstra, 2002; Uygun & Gürel, 2020). The aim of the present study is to explore how proficient Turkish-English late bilinguals process Turkish derived words. 61 monolingual Turkish speakers and 46 proficient Turkish-English late bilingual speakers were tested via a masked priming experiment. The stimuli consisted of (i) transparent words (*dalga* “wave”, *dal* “dive” and *-ga* is the derivational suffix), (ii) opaque words (*karga* “crow”, *kar* “snow” but *-ga* does not function as a derivational suffix), and (iii) form/control words (*devre* “period”, *dev* “giant”, *-re* is not an existing derivational suffix). The results showed no significant group differences in the morphological processing of Turkish derived words. While both monolingual and bilingual speakers employed decomposition for transparent and opaque words, no morphological parsing was observed for the form/control words.

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<sup>1</sup> This study was supported by Scientific and Technological Research Council of Türkiye (TUBITAK) under the Grant Number 223K342. The authors thank to TUBITAK for their supports. We also thank Ayşe Gürel for her help and recommendation in designing the stimuli list and Ece Nur Temuçin for her help with participant recruitment and data collection.

These results suggest that not only monolingual but also bilingual speakers decompose derived words regardless of their transparency, suggesting that high proficiency in a second language does not affect the morphological processing route of the first language.

**Keywords:** Turkish derivation, Morphological processing, Semantic transparency, First language, Proficient late bilinguals

## ÖZ

Dil konuşucularının ikinci bir dilde yetkin hale gelince ana dilleriyle ilgili farklı işleme örüntüleri geliştirebilecekleri öne sürülmüştür. Bu alandaki çalışmaların çoğu konuşukları ana dil yaşadıkları toplumda bir azınlık dil olan miras dil konuşucuları ile yürütülürken, konuşukları ana dil yaşadıkları toplumdaki çoğunluk dil olan katılımcılar ile yapılan çalışmaların sayısı çok azdır. Az sayıdaki bu çalışmalar ise, ikinci bir dilde yüksek düzeydeki yetkinliğin ana dilin çoğunluk dil olduğu ortamlarda bile ana dilin işlenmesini etkileyebileceğini göstermektedir (van Hell & Dijkstra, 2002; Uygun & Gürel, 2020). Bu çalışmanın amacı ileri düzeyde İngilizce bilen ve İngilizceyi ileri yaşta öğrenen Türkçe-İngilizce iki dilli konuşucularının Türkçede yapım ekleriyle üretilmiş sözcükleri nasıl işlediklerini araştırmaktır. 61 tek dilli Türkçe konuşucusu ile 46 Türkçe-İngilizce iki dilli konuşucusu maskelenmiş hazırlama deneyi kullanılarak test edilmiştir. Çalışmada kullanılan sözcükler (i) anlamsal olarak geçirimli (*dalga* – *DAL*, *-ga* yapım eki olarak işlev göstermektedir), (ii) anlamsal olarak geçirimsiz (*karga* – *KAR*, *-ga* yapım eki gibi görünmesine rağmen bu işlevi göstermemektedir) ve (iii) örtüşük yazılımlı sözcüklerden (*devre* – *DEV*, *-re* mevcut bir yapım eki değildir) oluşmaktadır. Sonuçlar Türkçede yapım ekleriyle türetilmiş sözcüklerin biçimbilimsel işlenmesinde iki grup arasında bir fark olmadığını göstermektedir. Her iki grupta yer alan katılımcılar anlamsal olarak geçirimli ve geçirimsiz sözcükleri biçimbirim bileşenlerine ayırarak işlemlerken, örtüşük yazılımlı sözcüklerde ise bu çözümleme gözlenmemiştir. Bu sonuçlar, hem tek dilli hem de iki dilli katılımcıların yapım ekleriyle üretilmiş sözcükleri biçimbirim bileşenlerine ayırırken anlamsal geçirimlilikten etkilenmediklerini göstermektedir. Bu durum, ikinci bir dilde yüksek düzeyde yeterliliğe sahip olmanın ana dilin biçimbilimsel işlenmesini etkilemediği anlamına gelmektedir.

**Anahtar Sözcükler:** Türkçede yapım ekleri, Biçimbilimsel işleme, Anlamsal geçirimlilik, Ana dil, İkinci dili geç öğrenen ve bu dili ileri düzeyde bilen iki dilliler

## 1. Introduction

A fundamental question in bilingualism concerns how two languages interact in the bilingual mind and whether frequent exposure to a second language (L2) leads to changes in first language (L1) processing. Early work suggested that exposure to more than one language could lead to deviations in linguistic forms, particularly in phonology (Nagle et al., 2023), lexicon (Fridman & Meir, 2023), and syntax (D'Alessandro et al., 2025). When the representation and processing of morphologically complex words are considered, some studies have documented L1-to-L2 influence (Basnight-Brown et al., 2007; Portin et al., 2008), yet recent

research highlights that L2 proficiency can also shape L1 representation and its processing mechanisms (Uygun & Gürel, 2020). This bidirectional influence suggests that bilinguals constantly negotiate between their two linguistic systems, which may impact how they process words in their L1.

The view that even L1 speakers can develop nonnative-like processing strategies as they learn an L2 and become proficient L2 users has been considered relatively counter-intuitive (Clahsen & Felser, 2006). This perspective has given rise to a substantial body of research into heritage speakers (HS), examining whether and how prolonged L2 exposure and L2 proficiency—as well as factors such as the quality and quantity of L1 input, the amount of L1 use, aptitude, and motivation—may reshape the way their L1 is represented and processed. In doing so, researchers have investigated a range of linguistic domains such as phonology, morphology, syntax, lexicon, and semantics, highlighting the complex interplay between L1 and L2 systems (Kasparian & Steinhauer, 2017; Montrul, 2008; Polinsky, 2018; Polinsky & Putnam, 2024; Schmid & Yılmaz, 2021). The L1 of HS has traditionally been studied in immigrant populations, where L1 is no longer the dominant language, and speakers shift towards using L2 in their daily interactions (Isurin & Wilson, 2022). However, there is still no consensus regarding the extent and nature of heritage language effects, leaving open the question of whether they primarily reflect limitations in accessing existing L1 representations, structural shifts prompted by L2 proficiency, or increased cognitive demands during real-time L1 processing (Felser & Uygun, 2022; Kasparian & Steinhauer, 2017; Polinsky & Scontras, 2020; Schmid & Köpke, 2017; Shin, 2024).

The present study focuses on the key issue of whether highly proficient L2 users process derived words in their L1 differently from monolinguals. Understanding this phenomenon is crucial for bilingual morphological processing, as prior research has demonstrated that even when an L1 remains dominant, L2 proficiency can significantly influence the processing of morphologically complex words (Uygun & Gürel, 2020). Much of the existing research has examined HS, whose L1 is a minority language and who receive limited L1 input over time. However, little attention has been paid to how L2 proficiency affects L1 morphological processing when individuals continue to reside in an environment where their L1 serves as the majority language. This gap in the literature raises an important question: To what extent does high proficiency in an L2 reshape L1 morphological processing even when the L1 continues to be dominant?

### **1.1 L2 effects on L1 in the L2 setting: Morphological processing studies on heritage Turkish**

HS are described as a subset of bilinguals raised in homes where a language other than the dominant community language was spoken (Scontras et al., 2018). This is usually the case for immigrants who move

to a country where another language is spoken and for their children who were exposed to a language in their childhood but then were exposed to the language of the host country (Schmid, 2010; Scontras et al., 2015). The study of HS contributes to our understanding of language acquisition, storage, and language processing. By examining the linguistic knowledge of HS, researchers investigate the linguistic system developing under reduced exposure/input conditions to explore how HS acquire their L1, how their L1 develops or fails to develop, how their L1 is represented and processed, which linguistic domains are fully acquired, and which are susceptible to change and deviate from the baseline (Montrul, 2013).

Recently, HS studies have started to investigate the morphological processing of complex word forms by using time-sensitive tools with an attempt to explore the real-time processing of the morphologically complex words. In one of these studies, Jacob and Kırkıcı (2016) compared the morphological processing of Turkish HS living in Germany with Turkish native speakers based on the materials from Kırkıcı and Clahsen's (2013) study, which tested the regular aorist *-Ar* and the deadjectival *-Ik* nominalizations. Both groups showed significant morphological priming effects not only for the regular aorist (e.g., *sorar* – *SOR* “asks – ASK”) but also for the deadjectival suffix (e.g., *sağlık* – *SAG* “health – HEALTHY”); however, significant priming effects were also observed in the orthographic control condition (e.g., *devre* – *DEV* “period – GIANT”) only for HS, suggesting that, unlike Turkish native speakers, HS rely more on orthographic (surface form) properties of the words as they fail to access morphemic constituents in online processing. In another study, Jacob et al. (2019) investigated another inflected form, the reported past suffix *-mİş* (e.g., *satmış* – *SATMAK* “s/he sold – SELL”) together with the deverbal nominalization suffix *-(y)İcİ* (e.g., *saticı* – *SATMAK* “seller – SELL”) with native Turkish speakers and HS living in Germany. The results displayed significant priming magnitudes in both groups for the inflected and derived forms. Contrary to Jacob and Kırkıcı (2016), the results of the semantic (e.g., *postane* – *MEKTUP* “post office – LETTER”) and orthographic (e.g., *haziran* – *HAZİNE* “June – TREASURE”) conditions indicated that the observed priming effects were purely morphological in nature because no significant priming effect was obtained for these conditions. The authors concluded that despite acquiring Turkish under disadvantaged conditions, HS can develop native-like processing mechanisms. Uygun and Clahsen (2021) tested the morphological processing of regular (*-Ar*) and irregular (*-Ir*) aorist forms in HS living in Germany and compared their processing routes to Turkish native speakers. While the native speakers and HS exhibited priming effects for both regular (e.g., *duyar* – *DUY* “hears – HEAR”) and irregular (e.g., *gelir* – *GEL* “comes – COME”) aorist forms, the HS also displayed priming effects for the semantic condition (e.g., *kafa* – *BAŞ* “head – HEAD”), which involved synonyms and antonyms. The researchers concluded that HS showed more reliance on meaning-based associations in their processing. Recently, Eldem-Tunç and Fuchs (2024)

sought to describe the morphological processing of the denominal adjective marker *-sız* (e.g., *sınırsız* – *SINIR* “limitless – LIMIT”) and the deadjectival nominalizer *-lık* (e.g., *hastalık* – *HASTA* “sickness – SICK”) in Turkish HS living in the US. The researchers observed similar processing patterns in Turkish native speakers and HS and proposed that morphological decomposition was not affected under heritage language conditions.

As can be seen, more research is needed on the morphological processing patterns of the HS to reach any generalizable conclusions because of the diverse observations made. Research on HS focuses on the effects of L2 (the majority language of the society) on L1, which is the minority language and functions as the first language of the immigrants. However, only a handful of studies have questioned the effect of proficient L2 knowledge on L1 speakers, who reside in a country where L1 is the dominant language.

### **1.2 L2 effects on L1 in the L1 setting: Morphological processing studies on L1 Turkish**

Since there is only one study that explores the effect of L2 knowledge on the morphological processing of L1 Turkish, we will briefly summarize some studies that focused on the same concept but tested different phenomena, namely word fluency and word recognition. In one of these studies, Ayçiçeği-Dinn et al. (2017) questioned whether an L1 would suffer when students took all their classes in a foreign language even if they lived in their home country. They compared students, who were studying psychology, economics, and English literature at a university in Türkiye. The researchers found significantly lower word fluency scores for the English literature students when compared to psychology and economics students. The self-reported L1-Turkish speaking and writing abilities were also found to be smaller in this particular group. The researchers concluded that prolonged engagement with an L2 might put L1 at risk for temporary attrition. More recently, Ma and Vanek (2024) investigated how learning an L2 might influence a person's L1 even when they are surrounded by the L1 environment. Specifically, they recruited two groups of participants: 25 Chinese teachers of English and 25 Chinese teachers who did not teach English from the same school. They employed a time-sensitive word decision task where the participants had to quickly decide if the presented words were real Chinese words. They reported that Chinese teachers of English were slower to respond to common Chinese words in the word decision task. These findings are taken to support the view that extended use of and exposure to L2 can result in some weakening of a person's L1 spoken vocabulary, even while they are mainly using their L1 in everyday life.

The only research that most closely aligned with the context of the present study is that of Uygun and Gürel (2020). The researchers examined the potential changes in the processing of morphologically complex words, namely Turkish compounds in monolingual Turkish speakers and

proficient Turkish-English late bilinguals, by employing a masked priming experiment. Their stimuli consisted of fully transparent compounds, in which the meanings of both words were related to the meaning of the whole word (e.g., *kuzeydoğu* “northeast”, *kuzey* “north”, *doğu* “east”), and partially opaque compounds, in which the meaning of one word was not related to the meaning of the whole word (e.g., *büyükelçi* “ambassador”, *büyük* “big”, *elçi* “delegate”). The results showed that monolingual participants decomposed Turkish compounds regardless of transparency. While they were able to activate both constituents in fully transparent compounds, they only activated the second constituent, which served as the head, in partially opaque compounds. Conversely, the bilingual group could not activate any of the constituents in partially opaque compounds and was able to activate only the first constituent (i.e., nonhead) in fully transparent compounds. These findings suggest qualitatively and quantitatively different processing patterns between monolinguals and bilinguals, even though the bilinguals resided in the L1 country.

In summary, the number of studies that deal with the question as to whether proficient L2 knowledge affects L1 in speakers residing in the L1 country is scarce, and the available studies have employed various data sets and data collection techniques. The aim of the present study is to explore how proficient Turkish-English late bilinguals living in Türkiye process Turkish derived words in comparison to Turkish monolinguals. Before moving on to the study, we will briefly introduce different accounts for the processing of derived words and the previous studies conducted with L1 and L2 speakers.

### **1.3 Previous research on the morphological processing of derivation in L1 and L2**

For over the past fifty years, psycholinguistic research has been focusing on the processing of morphologically complex words (e.g., *singing*, *singer*) with the goal of developing a model applicable across languages. Three main models have been proposed for the morphological processing of complex words. According to the Decomposition Model (Taft, 1979, 2004; Taft & Forster, 1975), morphologically complex words are parsed into their morphemic constituents (*sing+ing*, *sing+er*) prior to lexical access, suggesting that affixes and roots are represented separately in the lexicon. In contrast, the Full-Listing Model (Butterworth, 1983) posits that morphologically complex words are stored as whole units and are not decomposed into their constituents, assuming no morphological computation during word recognition. In contrast to these two views, research has also revealed that several factors such as, familiarity (e.g., Caramazza et al., 1988), frequency (e.g., Schreuder & Baayen, 1995), regularity (e.g., Clahsen et al., 2010), and semantic transparency (e.g., Schreuder & Baayen, 1995) play a crucial role in determining the processing route, leading to the proposal of the dual-route model. Although the findings of studies using masked priming experiments have shown that

morphologically complex words are processed by decomposing them into their morphemic constituents, debate still continues about how exactly the process of decomposition takes place and what factors affect this process.

Within this broader interest and ongoing discussions, research on derived word processing has expanded because words constructed with derivational suffixes may differ in their semantic transparency. Semantic transparency refers to the degree to which the meaning of a morphologically complex word can be inferred from its root form. In semantically transparent words, the meaning of the derived word can be computed from its root (e.g., *teacher* – *TEACH*, *singer* – *SING*). For example, *-er* is a derivational suffix in English that is added to verb forms and refers to the agent who does the action of the verb as a profession (i.e., a *teacher* is someone who *teaches* and does this as a profession). In contrast, semantically opaque words consist of a root and a pseudo-suffix that looks like a real derivational suffix, and the relationship between the derived word form and the root is not genuinely morphological (e.g., *corner* – *CORN*, *number* – *NUMB*). In these examples, *-er* resembles the derivational suffix in its form but does not function as a real derivational suffix; therefore, these words are also classified as pseudo-derived words (i.e., a *corner* is not someone who *corns*). Whether semantic transparency influences the morphological processing of derived words has been debated extensively, and the design of these studies usually employs three types of word forms: (i) semantically transparent (e.g., *teacher* – *TEACH*), (ii) semantically opaque (e.g., *corner* – *CORN*), and (iii) form/control words (e.g., *freeze* – *FREE*). The words in the form/control condition do not have a morphological relationship because *-ze* does not exist as a suffix in English; therefore, the word pairs in this condition resemble each other only in terms of orthography.

Different theories have been proposed for the morphological processing of derived words. The first one is the form-then-meaning account (Rastle et al., 2000, 2004). This account posits that both semantically transparent and opaque words are decomposed into their morphemic constituents, and semantic transparency does not play a role in the early stages of morphological processing. A substantial body of research investigating L1 processing through the masked priming paradigm found support for the form-then-meaning account (Boudelaa & Marslen-Wilson, 2005, in Arabic; Beyersmann et al., 2016; Rastle et al., 2000, 2004, in English; Longtin & Meunier, 2005, in French; Fleischhauer et al., 2021, in German; Frost et al., 1997, in Hebrew; Marelli et al., 2013, Experiment 1, in Italian; Heyer & Kornishova, 2018, in Russian; Lázaro et al., 2016, 2021, in Spanish). In one influential study, Rastle et al. (2004) examined the role of semantic transparency in derived word recognition using a masked priming design with 42 ms stimulus-onset asynchrony (SOA). The experiment included prime-target pairs for semantically transparent (e.g., *cleaner* – *CLEAN*), semantically opaque (e.g., *corner* – *CORN*), and form/control (e.g., *brothel* – *BROTH*) pairs. The results revealed

significant priming effects in both the transparent and opaque conditions, with priming magnitudes of 27 ms and 22 ms, respectively, indicating decomposition. However, the form/control condition yielded only a 4 ms effect, which was not significant and was interpreted as whole-word access. These findings were taken as support for the form-then-meaning account because in the early stages of visual word recognition, the parser uses morpho-orthographic information to process morphologically complex words and decomposes all derived words irrespective of semantic transparency.

Conversely, the form-with-meaning account suggests that semantic information plays a crucial role in the processing of complex words, and transparent words are processed easier than opaque words (Feldman et al., 2009, 2012, 2015). For example, Feldman et al. (2009) conducted a masked priming study with 50 ms SOA to explore the role of semantic transparency in processing English derived words. The results showed a significant priming magnitude difference favoring semantically transparent primes (30ms) over opaque primes (4 ms). The authors concluded that morpho-semantic information influenced the early stages of processing derived words. Most of the research supporting the form-with-meaning account indicated that in semantically opaque prime-target word pairs, prime words either showed no impact or had a weaker effect on their processing when compared to semantically transparent prime-target word pairs, which exhibited significantly larger effects.

Certain models have been proposed to interpret the obtained results. The most outstanding model is the Hybrid Model (Diependaele et al., 2005, 2009, 2011), which includes a dual-route processing model. In one of these studies with L1 English speakers, Diependaele et al. (2009) sought to describe the processing route of transparent and opaque English derived words. They observed a priming magnitude of 36 ms for transparent, 15 ms for opaque, and 1 ms for form/control conditions. These results showed that both morpho-orthographic and morpho-semantic information get activated in parallel upon encountering a morphologically complex word. Semantically transparent prime-target pairs use both morpho-orthographic and morpho-semantic information, resulting in much larger facilitation effects, whereas semantically opaque pairs only receive morpho-orthographic information, leading to less facilitation effect.

To the authors' knowledge, only two studies have explored this topic with native Turkish speakers. In one of these studies, Oğuz and Kırkıcı (2023) examined the processing of complex words by Turkish-speaking 2nd and 4th graders via a masked priming experiment by using four types of prime-target pairs: transparent (e.g., *gururlu* – *GURUR* “proud – PRIDE”; *gururla* – *GURUR* “with proud – PRIDE”), opaque (e.g., *elma* – *EL* “apple – HAND”), formal overlap (e.g., *hapıs* – *HAP* “prison – PILL”), and semantic relation (e.g., *çati* – *EV* “house – ROOF”). The transparent condition included both inflected and derived forms. A significant priming effect emerged only for transparent pairs, indicating

that Turkish children were sensitive only to suffixes in the early stages of word processing. In another study, Çağlar (2019) investigated the processing of transparent (e.g., *çizim* – *ÇİZ* “drawing – DRAW”), opaque (e.g., *tuzak* – *TUZ* “trap – SALT”), and form-overlap (e.g., *kasap* – *KAS* “butcher – MUSCLE”) word pairs among adult Turkish speakers. Results showed significant priming for both transparent (26 ms) and opaque (13 ms) words, but not for form overlap (7 ms). However, since the study primarily aimed to explore the transposed letter effect at morpheme boundaries, it was not fully suited to comparing the obtained priming magnitudes between transparent and opaque forms. Therefore, it remains an open question whether Turkish native speakers are influenced by semantic transparency when processing derived words.

Only a handful of studies have examined how semantic transparency affects derived word processing in late bilingual speakers. Diependaele et al. (2011) compared English monolinguals and Spanish-English and Dutch-English bilinguals using a masked priming task with 53 ms SOA. Both groups showed a similar graded pattern of priming effect, with the largest priming magnitude for transparent pairs and the weakest for form overlap. The opaque pairs elicited a priming magnitude in between the transparent and form overlap pairs. These results suggest that both monolinguals and bilinguals employ the same processing strategies and rely on both morpho-orthographic and morpho-semantic information for transparent pairs and only on morpho-orthographic information for opaque pairs. In another study, Zhang et al. (2017) examined Chinese-English bilinguals using transparent, opaque and semantic pairs. In Experiment 1, they used a 40 ms SOA and found significant priming effect only for the transparent condition. By using an 80 ms SOA, they observed significant priming effects for opaque primes only. Semantically related pairs did not produce any priming effects. However, the absence of a monolingual control group and form/control condition together with the discrepancies of the results limited the conclusions of the study. By employing inflected, derived, pseudo-complex, and stem-embedded forms, Lõo et al. (2022) investigated morphological processing in monolingual and bilingual English speakers. While the monolingual speakers showed priming only for true morphological relations (i.e., inflected and derived), the bilingual speakers showed priming across all conditions. However, the bilingual participants varied in L1 backgrounds, their proficiency was self-rated, and semantic transparency was not controlled; therefore, the results cannot be generalized. Finally, Viviani and Crepaldi (2022) found significant priming for transparent and opaque forms both in monolingual and bilingual English speakers together with a graded priming pattern favoring transparent items. Interestingly, they also observed significant priming effect in the form/control condition but only in the bilingual group. As can be seen, studies on L2 English speakers remain limited, and the results of these studies are not sufficient to give a general idea about the

morphological processing patterns of L2 English speakers and if semantic transparency affects their morphological processing pattern.

## 2. Method

### 2.1 Sample

We tested 61 monolingual Turkish speakers (31 females, between ages 18-55,  $M = 29.60$ ,  $SD = 9.86$ ), who were residing in Türkiye. 29 of them were high school graduates, 24 were university graduates, 7 were graduates with a master's degree, and 1 had a doctoral degree. This group will be referred to as monolingual speakers (MS). In addition, 46 highly proficient Turkish-English late bilingual speakers (27 females, between ages 20-43,  $M = 26.00$ ,  $SD = 6.54$ ) residing in Türkiye were tested. This group will be referred to as Turkish-English bilingual speakers (TEBS) and included 21 individuals with a high school diploma, 15 with a university degree, 8 with a master's degree, and 2 with a doctoral degree. All participants in the TEBS group had learned English when they started school (between ages 7-11,  $M = 8.93$ ,  $SD = 1.11$ ) and attended English lessons for a long time (between years 9-15,  $M = 12.48$ ,  $SD = 1.47$ ). To evaluate their English proficiency, all participants completed the Oxford Quick Placement Test, which consisted of 40 multiple choice questions that measured the grammatical and vocabulary knowledge of the participants. The results of the test indicate high scores in English proficiency ( $M = 34.98$ ,  $SD = 2.61$ , *Maximum Score* = 40). The self-rating scores of the participants also showed a high proficiency in their English (Speaking:  $M = 6.98$ ,  $SD = 1.39$ ; Listening:  $M = 7.98$ ,  $SD = 1.29$ ; Reading:  $M = 8.30$ ,  $SD = 1.23$ ; Writing:  $M = 7.26$ ,  $SD = 1.42$ , *Maximum Score* = 10). The TEBS group also used English actively in their daily lives (English:  $M = 53.48$ ,  $SD = 11.65$ ; Turkish:  $M = 46.52$ ,  $SD = 11.65$ , *Maximum Score* = 100). All participants in both groups were native speakers of Turkish and spoke standard Turkish. All were right-handed and did not have any health concerns such as issues with sight, hearing, learning, or language. All participants were informed about the study, and their consent forms were collected.

### 2.2 Instrument

The stimuli list consisted of three conditions: (i) semantically transparent words (e.g., *dalga* – DAL “wave – DIVE”), (ii) semantically opaque words (e.g., *karga* – KAR “crow – SNOW”), and (iii) form/control words (e.g., *devre* – DEV “period – GIANT”). In semantically transparent words, the meaning of the derived word can be computed from its root (e.g., *dalga* – DAL “wave – DIVE”). For example, *-ga* is a derivational suffix in Turkish that is added to verb forms to derive a noun. Semantically opaque words, however, consist of a root and a (pseudo)suffix that looks like a real derivational suffix, and the relationship between the derived word form and the root is not genuinely morphological (e.g., *karga* – KAR

“crow – SNOW”). As can be seen in the example, *-gA* resembles the derivational suffix orthographically but does not function as the real derivational suffix *-gA*. Finally, form/control words do not involve an existing derivational suffix; therefore, these word pairs do not involve any morphological relationship (e.g., *devre – DEV* “period – GIANT”). To illustrate, the word *dev* “giant” is completely involved in the word *devre* “period”, but *-re* is not an existing suffix in Turkish; therefore, these word pairs do not have any morphological or semantic relation but resemble each other only in terms of orthography. 22 prime-target pairs were created for each condition, making a total of 66 pairs. Table 1 presents a sample set of the prime-target word pairs used across three conditions in the masked priming experiment.

**Table 1.** Sample prime-target word pair sets across three conditions

Condition	Prime Word	Target Word
Transparent	<i>dalga</i>	DAL
Opaque	<i>karga</i>	KAR
Form/Control	<i>devre</i>	DEV

We started with a total of 721 prime-target word pairs across three conditions. Çotuksöken (2011) was used as a reference for checking the existence of the Turkish derivational suffixes. The spelling and etymology of the selected words were examined and verified through the online Turkish dictionary of the Turkish Language Association (<https://sozluk.gov.tr/>). Following this stage, a transparency judgment questionnaire was administered to determine the level of semantic transparency between the root form and the derived form (e.g., *DAL – DALGA* “DIVE – WAVE”). The questionnaire was prepared via Google Forms and implemented online. 70 L1 Turkish speakers, who did not participate in the masked priming experiment, were asked to rate the level of semantic transparency of the root-derived form pairs on a seven-point scale (1: strongly unrelated, 7: strongly related). Based on the results of the judgment questionnaire, semantically transparent and opaque root-derived form pairs were determined. Root-derived form pairs with a mean score of 5.5 and over were classified as semantically transparent, while the pairs with a mean score of 2.5 and below were categorized as semantically opaque, and these pairs were used as the prime-target pairs in the masked priming experiment.

In the next step, several elimination criteria were applied to semantically transparent and opaque prime-target pairs. The first elimination criterion was syllable count. Target words with more than one syllable and prime words with more than three syllables were excluded from the list. The second elimination criterion was the number of letters. Target words with more than four letters and prime words with more than seven letters were removed. The next elimination criterion was interlingual homographs. Interlingual homographs are words that exist in multiple languages but do not carry the same meaning (Poort, 2018). For instance, the Turkish word *boy* means height, while in English, the same word refers

to a male child. The final elimination criterion was the root-root relationship in the prime words. For example, the word *etçil* “carnivore” is formed by adding the suffix *-Cil* to the root *et* “meat”. The suffix *-Cil* carries the meaning of ‘inclined to or related to something specific’. It should be noted, however, that *çil* “freckles” is also a noun in Turkish. Therefore, all prime words with a root-root relationship were removed from the list of words to be used in the experiment. As a result of this elimination process, a total of 44 prime-target word pairs were determined, with 22 prime-target pairs in each semantically transparent and semantically opaque category. The same elimination criteria were applied to the 224 form/control prime-target word pairs, and as a result, 22 prime-target pairs were selected.

These 66 prime-target word pairs were classified as related because the primes were morphologically, orthographically, and/or semantically related to the target words. These prime and target words were matched with each other in terms of frequency, length, and orthographic overlap. The frequency of the prime and target words was checked using TS Corpus (Sezer, 2017). Length was controlled in terms of the number of letters. The orthographic overlap was also calculated because target words were fully contained in the related prime words. The mean values of these variables for three different word groups were compared using a one-way ANOVA test, and no statistically significant differences were obtained for any of the variables (target word frequency  $F(2, 65) = 0.49; p = .612$ ; prime word frequency  $F(2, 65) = 0.61; p = .546$ ; target word length  $F(2, 65) = 0.77; p = .464$ ; prime word length  $F(2, 65) = 2.35; p = .104$ ; orthographic overlap  $F(2, 65) = 2.85; p = .065$ ).

**Table 2.** Sample related and unrelated prime-target word pair sets across three conditions

Condition	Related Prime Word	Unrelated Prime Word	Target Word
Transparent	<i>dalga</i>	<i>tatlı</i>	DAL
Opaque	<i>karga</i>	<i>evlat</i>	KAR
Form/Control	<i>devre</i>	<i>açlık</i>	DEV

In addition to the 66 related primes, we added 66 unrelated primes. These unrelated primes were statistically matched with the related primes in terms of length ( $t(65) = 0.13, p = .894$ ) and frequency ( $t(65) = 0.56, p = .575$ ). The unrelated prime words were entirely independent from the target words they were paired with by means of morphology, semantics, and orthography (Table 2). In addition, filler words were added to the experiment to prevent participants from realizing the purpose of the experiment. The prime words used in fillers comprised simple past tense, reported past tense, and the locative and ablative case suffixes (e.g., *bindi* – *SÜT* “got on – MILK”). In the filler word pairs, the target words ( $F(3,128) = 2.19, p = .093$ ) and the prime words ( $F(3,128) = 1.47, p = .234$ ) were statistically matched in terms of length across three different word

conditions. Finally, 132 nonwords were added to the stimuli list so that half of the words in the experiment required a ‘no’ response. Nonwords were created by changing 1-2 letters of an existing word without violating the phonotactic rules of Turkish (e.g., *ZİÇ*). The existence of the nonwords was checked via the online Turkish dictionary (<https://sozluk.gov.tr/>).

### 2.3 Design

By employing E-Prime 3.0 (Psychology Software Tools, Pittsburgh, PA), a masked priming experiment was conducted to accurately measure the participants’ reaction times (RTs) and accuracy. Because each target word had a related and an unrelated prime, the prime-target word pairs were distributed over two presentation lists by following a Latin Square design to ensure that no participant saw the same target word more than once. All participants completed the experiment in a quiet, dimly lit room with minimal distractions. Before the experiment started, all participants were asked to fill in the demographic background questionnaire and the consent form. After that, detailed instructions about the procedure of the experiment were provided. At the beginning of the experiment, a short practice session was conducted to familiarize the participants with the masked priming procedure. In the practice session, there were a total of 10 items. The experiment began when participants declared that they understood the procedure and were ready to proceed. During the main experiment, participants were asked to decide as accurately and quickly as possible whether the letter string shown on the computer screen was a Turkish word by pressing the designated ‘YES’ or ‘NO’ buttons. The ‘YES’ button was always on the side of the participant's dominant hand. Each trial started with a blank screen displayed for 500 milliseconds, followed by a mask (#####) that remained on the screen for 500 milliseconds. The number of hashes in the mask was equal to the number of letters that made up the prime word. Following the mask, the prime word in lowercase letters was shown to the participants for 42 milliseconds. After the prime word was displayed, the target word in capital letters appeared and remained on the screen until the participant made a response. The experiment lasted approximately 10 minutes. After the experiment, the bilingual participants completed the Oxford Quick Placement Test.

### 2.4 Data analysis

The analysis of participants’ RTs was carried out only on the correct responses. Thus, all incorrect answers (MS = 6.56%; TEBS = 5.53%) of the participants were removed before the data analysis. Then, the data was log-transformed, and RTs that were above or below 2.5 standard deviations (MS = 2.47%; TEBS = 2.51%) of a participant’s mean log RTs were removed. The remaining log-transformed RT data was analyzed using the R statistical program (R Development Core Team, 2021).

A linear multiple regression model was used in the analysis of the data, and *lme4* package was used in the model building process (Bates et al., 2015). In the data analysis, participants' RTs were the dependent variable, while *condition* (Transparent vs. Opaque vs. Form), *prime type* (Related vs. Unrelated) and *group* (MS vs. TEBS) were the independent variables. The models included item and participant as random effects, and condition, prime type, group, and their interactions as fixed effects. For single comparisons, treatment contrasts were employed, while sum-coded contrasts (-0.5, 0.5) were employed for the main effects and interactions. In simplifying the model (Barr et al., 2013), random slopes for item and participant were retained for each fixed effect only when they significantly enhanced model fit, as measured by the Akaike Information Criterion (AIC). The comparison made with the lowest AIC score aims to keep only significant variables in the model and penalize complexity (Venables & Ripley, 2002). The best-fit model only included the random slope for prime type by participant. The effect sizes are reported by using model coefficients in log odds ( $\beta$ ), standard errors (*SE*), *t*-statistics, and *p* values. The *p* values in the data analysis were calculated using the *lmerTest* package (Kuznetsova et al., 2014).

In the analyses, participants' RTs for related and unrelated prime-target word pairs in each condition were compared. If the RT difference (i.e., priming) between the related vs. unrelated prime-target word pairs in a condition is significant, this suggests that the prime facilitates the recognition of the target words in this condition, indicating morphological decomposition. Conversely, a non-significant RT difference in a condition indicates no facilitation of the prime word, resulting in storing the target words of that condition as a whole unit in the mental lexicon. Following this, the three different word conditions were compared with each other to unveil whether differences exist in their processing patterns.

### 3. Findings

Table 3 provides the back-transformed mean RTs by condition, prime type, and group.

**Table 3.** Back-transformed mean RTs (and standard deviations) for conditions and groups

	MS			TEBS		
	Transparent	Opaque	Form	Transparent	Opaque	Form
Related	562.78 (156.77)	592.57 (185.97)	610.84 (173.81)	587.44 (157.59)	602.86 (170.99)	637.88 (196.06)
Unrelated	590.34 (143.81)	607.42 (192.81)	600.91 (149.09)	614.11 (159.78)	620.76 (170.20)	629.27 (151.33)
Priming	27.56 ms	14.85ms	-9.93 ms	26.67 ms	17.90ms	-8.61 ms

Regarding the RT data, Table 4 presents the results from the best-fit model testing the morphological priming effects. The results showed a main effect of prime type ( $\beta$ : -0.037, *SE*: 0.010, *t* = -3.607, *p* < .001) indicating that participants employed decomposition in general when

processing the words. However, the main effect of group was not significant, revealing no difference between the groups. In addition, we did not obtain a significant interaction of prime type and group, which showed that both groups used the same processing strategies when processing the words used in the experiment (see Table 4a).

**Table 4.** Linear mixed effects model output of the best-fit model

	$\beta$	<i>SE</i>	<i>t</i>	<i>p</i>
<i>(a) Overall Model</i>				
Prime type (related vs. unrelated)	-0.037	0.010	-3.607	<b>.000</b>
Group (MS vs. TEBS)	-0.035	0.026	-1.315	.188
Prime type*Group	0.002	0.009	0.156	.876
<i>(b) Revelled for Transparent</i>				
Condition1 (Transparent vs. Opaque)	-0.037	0.012	-3.084	<b>.002</b>
Condition2 (Transparent vs. Form)	-0.052	0.012	-4.299	<b>.000</b>
Prime type (related vs. unrelated)	-0.062	0.017	-3.623	<b>.000</b>
Group (MS vs. TEBS)	-0.040	0.027	-1.489	.136
Condition1*Prime type	0.015	0.022	0.730	.466
Condition2*Prime type	0.059	0.023	2.559	<b>.010</b>
Condition1*Group	0.019	0.012	1.688	.092
Condition2*Group	0.002	0.012	0.203	.838
Prime type*Group	0.003	0.016	0.159	.874
Condition1*Prime type*Group	0.009	0.024	0.387	.698
Condition2*Prime type*Group	0.006	0.024	0.247	.804
<i>(c) Revelled for Opaque</i>				
Condition3 (Opaque vs. Form)	-0.016	0.011	-1.432	.152
Prime type (related vs. unrelated)	-0.046	0.016	-2.894	<b>.004</b>
Group (MS vs. TEBS)	-0.021	0.027	-0.757	.450
Condition3*Prime type	0.044	0.022	2.015	<b>.044</b>
Condition3*Group	0.022	0.012	1.884	.060
Prime type*Group	0.006	0.017	0.383	.702
Condition3*Prime type*Group	0.015	0.024	0.629	.530
<i>(d) Revelled for Form</i>				
Prime type (related vs. unrelated)	0.003	0.016	0.169	.866
Group (MS vs. TEBS)	-0.043	0.027	-1.575	.116
Prime type*Group	0.008	0.017	0.505	.614

Formula in R: log (RT) ~ condition \* prime type \* group + (1 | item) + (1 + prime type | participant).

As a next step, analyses were carried out by releveing each condition with an attempt to explore how the releveled condition was processed, if the groups differed from each other in processing that condition, and whether that condition was processed differently from the other two conditions. When the condition was releveled for transparent words (see Table 4b), a significant main effect of prime type ( $\beta$ : -0.062, *SE*: 0.017, *t* = -3.623, *p* < .001) was obtained. This effect showed that transparent words were decomposed into their constituent morphemes. In addition, we observed a significant main effect of condition, in which transparent words were processed significantly faster than opaque ( $\beta$ : -

0.037,  $SE: 0.012$ ,  $t = -3.084$ ,  $p < .003$ ) and form ( $\beta: -0.052$ ,  $SE: 0.012$ ,  $t = -4.299$ ,  $p < .001$ ) conditions. Most importantly, no significant main effect or interactions involving the factor group were found, which indicated that both the MS and TEBS groups employed the same processing mechanism, namely decomposition, when processing transparent derived words. Finally, a significant two-way interaction of condition and prime type between transparent and form conditions ( $\beta: 0.059$ ,  $SE: 0.023$ ,  $t = 2.559$ ,  $p < .011$ ) demonstrated that while transparent words were accessed via decomposition, the words in the form condition were accessed by employing full-listing.

Table 4c displays the results of the analysis when the condition was relevelled for opaque words. The significant main effect of prime type ( $\beta: -0.046$ ,  $SE: 0.016$ ,  $t = -2.894$ ,  $p < .005$ ) reflected that conscious analysis of constituent morphemes was also employed for opaque words. Mirroring the transparent condition, no significant main effect of group and no significant interaction with the factor group were obtained. We also found a significant two-way interaction of condition and prime type between opaque and form conditions ( $\beta: 0.044$ ,  $SE: 0.022$ ,  $t = 2.015$ ,  $p < .045$ ). This significant interaction implied that participants employed different processing mechanisms when accessing these two conditions, namely decomposition for opaque words but whole-word access for words in the form condition.

Finally, the releveling was conducted to the form condition (see Table 4d). Unlike the transparent and opaque conditions, we did not observe a significant main effect of prime type ( $p = .866$ ), indicating that morphological decomposition does not take place in accessing the words in the form condition, and both groups processed these words as unanalyzed whole forms. These results demonstrated that both the MS and TEBS groups used the same processing mechanisms when accessing not only transparent and opaque derived words but also the words in the form condition. Besides, the semantic transparency of the derived words did not influence the processing routes of both groups, providing further support for the form-then-meaning account.

#### 4. Discussion

By employing a masked priming experiment, the aim of the present study was to explore how proficient Turkish-English late bilinguals residing in Türkiye process semantically transparent and opaque Turkish derived words and compare their processing patterns to the monolingual speakers.

The results of the RT data showed that both the MS and TEBS groups used the same processing routes when processing derived words. More specifically, they decomposed Turkish derived words regardless of transparency, which indicates that the transparency level of the derived words does not affect the processing mechanisms, supporting the claims of the form-then-meaning account. Despite obtaining larger priming

magnitudes for the transparent words (MS = 27.56 vs. TEBS = 26.67) when compared to opaque words (MS = 14.85 vs. TEBS = 17.90), this difference did not turn out to be significant and was only a numerical difference. In addition, both groups did not exhibit morpheme-based processing for the words in the control condition, and the obtained priming magnitudes for this condition did not indicate any facilitation effect but an inhibition effect for both groups (MS = -9.93 vs. TEBS = -8.61). These results clearly demonstrate that both groups employed a morpho-orthographic decomposition when processing derived words, and they used morpheme-based lexical access when they processed root + (pseudo)suffix forms but no morphological analysis for root + nonexistent forms. The results of the MS group are in line with many previous studies conducted in various languages with L1 speakers (see Hasenäcker, 2016). The results also resonate with the studies that compared L1 and L2 speakers because our results posit no morphological processing differences between the groups (see Diependaele et al., 2011).

However, the results of the present study contradict Uygun and Gürel (2020), which is the only study that is most closely aligned with the present study. While Uygun and Gürel (2020) reported different processing mechanisms between the MS and TEBS groups, our results did not confirm their findings. There are several reasons why the findings of the present study do not confirm the results of Uygun and Gürel (2020).

The first reason might be related to the certain characteristics that distinguish compounding and derivation from each other. For example, Booij (2005, p. 109) emphasized that compounds consist of the combination of two or more lexemes (e.g., *football* is formed by the stems of *foot* and *ball*), whereas derivation is characterized by the addition of an affix (i.e., bound morpheme) to a stem (e.g., *artist* is formed by the stem *art* and the bound morpheme *-ist*). In addition, ten Hacken (1994) proposed that compound elements can either be the head or non-head of the structure, but affixes are of a different nature. For instance, derivational suffixes are always placed in the final position of a derived word, so the position of the suffix is quite predictable. However, in compound words, the position of each constituent is unpredictable because, for example, the lexeme *book* is the first constituent in the English compound *bookstore* and the second constituent in *bankbook*. Finally, semantic transparency can play a more privileged role in compounds because compound words consist of root + root words rather than root + affix forms. While derived forms are divided into two in terms of transparency (transparent vs. opaque), compounds words are divided into four groups depending on the transparency of the constituents (Libben et al., 2003): transparent-transparent (e.g., *bedroom*), opaque-transparent (e.g., *nickname*), transparent-opaque (e.g., *shoehorn*) and opaque-opaque (OO) (e.g., *deadline*). These characteristic differences between compounds and derived forms might have led to the observed differences between the two studies since compounding is a more complex word formation process

when compared to the derived forms, and semantic transparency plays a more prominent role in the processing of compounds.

The second and more crucial reason of the divergent results is related to the design of the studies. While both studies used masked priming experiments, the presentation of the prime-target pairs differed from each other. Uygun and Gürel (2020) used the roots of the compound as primes and the compound word as the target (e.g., *kuzey* – *KUZEYDOĞU* “north – NORTHEAST” and *doğu* – *KUZEYDOĞU* “east – NORTHEAST”). The design of Uygun and Gürel (2020) provides more information on the representation of the complex words in the mental lexicon and investigates whether seeing the constituent of a compound word for a very short time facilitates the access and activation of the compound word in the mental lexicon, which is also known as mental representation. Conversely, the present study used the derived word as the prime and the root form as the target (e.g., *dalga* – *DAL* “wave – DIVE”). The design of the present study allows us to investigate if seeing the complex form of a word very shortly facilitates the access of its root form. If this facilitation works, this means the participants decompose the complex form into its morphemic constituents and can reach the root forms successfully. This design provides precise information on the morphological processing of the complex word forms in different groups with different language learning histories and is a widely accepted design in the masked priming experiments.

All in all, the differences between the processes of compounding and derivation, together with the differences in the presentation of the prime-target pairs, might be the reasons for the divergent results of the two studies that investigate the effect of high proficiency in L2 on L1 word processing.

## 5. Conclusion

The present study questioned the potential changes in proficient Turkish-English late bilingual speakers’ processing of Turkish derived words. By employing a masked priming experiment, which measures the accuracy and the RTs of the participants, the study focused on the extent to which high L2 proficiency can modulate the morphological processing of Turkish derived words in the bilingual speakers living in Türkiye when compared to monolingual speakers. The findings revealed that both groups employed decomposition for derived words regardless of semantic transparency. In addition, both groups also used whole-word access for the words in the form condition. These results indicate no qualitative nor quantitative differences between the bilinguals and monolinguals. However, more studies on different word formation processes that employ the same experimental design are needed to draw any safe conclusions on the morphological processing of bilinguals living in the L1 setting.

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