PROCESSING OF ENGLISH DERIVED WORDS IN ADVANCED SECOND LANGUAGE LEARNERS: EFFECTS OF L1 TYPOLOGY, MORPHOLOGICAL AWARENESS, SUFFIX COMPLEXITY, AND L2 PROFICIENCY

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Previous studies of L2 morphological processing are controversial regarding whether L2 learners decompose morphologically complex words similarly to native speakers, and whether there are L1 influences in L2 morphological processing. The current study was the first to systematically examine (1) whether L2 English learners of typologically different L1s differ in their morphological awareness, and (2) whether effects of L1 typology, morphological awareness, suffix complexity, and L2 proficiency exist on L2 processing of derived words.

The current study examined on-line L2 morphological processing in a masked priming lexical decision task. Apart from a native English group, three L2 groups of typologically different L1s were recruited, including Turkish, Chinese, and Vietnamese. After the lexical decision task, participants were measured in terms of their morphological awareness, orthographic awareness, and English proficiency.

Results revealed differential priming patterns between the English group and the L2 groups and also among the L2 groups themselves. Although in the morphological condition (e.g., hunter-hunt) all groups demonstrated facilitation, the English group showed inhibition in both the opaque (e.g., corner-corn) and form (e.g., surface-surf) conditions, whereas the Chinese group showed facilitation in both conditions, the Vietnamese group showed a trend of facilitation in both conditions, and the Turkish group showed a trend of inhibition in both conditions. The on-line processing patterns matched the morphological awareness results in the relatedness task,

in that the Turkish group marginally outperformed the English group, whereas the Chinese and Vietnamese groups did not differ significantly from the English group, suggesting clear L1 influence. For almost all groups, morphological awareness interacts with priming in the opaque and/or form conditions with regard to reaction time and/or accuracy. Moreover, the English and Turkish (but not Chinese or Vietnamese) groups were sensitive to a modulation of priming effects by suffix complexity, providing further evidence for L1 influence and an advantage for an L1 with complex morphology.

This study has both theoretical implications for the representation and processing of the bilingual lexicon by demonstrating clear L1 typological influences, and educational implications for how we could incorporate L1 differences into L2 instruction.

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PREFACE

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1.0 INTRODUCTION

To know a word means to have a lexical entry in the mental lexicon. A lexical entry (Levelt, Roelofs, & Meyer, 1999; Levelt, 2001) contains a range of lexical information, including the lexeme level of morphology and form, and the lemma level of meaning and syntax, with the different subcomponents independent while also linked. Morphology, as one subcomponent for lexical entries, has been represented differently in traditional descriptive theories versus connectionist theories.

In morpheme-based linguistic theories of morphology (Spencer & Zwicky, 1998), morphology studies the internal structure of words with morphemes being the smallest unit conveying meaning. English, for example, contains words that are morphologically simple and contain only one morpheme, e.g., “happy”, and words that are morphologically complex, e.g., “happiness”, which contains two morphemes, the root “happy” and the suffix “-ness”. Morphological processes include derivation and inflection. Derivation is the process of forming a new word on the basis of an existing word, usually by adding derivational affixes to the root/stem word (either prefixes, e.g., “un-” in “unhappy” or suffixes, e.g., “-ness” in “happiness”). By adding “-ness”, the root word adjective “happy” changes into a noun “happiness” and, in terms of meaning, changes from “happy” to “the quality or state of being happy”. Derivation affixes change the syntactic category of the root/base, whereas inflectional affixes are added to express a grammatical function or requirement such as tense, gender, case, and number (e.g., walk - walked; cat - cats) but do not change the syntactic category of the base. The grammatical information carried by the derivational suffixes themselves determines the syntactic category of the derived word. For example, regardless of the semantic content of the base, derived words ending with the suffix -ness (“happiness”, “kindness”, “liveliness”, etc.) are nouns, and derived words ending with the suffix -able (“calculable”, “taxable”, “payable”, etc.) are adjectives.

Derived words differ in their semantic and phonological relationships with their roots. The semantic relationship between the root and the derived word can be either transparent or opaque. Transparent derived words are closely related in meaning to their roots, and the meaning of the derived word can thus be composed or predicted based on the meaning of the root and the affix. For example, the meaning of “happiness”, “the quality or state of being happy” can be readily composed from the root word adjective “happy” and the suffix “-ness”, which denotes a state or condition. The meaning of an opaque word, in contrast, has undergone semantic drift, and cannot be readily composed from the meaning of the root and the suffix. Very dramatic semantic drift has occurred for certain words. For example, “department”, meaning “a division of a large organization, dealing with a specific subject, commodity or area of activity”, is a rather opaque derived word, considering the meaning of the root verb “depart”, meaning “to leave”. Note that the transparent or opaque semantic relationship between a root and a derived word is not a categorical distinction, but rather is on a continuum. For example, the meanings of the derived word “ignorant”, “lacking knowledge or awareness in general; uneducated or unsophisticated”, deviate a little from the original meaning of the root “ignore”, “to refuse to take notice of or acknowledge”.

Similarly, the phonological transparency of roots in derived words varies from word to word, i.e., whether the root within the derived word preserves its phonology as when the root stands alone as a free word. For example, the root “drink” in “drinkable” preserves its phonology as in the standalone verb “drink”. In the derived word “derivation”, however, the root “derive” undergoes not only vowel reduction of the second syllable, from [ɑɪ] to [ɪ], but also stress change from the second syllable of the root to the following syllable, and orthographically a deletion of the silent letter ‘e’. Moreover, there can also be consonant modifications due to derivation. For example, apart from a stress change, in “plasticity”, the last consonant in the root undergoes modification, from [k] to [s].

Most of the semantic and phonological alternations of roots within derived words are brought about by the properties of the specific derivational suffixes. Derivational affixes have traditionally been classified into stratums (Giegerich, 1999; Selkirk, 1982; Spencer, 1991). Suffixes from different stratums can be distinguished by a number of properties (Plag & Baayen, 2009). Stratum 1 affixes, e.g., “-ity”, are usually Latinate, less phonologically and semantically transparent, less productive, frequently attach to bound roots, and cause stress shifts, resyllabification, and other morphological alternations. In contrast, stratum 2 affixes, e.g., “-less”, are mostly Germanic, more transparent phonologically and semantically, more productive, and do not cause stress shift, resyllabification, or other morphological alternations. The layered structure constrains the combinational properties of affixes such that Stratum 1 affixes almost never occur outside a Stratum 2 affix, e.g., “*atom#less+ity” (Plag & Baayen, 2009). Suffixes can also be classified into neutral and non-neutral suffixes depending on whether they cause phonological alternations of the stem (Chomsky & Halle, 1968). Neutral suffixes (e.g., “-ness”), usually Stratum 2 suffixes, do not cause phonological alternations of the stem, whereas non-neutral suffixes (e.g., “-ic”), usually Stratum 1 suffixes, can cause phonological alternations of the stem. The preceding discussion is based on traditional descriptive accounts of morphology. However, theories of morphology vary according to the position linguists and psycholinguists take to the overall nature of the language itself. In the next section different approaches to morphological theory and processing are reviewed.

1.1 CONTROVERSIES IN THE L2 MORPHOLOGICAL PROCESSING LITERATURE

Second language learners are known to have special difficulty with morphology but the reasons for this difficulty remain a matter of intense debate currently. There has been a growing interest in recent years on whether L1 native speakers and second/foreign language (L2) learners process morphologically complex words in real-time in the same way when they silently read and whether the underlying linguistic systems constitute the ‘same’ type of knowledge systems. The current study is innovative in that it focuses on appropriate first language (L1) influence and controls stimuli to a greater degree than in previous research. Due to the paucity of inflectional affixes in English, their limited semantic content, more transparent morphemic structure (Feldman, 1994), as well as their dependence during processing on the grammatical context (Bozic, Tyler, Su, Wingfield, & Marslen-Wilson, 2013), this study focuses on derivations only.

Within the L1 lexical processing literature, different accounts have been proposed for the processing of morphologically complex words, including sublexical models, supralexical models, dual-route parallel models, and parallel distributed processing (PDP) models.

Sublexical and supralexical models are both single-route models. A single-route theory means that there is one single route to lexical access. Sublexical models of morphological processing (Amenta & Crepaldi, 2012; Fiorentino & Poeppel, 2007; Meunier & Longtin, 2007; Pinker, 1999; Rastle & Davis, 2008; Taft, 2004; Taft & Forster, 1975, 1976) argue for an obligatory decomposition process for complex words before access to the full-form and the recognition of the meaning of the whole word. Supralexical models of morphological processing (Diependaele, Sandra, & Grainger, 2005; Giraudo & Grainger, 2000, 2001), on the other hand, claim that activation of morphemes occurs at a post-access processing stage after access to the full-form. Dual-route parallel models (Allen & Badecker, 2002; Baayen, Dijkstra, & Schreuder, 1997; Baayen & Schreuder, 1999, 2000; Frauenfelder & Schreuder, 1991; Laudanna & Burani, 1995; Schreuder & Baayen, 1995), however, allow two possible independent[1] routes to lexical access, with one route being morphological decomposition and the other being full-form access, whichever is faster wins the "horse race". Various recent findings have posed problems for the single-route models (Kuperman, Bertram, & Baayen, 2010), especially those on the interaction between properties of full-forms (e.g., whole word frequency, word length) and those of constituents (e.g., base frequency, suffix frequency) (Baayen, Wurm, & Aycock, 2007; Niswander-Klement & Pollatsek, 2006; Winther Balling & Baayen, 2008). Sublexical models would predict either effects of the constituents but not effects of the whole-word form, and supralexical models would predict effects of the whole-word form but not effects of the constituents. For example, as pointed out by Kuperman et al. (2010), the observation by Baayen et al. (2007), such that there was an interaction between whole word frequency and base

[1] Most dual-route parallel models assume independence of the two routes. Baayen and Schreuder (2000), however, proposed an interactive, dual-route parallel computational model.

frequency for both derived and inflected English words in a lexical decision task, could not be explained by single-route models.

Parallel Distributed Processing (PDP) connectionist accounts (Plaut & Gonnerman, 2000; Rueckl, Mikolinski, Raveh, Miner, & Mars, 1997; Seidenberg, 1987; Seidenberg & McClelland, 1989) are different from single- and dual-route models in that PDP accounts do not posit explicit and discrete representations of morphemes. Rather, morphological effects emerge due to a fine-tuning of the processing system to the statistical structure in patterns of activation of orthographic, phonological, and semantic codes. That PDP models do not posit explicit representation of morphemes is in a similar spirit as many current theories of morphology considering the construct of morpheme to be obsolete or epiphenomenal (Anderson, 1992; Aronoff, 1994; Beard, 1977; Booij, 2015; Bybee, 1988, 1995). On the distributed connectionist approach, morphological relationships between words are not explicitly represented, and thus storage of lexical entries do not involve explicit specifications of word structure specified by traditional descriptive accounts. Likewise, patterns of lexical processing that superficially favor rule-based morphological decomposition arise from long-time learned sensitivity to the systematic relationships among the surface forms of words and their meanings within the whole language system (Plaut & Gonnerman, 2000).

Controversies in previous research on L2 processing of morphologically complex words, both derivational and inflectional, focus on two main issues. The first controversial issue is whether L2 learners decompose morphologically complex words similarly to native speakers. Different theories relevant to L2 morphological processing have been proposed, including claims for clear differences between L1 and L2 morphological processing such that L2 learners rely more on lexical storage than morphological parsing (Bowden, Gelfand, Sanz, & Ullman, 2010;

Clahsen, Balkhair, Schutter, & Cunnings, 2013; Clahsen, Felser, Neubauer, Sato, & Silva, 2010; Jacob, Fleischhauer, & Clahsen, 2013; Kraut, 2015), consistent with the Shallow Structure Hypothesis (Clahsen & Felser, 2006), and the Declarative/procedural model (Ullman, 2001a, 2001b, 2004, 2005), and accounts claiming no qualitative differences between L1 and L2 morphological processing (Diependaele, Duñabeitia, Morris, & Keuleers, 2011).

Most studies have found that L2 learners do not decompose, at least not to the same extent as native speakers, while others found basically similar patterns in both L1 and L2. Research in L2 morphological processing has been scarce and controversial as compared to the L1 literature (Clahsen et al., 2010). The studies reviewed in Clahsen et al. (2010) generally showed L2 processing of morphologically complex words to be more reliant on whole-word lexical storage and less on grammatical rules and principles. Those findings are consistent with the Shallow Structure Hypothesis (Clahsen & Felser, 2006) such that L2 learners, regardless of proficiency, compute shallower grammatical structures and rely more on lexical, semantic, and pragmatic information as compared to native speakers, and the Declarative/procedural model (Ullman, 2004, 2005) such that L2 learners rely more than declarative memory and employ less procedural knowledge and computations. Event-related potentials (ERP) studies comparing the time-course morpho-syntactic and semantic priming effects (Bosch, Krause, & Leminen, 2016) have found L2 morphosyntactic processing for advanced L2 learners to be temporally and spatially more extended than L1 processing despite of their behavioral findings of native-like[2] L2 morphological processing and lexical-semantic processing.

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[2] The native speaker control group were not reported with regard to whether they were monolinguals or early-balanced bilinguals.

In stark contrast to these claims, other studies, e.g., Diependaele et al. (2011), have shown similar patterns of L1 and L2 morphological processing, all compatible with the sublexical, or parallel dual-route, or connectionist accounts. Similarly, an L2 subgroup with high reading speed demonstrated the same processing pattern of inflectional English morphology as native speakers in Feldman, Kostić, Basnight-Brown, Durdević, and Pastizzo (2010). L2 learners at high levels of proficiency have also shown native-like sensitivity to subtle morphosyntactic feature information as demonstrated by priming differences due to the affixes' paradigmatic feature representations (Bosch et al., 2016). However, in both studies (Diependaele et al., 2011; Feldman et al., 2010), there were significant facilitatory priming effects in both the morphological and the orthographic conditions, which did not suffice as evidence for morphological decomposition because L2 learners may only be showing a facilitatory orthographic priming effect in the morphological condition (Heyer & Clahsen, 2015). Moreover, as is pointed out by Kirkici and Clahsen (2013), no significant differences regarding the opaque vs. form control priming effects (despite a trend of a graded pattern) in L1 Spanish or L1 Dutch learners of L2 English were found in the study of Diependaele et al. (2011), rendering their account of decomposition in the opaque condition untenable.

The second controversial issue is whether there is L1 transfer in the L2 processing of morphologically complex words. Among studies that examined L1 transfer in L2 morphological processing and production, the majority found no transfer, in contrast to the very prominent and acknowledged L1 influence in various aspects of L2, e.g., pronunciation (Flege & Davidian, 1984; Hancin-Bhatt, 1994), phonology (Sato, 1984), and syntax. Despite of the scarcity, there have been a few studies demonstrating possible L1 transfer effects in processing of either inflections or derivations. A primed lexical decision task studying L2 processing of inflected words in L1 Spanish and L1 Chinese learners of L2 English (Rehak & Juffs, 2010) did find effects of L1 transfer. In a self-paced reading task examining L2 processing of derived words, Dronjic (2013) also demonstrated L1 transfer from an agglutinative L1 (Korean) to L2 English, as shown by the intermediate performance of L1 Korean speakers between L1 English and L1 Chinese speakers. Hancin-Bhatt and Nagy (1994) also showed growth of knowledge in the systematic relationships between Spanish and English suffixes in Spanish-English bilingual students in 4th, 6th, and 8th grade and indication of the transfer in the learning of derivational morphology. Murakami and Alexopoulou (2015) found L1 influence in the accuracy of grammatical morphemes and their acquisition order in their corpus analysis of written exam scripts on L2 English grammatical morphemes as well, which supported a meta-analysis by Luk and Shirai (2009). Vainio, Pajunen, and Hyönä (2014) tested L2 processing of Finnish simple nouns, transparently inflected nouns and semi-transparently inflected nouns by native Russian (with common case inflection) and native Chinese (with no case inflections) speakers. They found clear L1-L2 transfer such that the Finnish and Russian groups responded slower for morphologically complex words, whereas the Chinese group responded slower for semitransparent nouns as compared to simple or transparently inflected nouns but did not differ in their reaction times to simple as compared to transparently inflected nouns.

A few ERP studies on morphosyntactic processing have also demonstrated L1 effects (De Diego Balaguer, Sebastian-Galles, Diaz, & Rodriguez-Fornells, 2005; Dowens, Vergara, Barber, & Carreiras, 2010). Dowens et al. (2010) collected ERPs of L1 English-L2 Spanish late learners with long exposure to the L2 environment while reading sentences with morphosyntactic violations and also demonstrated clear transfer processes from L1 to L2, i.e., significant amplitude and onset latency differences between morphosyntactic features of the L2 present in the L1 (number agreement) and morphosyntactic features of the L2 not present in the L1 (gender agreement). In an ERP study with highly proficient early Catalan-Spanish bilinguals with a repetition-priming paradigm, De Diego Balaguer et al. (2005) found the same centro-parietal N400 priming effect in L1 and L2 speakers in regular verbs with similar suffix in L1 and L2. In contrast, they found differences between L1 and L2 in irregular morphology with completely different alternations in L1 and L2, such that L1 showed attenuated N400 effect only in semi-regular verbs whereas L2 speakers showed reduced N400 priming effect in both semi-regular verbs and verbs with idiosyncratic changes. They suggested that at least for two languages having very similar morphological systems, the similarity between languages might help for similar suffixations, but may interfere for dissimilar structures.

A question that naturally arises is why such different claims have been made in the L2 morphological processing literature with regard to whether L2 speakers decompose on-line similarly to L1 speakers and with regard to whether there is L1 influence on L2 morphological processing. One reason could be that various methodological issues have been overlooked in one way or another during the construction of experimental materials. Specifically, the effects of morphological family size and morpheme frequency for both stem and affixes and the effect of neighborhood density, suffix form frequency, and boundary frequency that have been studied in Diependaele et al. (2011) in analyzing their correlations with the different priming conditions have not been systematically controlled for in their priming study, and neither did the studies reviewed in Clahsen et al. (2010) control for all these potential confounding covariates, as systematic differences may occur as a natural result of priming condition differentiation (Diependaele et al., 2011).

Another variable of interest is suffix complexity (Plag & Baayen, 2009). Plag and Baayen (2009) generalized the model of suffixes being ordered along a hierarchy of processing complexity correlating with suffix separability to a large set of suffixes. They provided evidence for higher rank in the hierarchy, i.e., higher mean complexity-ordering rank (CO-Rank), correlating with suffix productivity. Suffixes with higher mean CO-Ranks are more productive than those with lower mean CO-Ranks. Most studies include only one or two suffixes in their experimental materials and their findings can hardly be representative of morphological processing in general, especially when considering a potential effect of suffix complexity or productivity on morphological priming effects. As Ford, Davis, and Marslen-Wilson (2010) have demonstrated, the effect of base morpheme frequency, evidence for compositional representation, is modulated by suffix productivity such that only productively suffixed words show facilitatory effects of base morpheme frequency, i.e., are represented as morphemes.

Apart from methodological considerations, various other relevant factors that have been overlooked in many previous L2 studies may well have contributed to conflicting results, including differences in (1) L1 typology, including morphology, orthography, and writing systems, (2) morphological awareness, and (3) L2 proficiency (vocabulary size). I address each of these issues in the following sections in turn.

1.2 ISSUES OVERLOOKED

1.2.1 Morphological typology

Studies have not systematically examined influence from different morphological typologies. Studies of L2 morphological processing reviewed in Clahsen et al. (2010) included processing of L2 German by L1 Russian speakers (Hahne, Mueller, & Clahsen, 2006), processing of L2 German by L1 Polish speakers (Neubauer & Clahsen, 2009), processing of L2 English by Chinese and Korean L1 speakers (Koda, 2000; Silva, 2008), and comparing processing of L2 English by L1 Chinese, Japanese, and German speakers (Silva & Clahsen, 2008). Silva and Clahsen (2008), for example, found similar priming patterns in Chinese, German, and Japanese learners of L2 English with L2 learners showing no priming effect for inflected primes and reduced priming for derived primes. Diependaele et al. (2011), on the other hand, included only L1 Spanish and L1 Dutch speakers in studying their processing of L2 English words. German, Spanish, and Dutch have cognates with English, whereas Japanese extensively borrows words from English and other languages, which could possibly be confounding factors. As a result, it is not clear whether L1 and L2 sharing the same morphological typology might contribute to L2 morphological awareness and/or similar L1 and L2 patterns of morphological processing, or if L2 morphological processing is mostly determined by the second language itself. The latter claim could be similar in spirit to findings in Frost, Kugler, Deutsch, and Forster (2005), who found form priming in English but no form priming in Hebrew for Hebrew-English[3] bilinguals who were native speakers of Hebrew at The Hebrew University with extensive knowledge of L2

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[3] Hebrew and English belong to completely different morphological types.

English. This result seems to suggest that there is not much L1 influence and for which they claimed, "the structure that eventually develops is determined by properties of the language itself" (p. 1308). Thus, more stringent and systematic inclusion of different L1 morphological backgrounds is called for.

1.2.2 Orthographic and writing system typology

Previous research has suggested influence of L1 writing system differences on priming effects. For example, Basnight-Brown, Chen, Hua, Kostic, and Feldman (2007) found differential L2 English form overlap priming effects (between irregular past primes and present tense targets sharing a stem) due to L1 writing system differences: facilitation for an alphabetic L1 Serbian group, and no facilitation for a logographic L1 Chinese group (although Chinese speakers have pinyin in their early schooling, their adult reading exposure is overwhelmingly logographic). Studies of L2 morphological priming did not systematically examine influence from L1 and L2 sharing the same orthography or not (Sun-Alperin & Wang, 2011) or similar writing systems (Perfetti & Dunlap, 2008). It is not clear whether L1 and L2 sharing the same writing system might also contribute to similar L1 and L2 morphological processing patterns.

1.2.3 Morphological awareness

Morphological awareness refers to the awareness of the morphemic structure of words, i.e., the meaning and structure of morphemes in relation to words, and the ability to reflect on and manipulate that structure (Carlisle, 1995; McBride-Chang, Wagner, Muse, Chow, & Shu, 2005).

Within the L1 literature, individual differences in morphological awareness have been shown to be a significant predictor in word recognition (McBride-Chang, Shu, Zhou, Wat, & Wagner, 2003), and contribute to reading comprehension and development in elementary years (Carlisle, 2000, 2003; Carlisle & Fleming, 2003; Carlisle & Goodwin, 2013; Deacon & Kirby, 2004; Gilbert, Goodwin, Compton, & Kearns, 2014; Kieffer & Lesaux, 2008, 2012; Kirby et al., 2012; Kuo & Anderson, 2006; Nagy, Berninger, & Abbott, 2006) and in high school and college level (Mahony, 1994). It also facilitates the ability to define morphologically complex words and the reading/decoding of derived words (Carlisle, 2000, 2003; Carlisle & Katz, 2006; Carlisle & Stone, 2005; Goodwin, Gilbert, & Cho, 2013; Kuo & Anderson, 2006; Mahony, Singson, & Mann, 2000; McCutchen, Green, & Abbott, 2008; Singson, Mahony, & Mann, 2000), spelling of morphologically complex words (Angelelli, Marinelli, & Burani, 2014; Carlisle, 2003; Kemp, 2006), vocabulary acquisition and development (McBride-Chang et al., 2005), and also for the development of written language proficiency (Carlisle & Goodwin, 2013; Rubin, 1988).

The effect of L2 morphological awareness on reading development has rarely been extensively examined. Exceptions include Lam, Chen, Geva, Luo, and Li (2012), Wang, Cheng, and Chen (2006), and Ramirez, Chen, Geva, and Kiefer (2010). Lam et al. (2012) studied the role of morphological awareness in reading development for kindergarteners and first graders who were Chinese-speaking English language learners and found its contribution in vocabulary and reading comprehension. Wang et al. (2006) showed evidence for cross-language morphological awareness transfer from L2 English to L1 Chinese on L1 character reading and reading comprehension. Ramirez et al. (2010) investigated the within and cross-language effects of morphological awareness (evaluated with two measures of derivational morphology) on word reading for L1 Spanish learners of L2 English, and found cross-linguistic transfer of morphological awareness from Spanish to English.

There are few L2 morphological processing studies that incorporated morphological awareness, except in Kraut (2015), Deng, Shi, Bi, Dunlap, and Chen (2016), and Deng, Shi, Dunlap, Bi, and Chen (2016). Kraut (2015) compared L2 learners of high or low frequency in their morphological awareness, and showed a significant gain in explicit knowledge of English morphology across proficiency levels, but did not examine a possible effect of morphological awareness on L2 on-line morphological processing. To the best of my knowledge, Deng, Shi, Bi, et al. (2016) and Deng, Shi, Dunlap, et al. (2016) are the only two studies examining the effect of morphological knowledge on L2 morphological processing.

Deng, Shi, Bi, et al. (2016) compared a high morphological awareness group and a low morphological awareness group matched for proficiency and found a full morphological priming effect in the masked priming task in the high awareness group but not in the low awareness group, as well as a significant processing cost in processing derivational words in the high relative to the low group in a self-paced reading task. The differential performances in the high versus the low group provided evidence for the effect of morphological awareness on morphological processing. Deng, Shi, Dunlap, et al. (2016) elicited differential ERP responses for L2 learners with high or low morphological knowledge (matched on L2 English proficiency) to pseudo-derived words in a sentence reading task: a significant P600 (evidence for rule-based decomposition) for the group with high morphological knowledge, as compared to a significant N400 (evidence for whole-word processing) for the group with low morphological knowledge. The results of Deng, Shi, Dunlap, et al. (2016) thus again provided evidence for the effects of L2 morphological awareness on on-line L2 morphological processing.

A relevant strain of research is on the L2 processing of morphological disagreement (mainly inflectional plural morphemes) to investigate whether competence or performance issues contribute to L2 morphological difficulty (Jiang, 2004) and on L1 transfer of morphological knowledge on L2 processing of plural inflections (Jiang, Novokshanova, Masuda, & Wang, 2011). L2 learners were found to be sensitive to subcategorization errors, but not number agreement, during self-paced reading, suggesting non-automatic morphological knowledge of L2 learners (Jiang, 2004). Positive L1 transfer, however, were found to affect on-line L2 morphological processing of the plural morpheme, with L2 English learners with a morphologically congruent L1 (Russian) demonstrating sensitivity to grammatical errors and L2 English learners with a morphologically incongruent L1 (Japanese) demonstrating no such sensitivity (Jiang et al., 2011). In L1 processing, the findings in Gimenes, Brysbaert, and New (2016) revealed cross-linguistic differences in the threshold value below which plural nouns show full decomposition and above which plural nouns show both surface and base frequency effects. For example, they found more plurals decomposed in French than in Dutch and more in Dutch than in English and attributed the cross-linguistic differences to morphological richness of the language. Their findings are consistent with the connectionist approach of Plaut and Gonnerman (2000) who found that in simulations morphological priming increased with semantic transparency in both morphologically rich (e.g., Hebrew, which is symbolic fusional) and impoverished (e.g., English, which is analytic) languages but morphological priming extended to the opaque condition only in the morphologically rich language and suggested that the degree of morphological organization of the entire system can influence the processing of all items in a language, not just the transparent morphologically complex words. The differences in morphological processing of the native languages suggest possible L1 influence on how they may process L2 morphologically complex words.

Therefore, a replicative study is called for to better establish the effect of morphological knowledge on real-time morphological processing, and in order to examine L1 effects on L2 morphological processing, a comparison across the L2 groups with regard to morphological awareness is called for.

1.2.4 Language proficiency

It is not surprising that language proficiency has been shown to influence on-line morphological processing. Gor and Jackson (2013) suggested the influence of language proficiency on L2 learners' ability of morphological decomposition by revealing an effect of morphological priming in English advanced learners of Russian for regularly inflected verbs, and an effect of priming for semi-regular and irregular class verbs only in the highest proficiency levels. Gor, Chrabaszcz, and Cook (2017) likewise showed similar magnitudes of processing advantage of citation over oblique forms regardless of the inflection (due to processing cost of recombination) in native speakers and the higher L2 proficiency group, as compared to a reduced advantage in the lower L2 group, documenting greater sensitivity to case inflection in lexical access as proficiency increases. Similarly, Liang and Chen (2014) validated the predictions of the declarative/procedural model by showing, with ERPs, more and less proficient L2 learners being equally sensitive to word form and meaning, but only the more proficient group demonstrating morphological priming effect, which provided evidence for changes in the way morphologically complex words are processed as proficiency increases. Pliatsikas and Marinis (2012) examined the processing of regular and irregular past tense morphology in highly proficient L2 learners of

English in a self-paced reading study with four conditions (regular verbs, irregular verbs, irregularized regular verbs based on their form similarity to irregular verbs, e.g., show-throw, and regularized irregular verbs). They found highly proficient L2 learners showing the same effects as native speakers, with longer reaction times for regularly inflected forms than for irregularly inflected ones, providing evidence for rule-based processing in proficient L2 learners of extended L2 exposure regardless of exposure type (naturalistic vs. classroom L2). Even Silva and Clahsen (2008), who claim that L2 learners do not process morphology, allow that higher proficiency learners might show effects of morphology.

Moreover, language proficiency, especially differences in spelling and vocabulary, has been demonstrated to influence morphological priming effects for transparent (e.g., worker-WORK) and opaque (e.g., corner-CORN) words (Andrews & Lo, 2013). Readers with relatively higher vocabulary than spelling showed robust priming for transparent pairs but little priming for opaque or form pairs, whereas readers with relatively higher spelling than vocabulary showed similar magnitudes of priming for transparent and opaque pairs. The measure capturing the common variance between spelling and vocabulary did not significantly modulate any priming effects.

However, Beyersmann, Casalis, Ziegler, and Grainger (2015) did not find the difference between spelling and vocabulary measures to interact with any priming effects. Nevertheless, they did found that the high proficiency group in their study demonstrated comparable magnitudes of priming in the suffixed word, suffixed non-word, and non-suffixed non-word conditions but the low proficiency group showed significantly reduced priming in the non-suffixed condition compared to the suffixed conditions. Beyersmann et al. (2015) suggested that participants with high proficiency are more expert and proficient in mapping sublexical orthography onto whole-word orthographic representations and therefore rely less on morphological segmentation whereas participants with low proficiency, with less activation of whole-word representations, would rely more on morpho-orthographic segmentation. The findings of Beyersmann et al. (2015) thus highlighted language proficiency to be an important factor to be taken into consideration for the explanation of divergent findings.

1.2.5 Individual differences: different reading profile and reading speed

Individual reading profiles, “semantic” (focusing more on lexico-semantic information) vs. “orthographic” (focusing more on orthographic information), have been found to affect morphological processing in different conditions (Andrews & Lo, 2013). Individuals with a semantic profile did not show effects of early morpho-orthographic decomposition whereas individuals with an orthographic profile did. Similarly, masked priming between morphologically simple orthographic neighbors has been found to be facilitatory for individuals with poor spelling ability but inhibitory for those with high spelling ability (Andrews & Hersch, 2010; Andrews & Lo, 2012).

Individual reading profiles with regard to reading speed have also been shown to affect morphological priming. Faster readers are sensitive to morpho-orthographic interactions by demonstrating larger transposed-letter (TL) priming effects within than between morphemes, whereas slower readers’ strategy of morphological processing seems to be insensitive to morpho-orthographic interactions (Duñabeitia, Perea, & Carreiras, 2014). A masked suffix priming effect, which has been suggested to be exclusively mediated by morpho-semantic information (Duñabeitia, Perea, & Carreiras, 2008) and position-specific (Amenta & Crepaldi, 2012;

Crepaldi, Hemsworth, Davis, & Rastle, 2016) has been found for slower readers but not fast readers (Medeiros & Duñabeitia, 2016).

Heritage native speakers and "prototypical" native speakers have also been found to differ in their reading profile, with the heritage group relying more on orthographic surface form and less on morpho-orthographic decomposition, due to the unique way of acquiring written Turkish in the heritage group (Jacob & Kırkıcı, 2016).

Therefore, in the comparison between L1 and L2 morphological processing, individual reading profiles and reading speed might differ across language groups, i.e., between L1 and L2, and/or between the L2 groups themselves. Conclusions regarding the comparison of L1 and L2 morphological processing patterns thus must consider those across-group differences with regard to reading profiles and reading speed.

1.3 GOALS OF THE CURRENT RESEARCH

A more comprehensive view of L2 morphological processing should: (1) acknowledge suffix complexity ordering (Plag & Baayen, 2009) and its effects on L2 morphological processing; (2) incorporate the effects of morphological awareness, and (3) more stringently examine whether there are L1 effects, both morphologically and in terms of orthography and writing system differences. The current study focused on these specific target domains.

The research questions that the current dissertation research aimed to examine, along with the hypotheses are:

(1) Are there L1 influences on off-line L2 morphological awareness?

I hypothesize that there are L1 influences on off-line L2 morphological awareness.

Specifically, the Turkish group, with a morphologically rich L1, will have higher L2 English morphological awareness than the Chinese group or the Vietnamese group, both with an L1 of isolating morphology.

(2) Does L2 proficiency affect morphological processing patterns in advanced second language learners?

Based on previous studies (Beyersmann et al., 2015; Gor et al., 2017; Gor & Jackson, 2013; Liang & Chen, 2014; Pliatsikas & Marinis, 2012), I hypothesize that L2 proficiency will affect morphological processing patterns such that the higher the L2 proficiency, the larger the morphological priming effects. However, a null effect of L2 proficiency is not unexpected considering the findings of Andrew and Lo (2013). If the proficiency test happens to capture common variances of spelling and vocabulary, L2 proficiency might not modulate priming effects. Moreover, the current study involves native speakers and advanced learners of English. Within a limited range of L2 proficiency, it is not unlikely that the modulation of proficiency on priming effects might not show up.

(3) Is there an L1 influence on on-line L2 morphological processing?

I hypothesize that there is an L1 influence on on-line L2 morphological processing. The Turkish group, from a morphologically rich L1, will show similar processing patterns as the native English group, whereas the Chinese and the Vietnamese groups, both from a morphologically isolating L1, will behave differently from the English group. The Chinese and the Vietnamese groups are hypothesized to differ in their orthographic processing, based on the fact of the Chinese language using a logographic writing system, and the Vietnamese language using an alphabetic writing system. English, Turkish, and Vietnamese all use an alphabetic Latin writing system, and therefore, the Vietnamese group, as compared to the Chinese group, will exhibit similar orthographic processing patterns to the native English group and the Turkish group.

(4) Does L2 morphological awareness affect L2 morphological processing?

Based on previous results of Deng, Shi, Bi, et al. (2016) and Deng, Shi, Dunlap, et al. (2016), I hypothesize that L2 morphological awareness will affect L2 morphological processing patterns such that higher L2 morphological awareness will lead to larger priming effects in the morphological condition.

(5) Are L1 and/or L2 speakers sensitive to suffix complexity during on-line L2 morphological processing?

Based on previous findings of advanced L2 learners being sensitive to subtle morphosyntactic feature information (Bosch et al., 2016), I hypothesize that in the current study, advanced L2 speakers, like L1 speakers, are sensitive to suffix complexity during on-line L2 morphological processing of English derived words.

(6) Are L2 learners of English tolerant of base orthographic/phonological alternations during their on-line morphological decomposition, similarly to native speakers?

I hypothesize that advanced L2 learners of English are tolerant of base orthographic/phonological alternations, just like native speakers, during their on-line morphological decomposition.

To answer these questions, the current research included an on-line masked priming lexical decision task, which examined participants' on-line English morphological processing patterns, and a series of off-line morphological and orthographic awareness tasks and a proficiency test. The materials were built based on the traditional descriptive theories viewing words as being composed of morphemes. Apart from a native English group, three L2 groups of typologically different L1s were recruited, including Turkish (Latin script, rich derivation), Chinese (logographic non-Latin script, little derivation), and Vietnamese (Latin script, little derivation).

2.0 OVERVIEW OF THE CURRENT RESEARCH

Sections 3.0-3.3 introduce the method of the masked priming lexical decision task and the off-line measures.

Section 4 reports the results of the off-line measures and deals with the question of whether there is an L1 influence on off-line L2 morphological awareness. Section 4.1 presents analyses and results of participants' demographic characteristics, morphological awareness, orthographic awareness, and language proficiency.

Sections 5-7 reports the results of the masked priming lexical decision task, as well as the effects of the off-line measures on participants' performance in the on-line masked priming lexical decision task.

Section 5.0 specifies the model characteristics true for all models in the current dissertation, including models for word targets and non-words alike.

Section 5.1 analyzed whether there was an effect of consciousness of the prime on the processing patterns for the word targets, based on the English data in which there is a somewhat matched split of reporting of consciousness and unconsciousness of the prime.

Sections 6 and 7 together answer the question of whether there is an L1 influence on on-line L2 morphological processing and whether L2 proficiency affects morphological processing patterns in advanced second language learners. Section 6 shows the lexical decision results for word targets, directly informing the main research question of morphological processing. Section

6.1 reports the models for word targets for the combined data as well as for each language group. Section 6.2 reports the results for word targets for the English group, Section 6.3 for Turkish, Section 6.4 for Chinese, and Section 6.5 for Vietnamese. Section 6.6 compared the language groups in terms of their processing patterns for words. Section 6.7 reports the models and results on the effects of sex on morphological processing results for word targets in the combined as well as each language group.

Section 7 reports the lexical decision results for non-words. Section 7.1 reports the results for English, Section 7.2 for Turkish, Section 7.3 for Chinese, and Section 7.4 for Vietnamese. Section 7.5 compared the language groups in terms of their processing patterns for non-words.

Section 8 is devoted to the analyses of effects of L2 morphological awareness on L2 morphological processing. Section 8.1 reports on the reaction time data and Section 8.2 reports on the accuracy data. Section 8.3 is a discussion section.

Section 9 deals with the effect of suffix complexity on L1 and L2 morphological processing patterns. Section 9.1 reports on the reaction time data and Section 9.2 reports on the accuracy data. Section 9.3 is a discussion section.

Section 10 analyzes the effects of alternation vs. no alternation on L2 morphological processing. Section 10.1 reports on the reaction time data and Section 10.2 reports on the accuracy data. Section 10.3 is a discussion section.

Sections 11.0-11.2 are the general discussion section.

3.0 METHOD: ON-LINE MORPHOLOGICAL PROCESSING OF ENGLISH DERIVED WORDS AND OFF-LINE MEASURES OF MORPHOLOGICAL AWARENESS, ORTHOGRAPHIC AWARENESS, ENGLISH PROFICIENCY, AND LANGUAGE HISTORY

The current study tested how different L1 backgrounds may affect L2 English on-line processing of morphologically complex derived words in a masked priming lexical decision task. The current study also examined participants' English morphological awareness, which was tested in a series of computerized on-line tasks. Measures of orthographic awareness and English proficiency, as well as their language history were also collected.

Masked priming lexical decision tasks have been extensively implemented in both L1 and L2 lexical processing studies to avoid consciousness of the prime and thus ensure the task tapping into automatic, strategy-free pre-lexical stages of visual word recognition (Forster, 1998; Forster & Davis, 1984; Jacob & Kırkıcı, 2016; Juffs, 2009; Marslen-Wilson, 2007; Marslen-Wilson, Bozic, & Randall, 2008). In a masked priming lexical decision task, a prime is briefly (30-80ms) presented in the center of the screen after the presentation of a "mask", usually consisting of nonsense hash signs with the same length as that of the prime, and a target will then replace the prime in the same position, on which participants are asked to make a lexical decision. Although the presentation of the prime usually does not reach the conscious level for participants, robust priming, i.e., a robust effect of the prime on the target response, has been readily found for prime-target pairs that are related (Forster & Davis, 1984).

The current research employs the masked priming lexical decision task to examine the prime-target morphological relationships on target response, in order to tap into early stages of lexical processing with regard to whether participants readily decompose the prime, as has been extensively used in both L1 and L2 morphological processing studies (Clahsen et al., 2010; Diependaele et al., 2011; Feldman, Kostic, Gvozdenovic, O'Connor, & Martín, 2012; Rastle & Davis, 2008).

3.1 PARTICIPANTS

Three L2 groups of non-native English learners were recruited for this experiment: Turkish (Latin script, rich derivation and inflection), Chinese (logographic non-Latin script, little derivation or inflection, although extensive compounding), and Vietnamese (Latin script, little derivation or inflection, although extensive compounding), with 42, 50, and 24 participants in each group, respectively. Fifty native English speakers were also included for comparison and to validate materials. The choices of the different L1 groups thus made possible comparisons between agglutinative (Turkish) and isolating (Chinese and Vietnamese) L1s in order to examine L1 morphological typology effects on L2 morphological processing. The inclusion of both Chinese (logographic, different from English) and Vietnamese (alphabetic, similar to English) L1s also made possible the comparison across scripts and writing systems so as to examine L1 script and writing system effects on L2 processing. The criteria for selection were without language or hearing problems and with normal or corrected to normal vision.

3.2 MATERIALS

3.2.1 Masked priming lexical decision task

Two balanced lists were created for the same 204 word targets. For the 204 word targets, 102 primes were related to the target and 102 unrelated. Primes related to the targets are either a transparent suffixed morphological derivative (34 total) of the target (e.g., hunter-hunt), a pseudo-suffixed word (34 total) containing the target plus a pseudo-suffix (e.g., corner-corn), or a pseudo-stemmed word (34 total) containing the target plus a letter string that never functions as a suffix in the English language (e.g., surface-surf), with the conditions being termed morphological, opaque, and form control, respectively. Unrelated primes were formed from a different stem than their target and had minimal letter overlap and were unrelated to the target in meaning. They were always suffixed words or pseudo-suffixed or pseudo-stem words (34 each) matched to the related primes on length and frequency, which were derived from both CobLog in COBUILD in the WebCelex English Lexical database (Baayen, Piepenbrock, & Gulikers, 1995) and LogHal in the English Lexicon Project (Balota et al., 2007). For a specific word target, its prime is related to the target (either pseudo-stem, pseudo-suffix, or real-suffix) in one list, and unrelated to the target in the list. Each list contained prime words with or without orthographic or phonological alternations of the stem for each suffix in the morphological condition for the word targets. Participants were randomly assigned to either List1 or List2.

Each word list was coupled with the same non-word list, consisting of 204 non-words. The non-word strings were regularly pronounceable in English and their length was similar to that of the word targets. Primes for the non-words were either the target string plus a pseudo-suffix (68 total) (e.g., blemish-blem), or plus a string that never functions as a suffix in the

English language (68 total) (e.g., smudge-smud), or a real suffixed word (68 total) that had minimal orthographic overlap with the target string (e.g., learner-mape), with the conditions being termed string, suffix, and unrelated, respectively.

The measures of frequency (CobLog and LogHal), orthographic neighborhood size (Ortho_N), phonological neighborhood size (Phono_N), bigram sum (BG_Sum), bigram mean (BG_Mean), and bigram frequency by position (BG_Freq_By_Pos) for both primes and targets were drawn from the CELEX English lexical database (Baayen et al., 1995) and the English Lexicon Project (Balota et al., 2007). The Ortho_N, Phono_N, BG_Sum, BG_Mean, and BG for primes and targets were not strictly matched across conditions, because of the difficulties in strict matching of those covariates due to the limitation of words familiar to L2 speakers.

A wide range (N = 17) of derivational suffixes (-age, -aryA, -en, -er, -ery, -fulA, -ian, -ish, -ist, -ive, -less, -lyAV, -ment, -ness, -ous, -ship, -th) were included in the morphological condition in the current study, making it possible to test participants' on-line processing of words with different derivational suffixes and thus ensure generalizability, unlike the predominant consideration of only a small number of derivational morphemes in previous research, which left open the question of whether results in many earlier studies generalize over the entire lexical space of suffixed words (Kuperman et al., 2010). All affixes for the stimuli in current dissertation research were limited to derivational suffixes only.

Among those suffixes, some are non-neutral and generally cause phonological alternations of the stem, e.g., "-en" or "-ian", and some are neutral and generally do not cause phonological alternations of the stem, e.g., "-er" or "-ish" (Chomsky & Halle, 1968). The 17 suffixes in the morphological condition for word targets had four derived words for each suffix. Thirteen suffixes (-age, -en, -er, -ery, -fulA, -ish, -ist, -ive, -lyAV, -ment, -ness, -ous, -th) had two derived words without orthographic or phonological alternations and two with alternations; two suffixes (-less, -ship) had all four derived words without alternations, and one suffix (-aryA) had three derived words without alternations and one with alternations, one suffix (-ian) had three derived words with alternations and one without alternations. Therefore, within the morphological condition for word targets, there were 30 primes with alternations of the base (hereafter termed the Alter condition) and 38 without alternations (hereafter termed the NoAlter condition). The current study was therefore able to examine the influence of base allomorphy, i.e., orthographic and phonological alternations, on L2 processing of morphologically complex words. It has been shown that activation of the base morphemes is not influenced by those frequent and predictable allomorphic changes for native speakers (McCormick, Rastle, & Davis, 2008, 2009), providing evidence for orthographic underspecification, but it remains to be seen whether the same holds true for L2 learners in their processing of derivational morphology, although scarce evidence has been shown that while L1 speakers showed facilitation to stem change irregulars, L2 speakers do not (Basnight-Brown et al., 2007). Appendix A lists all the materials used in the masked priming lexical decision task.

Lexical decision results for not only word targets, but also non-words, are important in statistical analyses in the current study because results on word targets would inform the orthographic and morphological processing of complex words, and results on the non-words would also provide information on participants' efficiency and automaticity in their processing of pure orthographic and phonological representations of the primes and the targets (Masson & Isaak, 1999, p. 399). Different L2 groups from different L1s with regard to scripts and writing systems might differ in automaticity of orthographical and phonological processing, which might show up in lexical decision results for non-words targets.

For the word targets, multiple comparisons (pairwise comparisons using t tests with pooled SD) with Bonferroni adjustment for *p* values were also conducted to compare the characteristics of the primes and targets in each condition (transparent, opaque, and form). Table 1 shows the characteristics of the related primes and targets for word targets.

Table 1. Word Characteristics in the Priming Study. The *p* value results of multiple comparisons with Bonferroni adjustment for *p* values for the characteristics of the primes and targets for word targets in each condition (transparent, opaque, and form), with significances and marginal significances in bold.

Word Targets	T	O	F	T-O	T-F	O-F
Primes						
Number of letters	7.088	6.824	6.706	0.429	0.105	1.000
Surface frequency CobLog	0.741	0.797	0.764	1.000	1.000	1.000
Surface frequency LogHal	7.499	7.807	8.035	1.000	0.391	1.000
Ortho_N	0.765	2.103	1.235	**0.000**	0.501	**0.034**
Phono_N	2.088	4.059	4.206	**0.080**	**0.052**	1.000
BG_Sum	22550.544	25398.574	20164.485	0.219	0.397	**0.003**
BG_Mean	3639.529	4392.194	3500.603	0.003	1.000	**0.000**
BG_Freq_By_Pos	3734.044	4342.765	3657.971	**0.080**	1.000	**0.039**
Targets						
Number of letters	4.088	3.956	4.059	0.946	1.000	1.000
Surface frequency CobLog	1.294	1.049	1.056	0.237	0.263	1.000
Surface frequency LogHal	9.995	9.382	9.308	0.209	0.127	1.000
Ortho_N	9.515	12.971	10.000	**0.015**	1.000	**0.046**

Phono_N	18.456	24.824	20.809	**0.026**	0.984	0.288
BG_Sum	9303.103	11768.235	11168.250	**0.054**	0.219	1.000
BG_Mean	2943.503	3951.706	3607.527	**0.002**	**0.074**	0.725
BG_Freq_By_Pos	1955.574	2528.750	2494.662	**0.010**	**0.018**	1.000

Therefore, the transparent, opaque, and form control conditions for word targets did not differ in terms of number of letters or surface frequency (either CobLog or LogHal) of the primes or targets, but did differ between certain conditions (either significantly or marginally) in terms of other prime or target characteristics, including Ortho_N, Phono_N, BG_Sum, BG_Mean, and BG_Freq_By_Pos. Consequently, all analyses conducted to test morphological processing comparing the conditions (transparent, opaque, or form control) would need to include those covariates in order to partial out possible effects of those covariates on the effect of Condition on the dependent variables.

For the non-words, I also compared the string and suffix conditions in terms of the characteristics of the primes and results are shown in Table 2.

Table 2. Non-word Characteristics in the Priming Study. The *p* value results of multiple comparisons with Bonferroni adjustment for *p* values for the characteristics of the primes and targets for non-words in each related condition (string vs. suffix), with significances and marginal significances in bold.

Non-words	string	suffix	string-suffix
Primes			
Number of letters	6.750	6.588	0.311
Surface frequency CobLog	0.755	0.742	0.907
Surface frequency LogHal	7.983	7.961	0.942

Ortho_N	1.044	1.691	**0.073**
Phono_N	2.544	3.485	0.185
BG_Sum	22855.074	24790.485	0.307
BG_Mean	3850.759	4443.394	**0.031**
BG_Freq_By_Pos	3564.294	4139.882	**0.057**
Targets			
Number of letters	4.132	4.147	0.862

Therefore, the string and suffix conditions for non-words did not differ in terms of number of letters of the primes or the targets, or the surface frequency (either CobLog or LogHal) of the primes, but did differ between certain conditions (either significantly or marginally) in terms of other prime characteristics, including Ortho_N, BG_Mean, and BG_Freq_By_Pos for the prime. Consequently, all analyses conducted to test morphological processing comparing the conditions (string and suffix) would need to include those covariates in order to partial out possible effects of those covariates on the effect of Condition on the dependent variables.

I further compared the Alter (N = 30) and NoAlter (N = 38) conditions of the morphological condition in terms of the characteristics of the primes and targets, and results are shown in Table 3.

Table 3. Alternation vs. Non-Alternation Targets. The *p* value results of multiple comparisons with Bonferroni adjustment for *p* values for the characteristics of the primes and targets for word targets in the morphological condition in different AlterCondition (Alter 30 vs. NoAlter 38) conditions, with significances and marginal significances in bold.

Word Targets	Alter	NoAlter	Alter-NoAlter
Primes			
Number of letters	7.000	7.158	0.571
Surface frequency CobLog	0.704	0.770	0.660
Surface frequency LogHal	7.473	7.519	0.923
Ortho_N	0.933	0.632	0.352
Phono_N	2.200	2.000	0.829
BG_Sum	21898.033	23065.684	0.649
BG_Mean	3549.935	3710.262	0.636
BG_Freq_By_Pos	3373.200	4018.921	0.168
Targets			
Number of letters	4.133	4.053	0.691
Surface frequency CobLog	1.074	1.468	**0.029**
Surface frequency LogHal	9.663	10.258	0.211
Ortho_N	8.300	10.474	0.227
Phono_N	18.233	18.632	0.904
BG_Sum	8265.033	10122.632	0.214
BG_Mean	2579.025	3231.248	0.136
BG_Freq_By_Pos	1581.033	2251.263	**0.020**

Therefore, the Alter and NoAlter conditions did not differ in terms of certain prime or target characteristics, including length, frequency (LogHal), Ortho_N, or Phono_N, BG_Sum, BG_Mean, but did differ between target conditions in terms of surface frequency CobLog and BG_Freq_By_Pos. Analyses conducted to test the effect of alternation on morphological processing would need to include those covariates in order to partial out possible effects of those covariates on the effect of AlterCondition on the dependent variables.

3.2.2 Morphological awareness measures in L2

Participants' derivational morphological awareness were evaluated by multiple measures, in consideration of the importance of (a) avoiding measurement problems within the field of morphological research (Bowers, Kirby, & Deacon, 2010; Carlisle, 2010; Carlisle & Goodwin, 2013; Gilbert et al., 2014) and (b) concerns on the variability of morphological awareness measures in their degree of tapping root-word vocabulary knowledge (Kieffer & Lesaux, 2012; Kuo & Anderson, 2006). Those multiple measures included a derivation task, a multiple choice word task, a multiple choice non-word task, a morphological relatedness task, and a suffix-ordering task. Scores were calculated for each specific task. Appendix B lists materials for all six tasks.

Kirby et al. (2012) noted one important characteristic relevant to the measurement of morphological awareness, the phonological transparency of the relationship between morphologically related words and the importance of including phonologically opaque items in addition to transparent items to ensure that participants are processing the morphological structure, not just the phonological structure, of the words. This manipulation has been consistently adopted in most studies measuring morphological awareness, and has also been controlled for in the current study, i.e., including materials of both transparent ones and those with alternations.

The derivation task (Carlisle, 1988, 2000; Kraut, 2015) asked participants to produce the derived form of a given base word to complete a sentence. The derivational suffixes targeted included -th, -ity, -(t)ion, -er, -ity, -ance, -able, -(i)ous. Task materials for the derivation task were adapted from Carlisle (2000) and Kraut (2015). For examples, please refer to Appendix B.

The multiple choice word task (Mahony, 1994; Singson et al., 2000) asked participants to which of the four given suffixed real word options fits in with a carrier sentence consisting of real words. The materials for the multiple choice word task were adapted from Mahony (1994) and Singson et al. (2000). The derivational suffixes targeted included -ity, -fy, -ize, -ive, -ist, -ate, -er, -(t)ion, -ism, -al, -ly, -ory/-ary, -ful, -ar, -ure, -ic, -ous, -ness, -able, and -en. For examples, please refer to Appendix B.

The multiple choice non-word task (Mahony, 1994; Singson et al., 2000) asked participants to choose which of the four given suffixed non-word options fits in with a carrier sentence consisting of real words. "A correct response indicated understanding of grammatical information carried by suffixes independently of their semantic content" (Nagy et al., 2006). The materials for the multiple choice non-word study were adapted from Mahony (1994) and Singson et al. (2000). The derivational suffixes targeted include -ic, -tion, -ate, -ity, -fy/-ify, -ist, -ive, -ize, -al, -ous/-ious, -ism, -able, -ian, -al, -ment, -ure, -ar, -en, -ness, -ly, -some, and -ful. For examples, please refer to Appendix B.

The morphological relatedness task (Derwing, 1976; Mahony, 1994; Mahony et al., 2000; Nagy et al., 2006) asked participants to decide whether words in each pair were related to each other. The relatedness task adopted the word relations test stimuli from Mahony et al. (2000).

The derivational suffixes targeted included -al, -ance, -ful, -ity, -ic, -(t)ion, -th, -ure, -le, and -ard (except for one prefix a-). For examples, please refer to Appendix B.

The suffix ordering task was built upon the correct and incorrect ordering conditions of the lexical decision task in Study 1 of Friedline (2011). Words in the correct and incorrect conditions were formed by combining a highly frequent base with two derivational suffixes of either correct or incorrect ordering. Suffix targeted at included 8 Class 1 suffixes (-able, -al, -ic, -ity, -ive, -ize, -ous, -y) and 8 Class 2 suffixes (-able, -ful, -ist, -ize, -less, -ly, -ness, -y) according to Spencer (1991). Participants were asked to decide whether a given string of letters was an English word or not. There were 44 trials total, 22 words (with correct suffix orderings) and 22 non-words. For the 22 non-words, 11 were due to violation of selectional constraints for the second suffix, and 11 were due purely to incorrect ordering of suffixes. For examples, please refer to Appendix B.

In sum, the target domain knowledge that the morphological awareness measures elicit included (1) knowledge of relationships between derived words and their bases; (2) knowledge of a range of derivational suffixes and their properties, including grammatical information regardless of semantic context; and (3) knowledge of orthographic and phonological alternations due to derivation processes.

3.2.3 Orthographic awareness measure

Materials were adapted from Treiman (1993) and Cassar and Treiman (1997) and complemented by the researcher. Participants were presented with pairs of English non-words and were asked to decide which non-word looked more like an English word. In each non-word pair, both non-words were pronounceable, but one of the two looked more like an English word because the other one violated certain orthographic constraints of English. There were 34 critical non-word pairs.

3.2.4 Proficiency measures

All participants were evaluated with regard to their vocabulary size as a measure of proficiency via LexTALE (Lemhöfer & Broersma, 2012). Vocabulary size is an important covariate in itself for this study, but has also been deployed as a broader measure of proficiency and ability for L2 learners (Roche & Harrington, 2013).

3.2.5 Language History Questionnaire

At the end of the study, participants completed a language history questionnaire, adapted from a subset of questions in Li, Zhang, Tsai, and Puls (2014) and distributed via Qualtrics.

3.3 PROCEDURE

At the beginning of the study, a visual masked priming lexical decision task was implemented. Items were presented to participants on a computer screen (on Desktops with a monitor of Dell E170S Windows 7 Enterprise with a resolution of 1024 by 768 and a refresh rate of 60 Hz) using E-Prime 2.0 (Psychology Software Tools, 2012). Six Turkish and five Vietnamese participants took the study on Dell laptops with Windows 10 Education, also with a resolution of 1024 by 768 and a refresh rate of 60 Hz. Participants were asked to make a decision, as quickly and as accurately as possible, by pressing keys on the keyboard, whether the string of letters presented on the screen is a word or not ("F" key for yes, "J" key for no). Each trial consisted of a 500 millisecond (ms) forward mask of a row of hash signs with the same length as that the prime, the prime briefly presented for 50 ms (3 refresh cycles), and then replaced by the target (Font: Courier New; Point Size: 18; Color: black) against a white background which is presented for up to 2500 ms or until the participant presses the buttons to make a lexical decision, and then a feedback of 500 ms. The inter-trial interval is 1000 ms (blank screen).

Target presentation was randomized for each participant. Targets were presented in lowercase with the reasoning of Alderson (2000, p. 75) on the difficulty in processing letters being related to automaticity of word recognition and on the greater processing difficulty of uppercase relative to lower-case letters. L2 learners with a rather different L1 orthography or script background, as compared to L2 learners with a similar L1 orthography and script, might encounter even greater difficulty (in the case of the current study, the Chinese group as compared to the Turkish and Vietnamese groups). Therefore, presenting the target in lowercase enhances the fairness of cross-group comparisons.

Participants were asked to practice with ten practice trials (5 word targets and 5 non-words) from the same pool as the materials in the real experiment, and they were asked to repeat the practice until they reached an accuracy rate of or above 80%. Participants were allowed to take a one-minute break after every 102 trials (3 breaks total). The masked priming lexical decision task took approximately 20-28 minutes.

After the masked priming lexical decision task, the same participants were measured in terms of their morphological awareness, orthographic awareness, English proficiency, and language history. Following Kraut (2015), the awareness tasks were “given after the masked priming experiment to avoid any possible instances of unwanted priming” (p. 882).

The sequence of testing for the different off-line measures was (1) morphological awareness measures, (2) the orthographic awareness measure, and (3) the English proficiency measure. The testing order of morphological awareness tasks was (1) derivation, (2) multiple choice word, (3) multiple choice non-word, (4) morphological relatedness, (5) suffix ordering task, and (6) orthographic awareness. Items within each task were randomized for each participant.

4.0 RESULTS

4.1 PARTICIPANTS’ DEMOGRAPHIC CHARACTERISTICS, MORPHOLOGICAL AWARENESS, ORTHOGRAPHIC AWARENESS, AND LANGUAGE PROFICIENCY

Table 4 shows the demographic characteristics of the four language groups. Linear regression analyses were conducted to test the differences among groups with regard to age, AoA, years of English learning, self-rating of English Listening, Speaking, Reading, Writing, and LexTALE.

Table 4. Demographic and proficiency characteristics of the four language groups.

Characteristics\L1	English	Chinese	Turkish	Vietnamese
Age	18.540	21.640	29.095	27.958
Female/Male	29/21	37/13	17/25	8/16
English AoA	0.080	8.673	12.220	11.830
Years of English learning	18.520	13.100	14.820	15.460
Self-Rating of English Listening	7.000	5.143	5.950	5.542
Self-Rating of English Speaking	7.000	4.714	5.350	5.208
Self-Rating of English Reading	6.980	5.163	6.050	5.583
Self-Rating of English Writing	6.957	4.674	5.550	5.042
English LexTALE	91.230	70.650	76.340	78.850

As is expected, the native English speakers are reliably different from the L2 groups in all categories, but differences among the L2 groups are also evident as detailed below.

4.1.1 Age

As for age, the English group was significantly younger than the Chinese (t = 3.443, p < .001), Turkish (t = 11.203, p < .001), and Vietnamese (t = 8.426, p < .001) groups. The Chinese group was significantly younger than the Turkish (t = 7.913, p < .001), and Vietnamese (t = 5.652, p < .001) groups. The Turkish group did not differ significantly in age from the Vietnamese group.

4.1.2 AoA

As for AoA, the Chinese group was significantly younger than the Turkish (t = 4.975, p < .001), and Vietnamese (t = 3.785, p < .001) groups. The Turkish group did not differ significantly in AoA from the Vietnamese group.

4.1.3 Years of learning

As for years of English learning, the Chinese group did not differ significantly in years of English learning from the Turkish group, and has a marginally shorter length of years of English learning than the Vietnamese (t = 1.935, p = .0547) group. The Turkish group did not differ significantly in years of English learning from the Vietnamese group.

4.1.4 Self-rating of English listening, speaking, reading, and writing

As for self-rating of English listening, the English group rated significantly higher than the Chinese (t = -10.069, p < .001), Turkish (t = -5.395, p < .001), and Vietnamese (t = -6.400, p < .001) groups. The Chinese group rated significantly lower than the Turkish (t = 4.128, p < .001), and marginally lower than Vietnamese (t = 1.745, p = .083) groups. The Turkish group were marginally higher in in self-rating of English listening from the Vietnamese (t = -1.724, p = .087) group.

As for self-rating of English speaking, the English group rated significantly higher than the Chinese (t = -12.430, p < .001), Turkish (t = -8.503, p < .001), and Vietnamese (t = -7.887, p < .001) groups. The Chinese group rated significantly lower than the Turkish (t = 3.261, p < .01), and Vietnamese (t = 2.168, p < .05) groups. The Turkish group did not differ significantly in self-rating of English speaking from the Vietnamese group.

As for self-rating of English reading, the English group rated significantly higher than the Chinese (t = -13.301, p < .001), Turkish (t = -6.452, p < .001), and Vietnamese (t = -8.277, p < .001) groups. The Chinese group rated significantly lower than the Turkish (t = 6.124, p < .001), and Vietnamese (t = 2.481, p < .05) groups. The Turkish group rated significantly higher in English reading than the Vietnamese (t = -2.660, p < .01) group.

As for self-rating of English writing, the English group rated significantly higher than the Chinese (t = -13.306, p < .001), Turkish (t = -7.908, p < .001), and Vietnamese (t = -9.243, p < .001) groups. The Chinese group rated significantly lower than the Turkish (t = 4.926, p < .001), and marginally lower than Vietnamese (t = 1.775, p = .078) groups. The Turkish group rated significantly higher in English reading than the Vietnamese (t = -2.393, p < .05) group.

4.1.5 LexTALE

Figure 1 is a boxplot of participants' LexTALE scores across language groups. The range of possible scores for the LexTALE test was 50 (if they just clicked through the test) and 100 (if they scored correctly on the whole test). The English group had significantly higher scores than the Chinese (t = -11.007, $p < .001$), Turkish (t = -7.609, $p < .001$), and Vietnamese (t = -5.330, $p < .001$) groups. The Chinese group had significantly lower scores than the Turkish (t = 2.908, $p < .01$), and the Vietnamese (t = 3.535, $p < .001$) groups. The Turkish group did not differ significantly from the Vietnamese group.

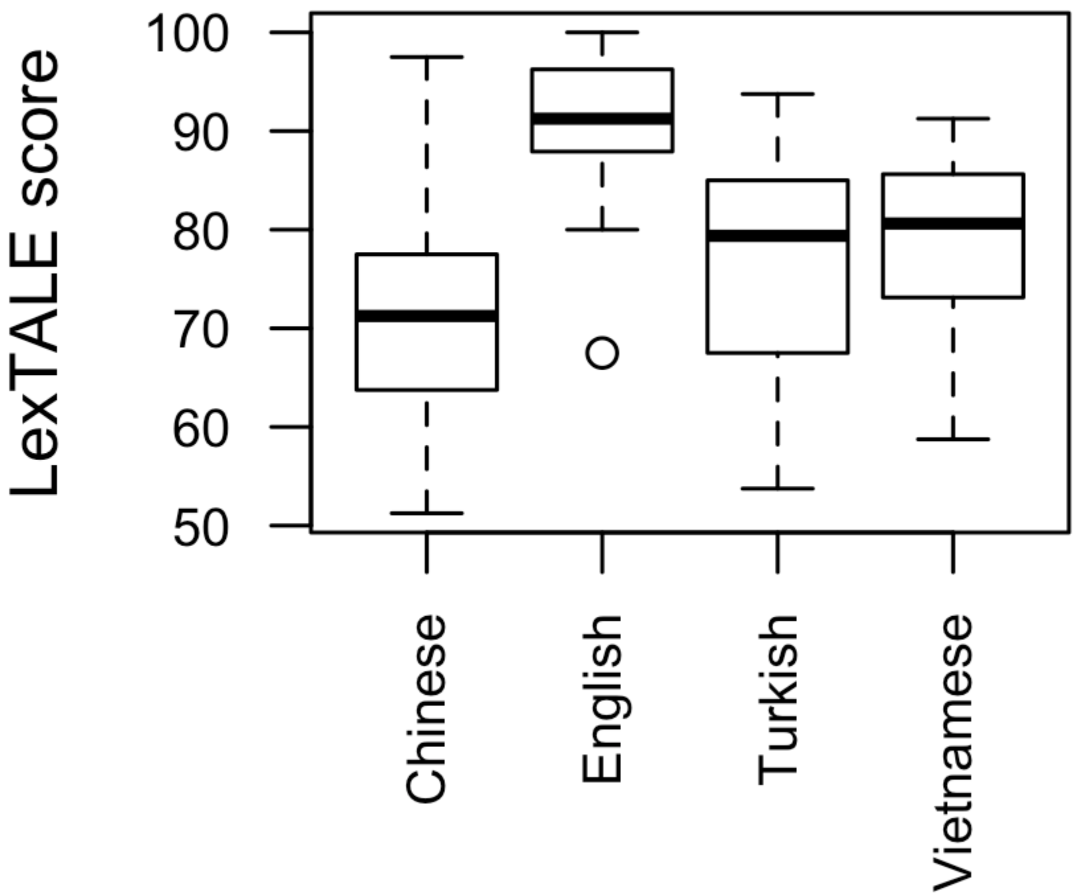

Figure 1. Boxplot of participants' LexTALE scores across language groups.

4.1.6 Morphological awareness

Participants from different L1s were expected to differ in their morphological awareness measures. Specifically, Turkish speakers, from an L1 with extensive derivation and inflection, were expected to show greater L2 English morphological awareness than the other two groups with little derivation in their L1s.

Following Kieffer and Lesaux (2008), in the scoring for the derivation task, I did not penalize participants' spelling errors to avoid confounding of variation in spelling with that in morphological awareness. For the derivation task scoring of correctness of response, I coded simple or derived words from a wrong stem as 0, e.g., a simple word "king" for given word "human" with the correct response being "humanity", or a derived word "height" for given word "long" with the correct response being "length". I also coded response of a wrong category as 0, even though the simple or derived word response itself is a real English word, e.g., a simple word "absorb" or a derived word "absorbable" for given word "absorb" with the correct response being "absorption". Incorrect spelling on the stem due to typo or ignorance of phonological alternations was not penalized, e.g., a derived word "abosorbtion" or "absorbtion" or "absobsion" or "absorbstion" or "absorbation" for the given word "absorb" with the correct response being "absorption" was coded as 1. Obvious typos on the suffix were not penalized either, e.g., a derived word response "lenght" or "lengthe" for given word "long" with the correct response being "length", or "assistence" for the given word "assist" with the correct response being "assistance". I coded some answers other than the intended correct answer as correct as well, including (1) for "absorption", "absorbability", (2) for "expansion", "expanse", (3) for "humanity", "humaneness" or "humanism" or "humanness", (4) for "mysterious", "mysterical" or "mystic", (5) for "profitable", "profitful", (6) for "warmth", "warmness".

The internal consistency estimate of reliability of the awareness tasks as measured by Cronbach's alpha (Cronbach, 1951) with items that were negatively correlated with the total score and reversed for the derivation, multiple choice word, multiple choice non-word, relatedness, suffix ordering, and orthographic awareness tasks were, for raw_alpha, .63, .64, .78, .63, .80, .68, respectively, and for std.alpha, which is the standardized alpha based upon the correlations (Falk & Savalei, 2011), .65, .71, .79, .74, .85, .74, respectively. Table 5 shows the means and standard deviations for different L1 groups in the morphological awareness tasks (including derivation, multiple choice word, multiple choice non-word, relatedness, and suffix ordering) and the orthographic awareness task.

Table 5. The means and standard deviations for different L1 groups in the morphological awareness and orthographic awareness tasks.

	means				SDs			
Task\L1	Chi	Eng	Turk	Viet	Chi	Eng	Turk	Viet
Derivation	0.738	0.880	0.796	0.799	0.440	0.325	0.404	0.402
MCWord	0.873	0.898	0.864	0.857	0.333	0.302	0.343	0.350
MCNon-word	0.848	0.855	0.829	0.838	0.359	0.353	0.377	0.369
Relatedness	0.849	0.898	0.932	0.898	0.358	0.303	0.252	0.303
SuffixOrder	0.783	0.860	0.835	0.810	0.412	0.347	0.371	0.393
Ortho	0.936	0.928	0.895	0.903	0.245	0.258	0.307	0.296

Linear regression models on the mean accuracies of each participant were fit for each awareness task, with the predictor variables of participants' L1 (English being the reference group) and their z-scores of LexTALE.

I found clear differences between L1s in certain morphological awareness tasks. This finding contrasts with Kraut (2015), who found no significant difference in scores on the morphological awareness test (including Derived Forms and Base Forms tests) between different L1s (Chinese, Spanish, Portuguese, and Arabic) within the low proficiency level or in the high proficiency level.

Participants' LexTALE z-scores were a significant predictor for their mean accuracy in each awareness task, including derivation ($t = 7.078$, $p < .001$), multiple choice word ($t = 4.258$, $p < .001$), multiple choice non-word ($t = 5.090$, $p < .001$), relatedness ($t = 3.361$, $p < .001$), and suffix ordering ($t = 4.675$, $p < .001$), and orthographic awareness ($t = 3.190$, $p < .01$).

In the derivation task, before accounting for LexTALE, the Chinese group ($t = -4.837$, $p < .001$), the Turkish group ($t = -2.751$, $p < .001$), and the Vietnamese group ($t = -2.235$, $p < .001$) all performed significantly worse than the native English group. After accounting for LexTALE, the Chinese, the Turkish, and the Vietnamese groups did not differ significantly from the native English group.

In the multiple choice word task, before accounting for LexTALE, the Chinese group did not perform significantly better or worse than the native English group ($t = -1.654$, $p < .05$) while the Turkish ($t = -2.174$, $p < .05$) or the Vietnamese ($t = -2.158$, $p < .05$) group significantly performed worse than the native English group. After accounting for LexTALE, the Chinese, the Turkish, and the Vietnamese group did not differ significantly from the native English group.

In the multiple choice non-word task, before accounting for LexTALE, the Chinese, the Turkish, and the Vietnamese groups did not differ significantly from the native English group. After accounting for LexTALE, the Chinese group significantly outperformed the native English group ($t = 3.101$, $p < .01$) while the Turkish ($t = 1.684$, $p = .094$) marginally outperformed the native English group but the Vietnamese group did not differ significantly from the native English group.

In the relatedness task (see Figure 2 on the boxplots of participants' scores in the relatedness task across language groups), before accounting for LexTALE, the Turkish group marginally outperformed the native English group ($t = 1.719$, $p = .088$) while the Chinese ($t = -2.582$, $p < .05$) performed significantly worse than the English group, but the Vietnamese group did not differ significantly from the native English group. After accounting for LexTALE, the Turkish group significantly outperformed the native English group ($t = 3.246$, $p < .01$) while the Chinese or the Vietnamese group did not differ significantly from the native English group.

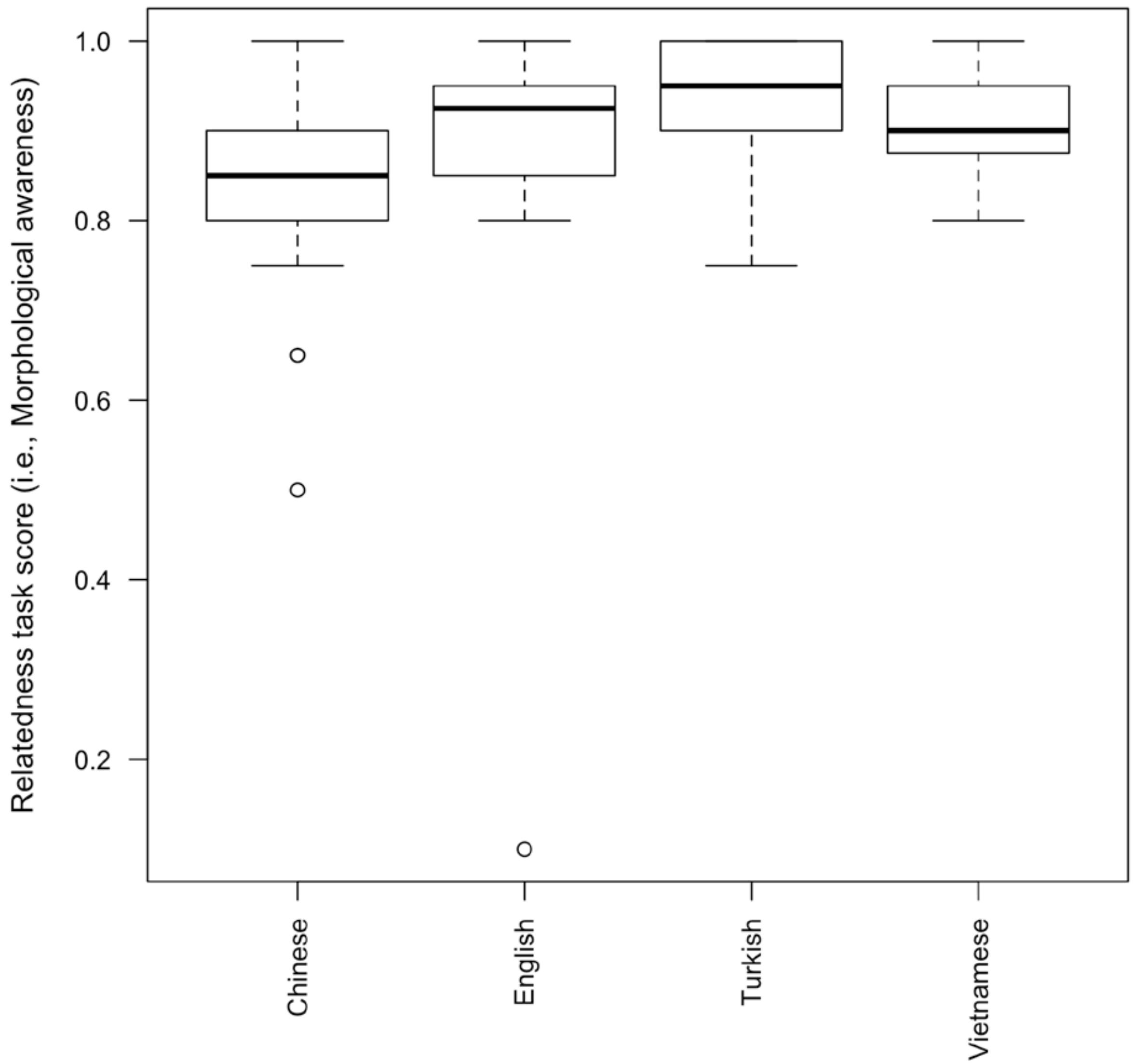

Figure 2. Boxplot of participants' score in the relatedness task (i.e., morphological awareness) across language groups.

In the suffix ordering task, before accounting for LexTALE, the Chinese (t = -4.983, p < .001) and the Vietnamese (t = -2.632, p < .01) groups performed significantly worse than the English group, whereas the Turkish group did not differ from the native English group. After accounting for LexTALE, the Chinese, the Turkish, and the Vietnamese groups did not differ significantly from the native English group.

In the orthographic awareness task, before accounting for LexTALE, the Turkish (t = -2.081, $p < .05$) performed significantly worse than the English group, whereas the Chinese and the Vietnamese groups did not differ significantly from the native English group. After accounting for LexTALE, the Chinese (t = 2.474, $p < .05$) performed significantly better than the English group, whereas the Turkish group and the Vietnamese group did not differ significantly from the native English group. This finding is contrary to our initial hypothesis because since Turkish and Vietnamese both employ an alphabetic orthography similar to English but Chinese uses a logography. Therefore, if any difference between language groups were to be found, Chinese participants should perform worse, rather than better, than the native English group. The Chinese advantage could be partially due to over-fitting of the LexTALE scores in the model.

To summarize, with regard to the research question whether there is an L1 influence on off-line L2 morphological awareness, the results of the morphological awareness tasks confirmed the initial hypothesis by showing clear L1 influence. The Turkish group marginally outperformed the native English group in the relatedness task even before accounting for LexTALE, i.e., the Turkish group, even with lower English proficiency relative to the native English group, nonetheless performed better than the native English group in their knowledge of the morphological relations between stems and derived words. After accounting for LexTALE, the Turkish group significantly outperformed the native English group. Before accounting for LexTALE, the Chinese and Vietnamese groups performed worse than the English group in most morphological awareness measures, but their disadvantage disappeared after accounting for their lower proficiency relative to the native English group. As the relatedness task was the only task that generated consistent (to a large extent) pattern results before and after accounting for LexTALE, and for most other tasks, the groups did not differ after accounting for LexTALE, in the subsequent analyses of the effect of participants' morphological awareness on morphological processing, participants' morphological awareness scores were based on their mean accuracy in the relatedness task only. In other words, participants' ability to determine whether two words were related or not was included as a variable in individual and group differences in on-line morphological processing ability.

4.1.7 Consciousness of the prime

Participants were also asked in the questionnaire to indicate whether they saw something between the presentation of the string of hash signs and the presentation of the string of English letters which they were asked to make lexical decisions on, and the ratio of conscious (yes, they reported seeing something) to unconscious (no, they didn't report saying anything) for each language group was 28/22 for English, 10/30 for Turkish, 14/36 for Chinese, and 4/20 for Vietnamese.

4.1.8 Effects of sex on LexTALE, morphological awareness, and consciousness of the prime

Because different language groups differ substantially in female/male ratios, I also analyzed whether there is an effect of sex on LexTALE, morphological awareness, or consciousness of the prime.

With regard to whether there was a sex effect on LexTALE in all four groups combined as well as in each group, results showed that for the combined data there was a significant main effect of L1 ($F(3, 158) = 43.303$, $Pr(>F) < .001$), a main effect of Sex ($F(1, 158) = 4.684$, $Pr(>F) < .05$), and no interaction between L1 and Sex. There was no main effect of sex on LexTALE scores in the English, Turkish, Chinese, or Vietnamese group.

With regard to whether there was a sex effect on morphological awareness in all four groups combined as well as in each group, results showed that for the combined data there was a significant main effect of L1 ($F(3, 158) = 6.045$, $Pr(>F) < .001$), no main effect of Sex, and no interaction between L1 and Sex. There was no main effect of sex on morphological awareness in the English, Turkish, Chinese, or Vietnamese group.

With regard to whether there was a sex effect on consciousness of the prime, for the combined data, females and males had a yes/no Consciousness count of 30/61 and 26/49, respectively. Female and male yes/no Consciousness counts for each language group are 16/13 and 12/9 for English, 4/13 and 6/19 for Turkish, 8/29 and 6/7 for Chinese, and 2/6 and 2/14 for Vietnamese. Pearson's Chi-squared test with Yates' continuity correction and logit linear regression both showed no effect of Sex on Consciousness for the combined data, or for the English, Turkish, or Vietnamese group. For Chinese, Pearson's Chi-squared test with Yates' continuity correction showed no relationship between Sex and Consciousness, and the logit linear regression also showed only marginal effect of Sex on Consciousness ($z = 1.655$, $Pr(>|z|) = .098$), with males having a marginally larger probability of being conscious of the prime. Therefore, no groups showed a sex difference in terms of consciousness of the prime based on both statistical tests of Pearson's Chi-squared test with Yates' continuity correction and logit linear regression.

5.0 MODEL SPECIFICATIONS TRUE FOR ALL MODELS

Linear mixed-effects analysis was conducted in R (R Core Team, 2014) using the lme4 package (Bates, Maechler, Bolker & Walker, 2015) on reaction times and a generalized (logit) linear mixed effects analysis on accuracy for all language groups. The dependent variables were (1) reaction time, which was later log-transform (Target.LRT), based on boxplots and the box-cox transformation procedure (Box & Cox, 1964), and (2) accuracy on a particular trial (whether the participant made a correct choice on that trial or not). The Target.LRT variable was treated as Gaussian/normal, and the accuracy variable, Target.ACC, was treated as binomial (either correct or incorrect). The dependent variables of reaction times and accuracy were appropriate based on the reasoning that if participants engage in orthographic, morphological, or semantic processing of the primes and if they are sensitive to the masked priming manipulation, measures of reaction times and accuracy will show such sensitivities.

All models chosen for word targets, and for non-words, and for all language groups, were those with the maximal random effect structures (Barr, Levy, Scheepers, & Tily, 2013) that were able to converge. Following Kuperman, Schreuder, Bertram, and Baayen (2009), local effects of ZPrevLRT and PrevACC, and the longitudinal effect of ZTrialNum were included. The reason for including ZPrevLRT and PrevACC (sum-coded) was to account for the possible local carryover effects (Baayen, Davidson & Bates, 2008; de Vaan, Schreuder & Baayen, 2007; Kuperman et al., 2009), i.e., the influence of the reaction time participants spent on the previous trial and whether they correctly responded to the previous trial on both the reaction time and accuracy of the current trial. ZTrialNum was included to partial out the longitudinal effect of the experimental task due to fatigue or habituation.

5.1 EFFECTS OF CONSCIOUSNESS OF THE PRIME ON MORPHOLOGICAL PROCESSING IN THE ENGLISH GROUP

Because the language groups differed in their proportions of participants who were conscious of the primes, one possible difference between language groups could be attributed to their differences in consciousness proportions. Because the task employed is a masked priming lexical decision task, I do not hypothesize that there will be a large percentage of participants who will report consciousness of the prime, and even if there is a considerable proportion, the nature of the task may not induce strategic differences and therefore no differences in priming patterns.

To analyze whether there is an effect of conscious visualization of the prime word or not on morphological processing for native English speakers, I analyzed the English group, considering that there were roughly comparable proportions of participants who were consciousness of the prime or not in this group (28 conscious vs. 22 unconscious). Consciousness was coded with two conditions, including Yes (yes they did report having seen something) or No (no they didn't report having seen anything).

The fixed effects in the models for LRT for English included Condition, Consciousness, the interaction between Condition and Consciousness, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy coded with unrelated as the reference condition. Consciousness was dummy coded with No being the reference condition. The random effects for LRT included the random intercepts and random slopes of Condition for participants and random intercepts for targets. Model summary results are presented in Table 15 in Appendix D.

For the native English group with regard to reaction time, there was no simple effect of Consciousness in the unrelated condition, or its interactions with the form, opaque, or morphological conditions, meaning that whether participants reported having seen something or not did not affect the priming of each condition relative to the unrelated condition, nor did it affect the reaction time in the unrelated condition.

The fixed effects in the models for ACC for English included Condition, Consciousness, the interaction between Condition and Consciousness, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy coded with unrelated as the reference condition. Consciousness was dummy coded with No being the reference condition. The random effects for ACC included the random intercepts and random slopes of Condition for participants and random intercepts for targets. Model summary results are presented in Table 16 in Appendix D.

For the native English group with regard to accuracy, there was no simple effect of Consciousness, or its interactions with the form control or morphological conditions, meaning that whether participants reported having seen something or not did not affect the priming effect of the form control or morphological conditions relative to the unrelated condition, nor did it affect the accuracy in the unrelated condition. There was, however, a marginal interaction between opaque and Consciousness ($t = -1.847$, $p = .065$), meaning that participants who reported consciousness of the prime were more primed (i.e., were even less accurate) in the opaque condition relative to the unrelated condition, i.e., their difference in accuracy in the opaque condition relative to the unrelated condition was larger than those participants who reported unconsciousness of the prime.

Overall, with regard to the question whether consciousness of the prime in the masked priming lexical decision task affects morphological processing patterns, the results confirmed the initial hypothesis. There was no significant effect of consciousness of the prime on the priming patterns in the morphological, opaque, or form control conditions, meaning that although there were differences across language groups in their proportions of participants with conscious visualization of the prime, consciousness could not be a significant factor contributing to cross-language differences in priming patterns across conditions.

6.0 L2 MORPHOLOGICAL PROCESSING: EXAMINING LEXICAL DECISION RESULTS FOR WORD TARGETS AND L1 EFFECTS

Box-plots of log-transformed response time for each language group for correctly identified word targets or non-words are presented in Figure 3 and 4, respectively.

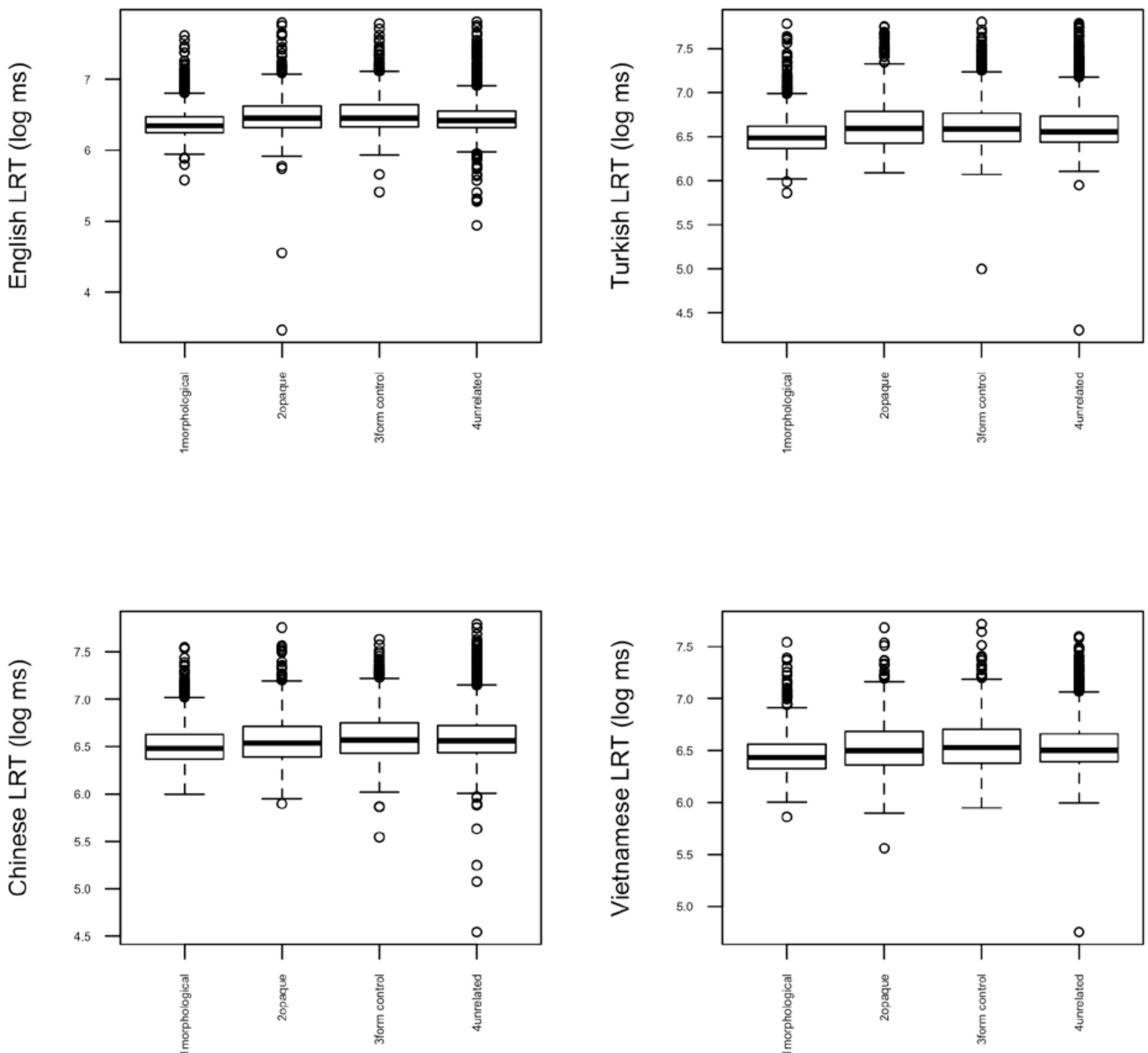

Figure 3. Box-plots of log-transformed response time (the scale for which is thus log ms) for each language group for correctly identified word targets.

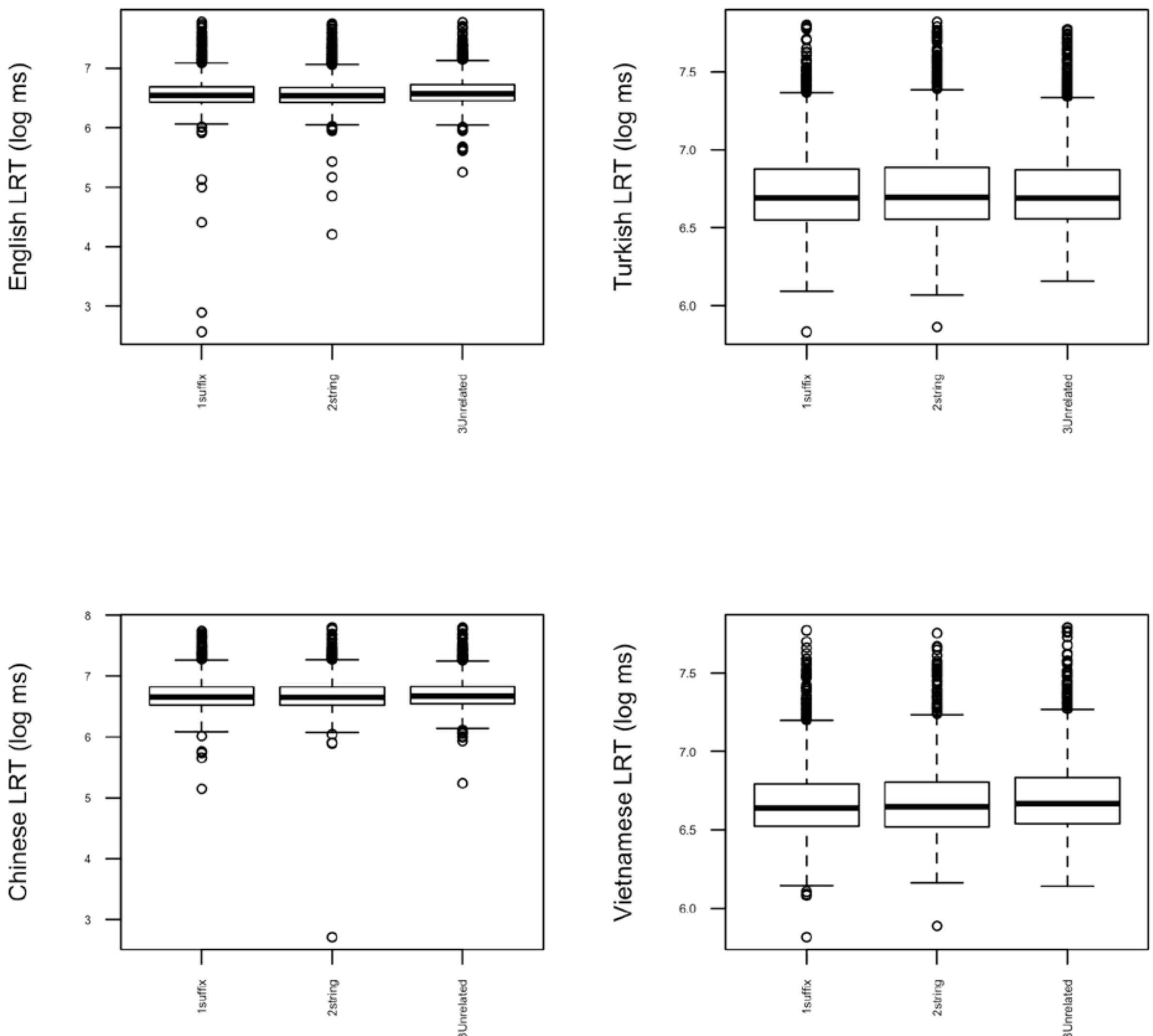

Figure 4. Box-plots of log-transformed response time for each language group for correctly identified non-words.

6.1 MODELS FOR WORD TARGETS FOR THE COMBINED DATA AS WELL AS FOR EACH LANGUAGE GROUP

The fixed effects in all reaction time models for words included Condition, ZLexTALE, the interaction between Condition and ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, and ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the reaction time models for all three groups (English, Turkish, and Chinese) included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in the reaction time models for Vietnamese included the random intercepts and random slopes of Condition for participants and random intercepts for targets.

The respective models were run with opaque being the reference as well. The random effect for Turkish with opaque being the reference included only the random intercepts and random slopes of Condition for participants and random intercepts for targets.

The fixed effects in all accuracy models for words included Condition, ZLexTALE, the interaction between Condition and ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the accuracy model for all language groups (English, Turkish, Chinese, and Vietnamese) include the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were run with opaque being the reference condition.

Figure 5 shows the mean log-transformed reaction times (log ms) in each condition for each language group for words, and Figure 6 shows the mean accuracy (on a scale of 0-1) in each condition for each language group for words.

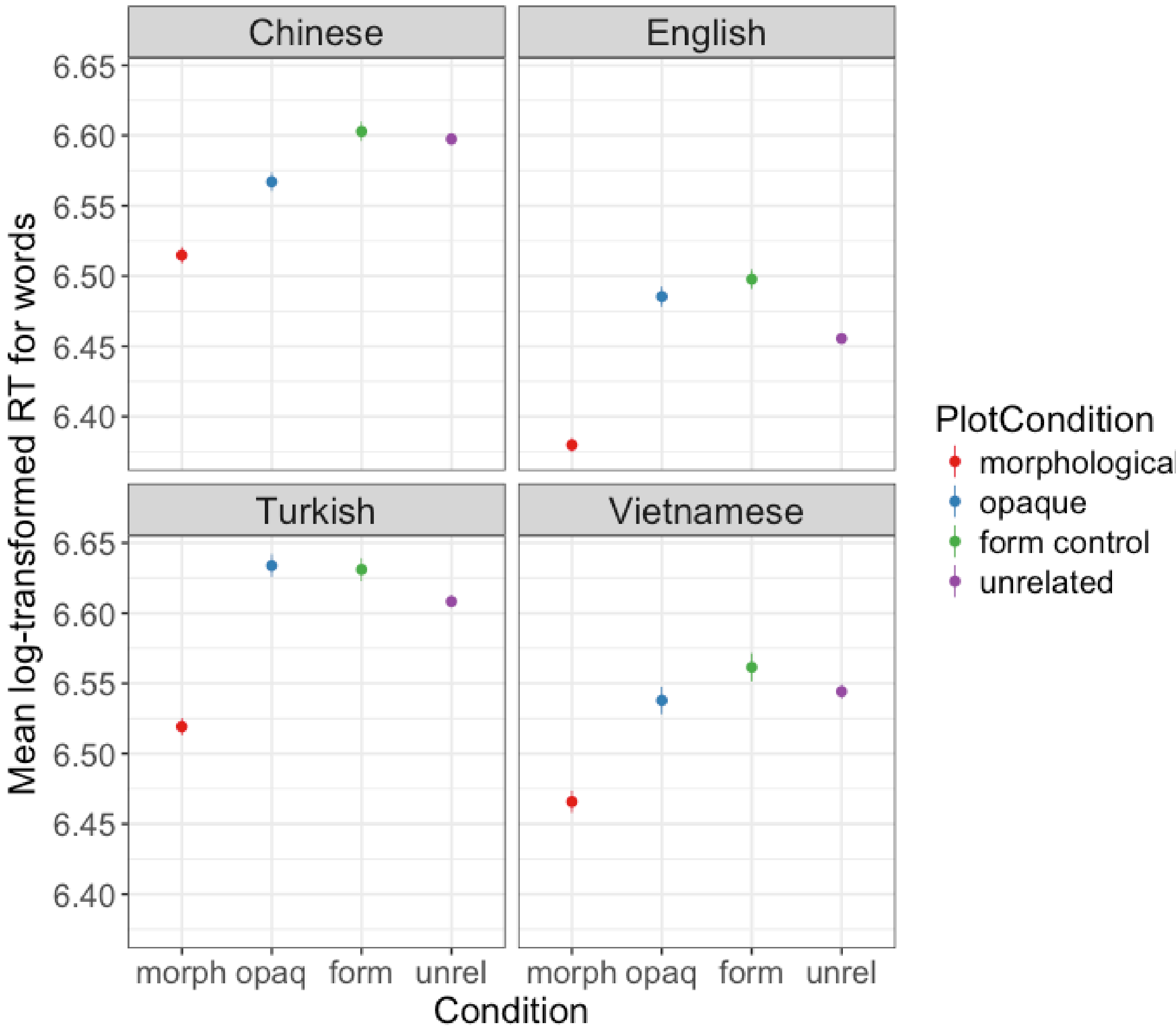

Figure 5. The mean log-transformed reaction times in each condition for each language group for words. Error bars represent ± standard error. The conditions were morphological (e.g., hunter-hunt), opaque (e.g., corner-corn), form control (e.g., surface-surf), and unrelated.

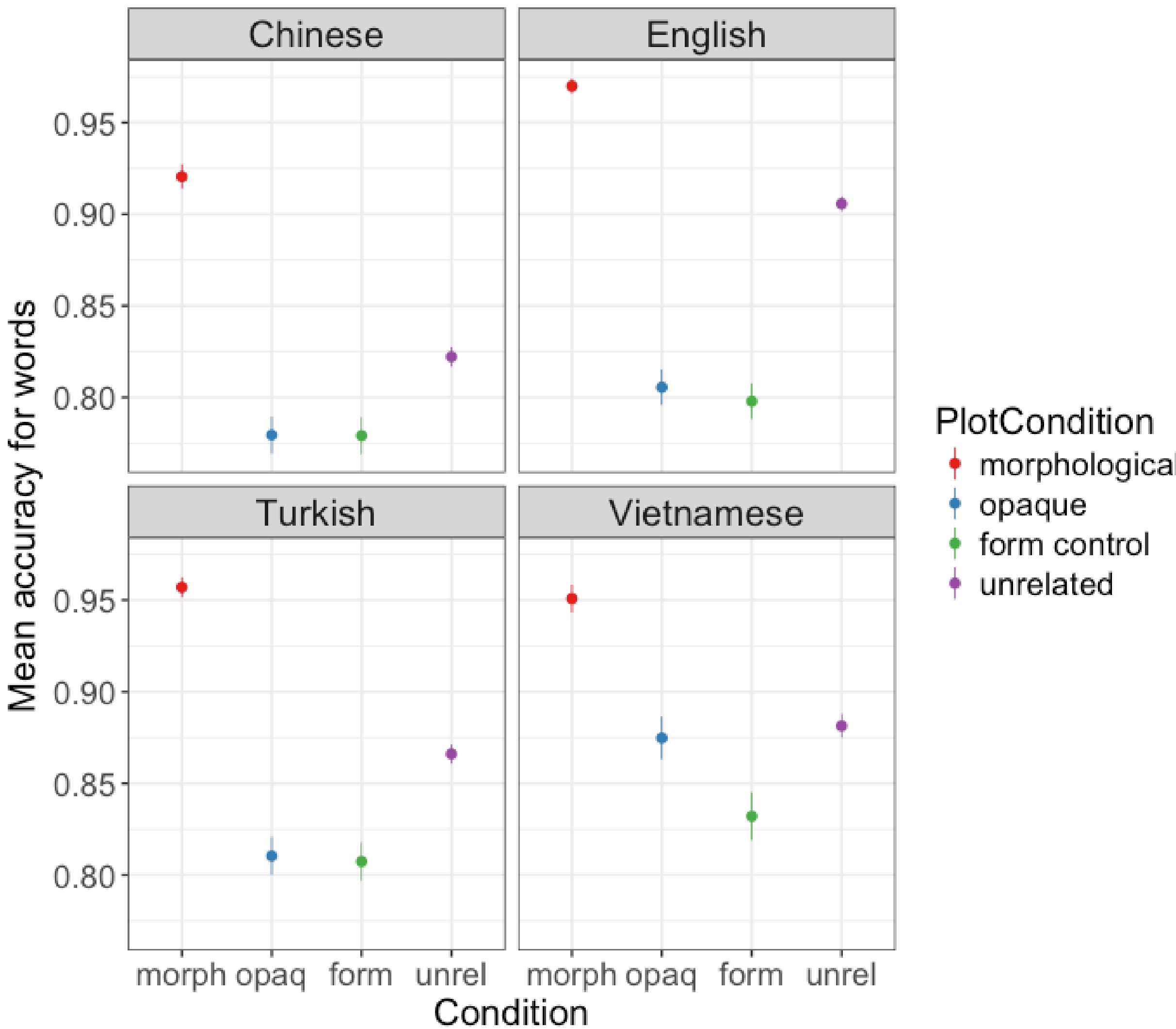

Figure 6. The mean accuracy in each condition for each language group for words. Error bars represent ± standard error.

6.2 MORPHOLOGICAL PROCESSING RESULTS IN THE ENGLISH GROUP FOR WORDS

6.2.1 Morphological processing results in the English group for words with regard to reaction time

Model summary results are presented in Tables 17-18 in Appendix D. As compared to the unrelated condition, native English speakers responded significantly faster in the morphological condition (t = -6.434, p < .001), marginally slower in the form control (i.e., orthographic overlap) condition (t = 1.926, p = .056), and significantly slower in the opaque condition (t = 2.207, p < .05). As compared to the opaque condition, native English participants did not respond faster or slower in the form condition (although there was a trend of the form condition being faster than the opaque condition as evidenced by the estimates), but did respond significantly faster in the morphological condition (t = -5.878, p < .001).

The effect of ZPrevLRT on LRT (t = 7.337, p < .001) was significant for native English speakers such that they were slower in their response if the previous response was slow than fast, and the effect of PrevACC on LRT (t = -3.153, p < .01) was significant such that they were faster if the previous response was correct than incorrect. The effect of ZTrialNum on LRT (t = -2.162, p < .05) was again significant meaning that they were faster the more into the experiment, showing a practice effect.

For native English speakers, LexTALE did not affect the reaction time in the unrelated condition, and LexTALE did not affect the priming effects of the form control, opaque, or morphological condition relative to the unrelated condition.

6.2.2 Morphological processing results in the English group for words with regard to accuracy

Model summary results are presented in Tables 19-20 in Appendix D. With regard to accuracy, as compared to the unrelated condition, native English speakers responded significantly more accurately in the morphological condition (t = 2.347, p < .05), and significantly less accurately in the form control (t = -6.809, p < .001) and opaque (t = -5.867, p < .001) conditions. As compared to the opaque condition, native English participants did not respond more or less accurately in the form condition (t = -1.123, p > .05) (although there was a trend of the form condition being less accurate than the opaque condition as evidenced by the estimates), but did respond significantly more accurately in the morphological condition (t = 5.193, p < .001).

The effect of ZPrevLRT on ACC (t = 2.946, p < .01) was significant for native English speakers such that the likelihood of participants' giving a correct response was higher if the previous response was slow than fast, and the effect of PrevACC on ACC (t = -3.654, p < .001) was significant such that the likelihood of participants' giving a correct response on a trial was lower if the previous response is correct than incorrect. The effect of TrialNum on ACC (t = -3.233, p < .01) was again significant meaning that there was a significant fatigue effect such that the more into the experiment, the less likely they would give a correct response.

For native English speakers, there was a significant effect of ZLexTALE on the ACC in the unrelated condition (t = 2.604, p < .01) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition. However, LexTALE did not affect the priming effects of the form control, opaque, or morphological condition relative to the unrelated condition.

6.2.3 Discussion: Morphological processing results in the English group for words

To summarize the English results, for both reaction time and accuracy, the native English group did not differ in the priming effects of the form control and opaque conditions. Therefore, the inhibitory priming effects found in both reaction time and accuracy in the form control and opaque conditions did not constitute evidence for an early stage of morpho-orthographic decomposition regardless of semantic information. Nevertheless, the inhibitory priming effects in the form control and opaque conditions did provide evidence for native English participants' sensitivity to orthography at this early stage.

The facilitatory priming effects in both reaction time and accuracy in the morphological as compared to opaque conditions showed involvement of morpho-semantic information during this early stage of processing.

6.3 MORPHOLOGICAL PROCESSING RESULTS IN THE TURKISH GROUP FOR WORDS

6.3.1 Morphological processing results in the Turkish group for words with regard to reaction time

Model summary results are presented in Tables 21-22 in Appendix D. With regard to reaction time, as compared to the unrelated condition, native Turkish speakers responded significantly faster in the morphological condition (t = -6.952, p < .001), but did not respond significantly faster or slower in the form control or opaque conditions, although there was a trend of inhibition in both the form and opaque conditions as evidenced by the estimates. As compared to the opaque condition, native Turkish participants did not respond faster or slower in the form condition (although there was a trend of the form condition being faster than the opaque condition as evidenced by the estimates), but did respond significantly faster in the morphological condition (t = -5.057, p < .001).

The effect of ZPrevLRT on LRT (t = 6.478, p < .001) and the effect of ZTrialNum on LRT (t = -2.932, p < .01) were both significant for native Turkish speakers. The effect of PrevACC on LRT (t = -1.207, p > .05) was not significant such that they were not affected by the correctness of the previous response.

For native Turkish speakers, LexTALE did not affect the reaction time in the unrelated condition, and LexTALE did not affect the priming effects of the form control, opaque, or morphological conditions relative to the unrelated condition.

6.3.2 Morphological processing results in the Turkish group for words with regard to accuracy

Model summary results are presented in Tables 23-24 in Appendix D. With regard to accuracy, as compared to the unrelated condition, native Turkish speakers responded significantly more accurately in the morphological condition (t = 3.540, p < .001), and significantly less accurately in the opaque condition (t = -2.014, p < .05), and did not respond significantly more or less accurately in the form condition (although there was a trend of the form condition being less accurate than the unrelated condition as evidenced by the estimates). As compared to the opaque condition, native Turkish participants did not respond more or less accurately in the form condition (although there is a trend of the form condition being more accurate than the opaque condition as evidenced by the estimates), but did respond significantly more accurately in the morphological condition (t = 4.295, p < .001).

The effect of ZPrevLRT on ACC (t = .508, p < .01) was not significant for native Turkish speakers such that the likelihood of participants' giving a correct response was not affected by the reaction time of the previous response. The effect of PrevACC on ACC (t = -1.696, p = .090) was marginally significant and the effect of TrialNum on ACC (t = -3.372, p < .001) was significant.

For native Turkish speakers, there was a significant effect of ZLexTALE on the ACC in the unrelated condition (t = 4.340, p < .001) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the form control, opaque, or morphological condition relative to the unrelated condition.

6.3.3 Discussion: Morphological processing results in the Turkish group for words

To summarize the Turkish results, for both reaction time and accuracy, the native Turkish group did not differ in the priming effects of the form control and opaque conditions. Therefore, similarly to the native English group, the trend of inhibitory priming effects found in both reaction time and accuracy in the form control or opaque conditions did not constitute evidence for an early stage of morpho-orthographic decomposition of such words, regardless of semantic information, in the Turkish group. Similarly to the native English group, the facilitatory priming effects in both reaction time and accuracy in the morphological as compared to opaque conditions showed involvement of morpho-semantic information during this early stage of processing.

6.4 MORPHOLOGICAL PROCESSING RESULTS IN THE CHINESE GROUP FOR WORDS

6.4.1 Morphological processing results in the Chinese group for words with regard to reaction time

Model summary results are presented in Tables 25-26 in Appendix D. As compared to the unrelated condition, native Chinese speakers responded significantly faster in the morphological condition ($t = -7.398$, $p < .001$), marginally faster in the form control (i.e., orthographic overlap) condition ($t = -1.918$, $p = .057$), and significantly faster in the opaque condition ($t = -3.960$, $p < .001$). As compared to the opaque condition, native Chinese participants responded marginally slower in the form condition ($t = 1.700$, $p = .090$), and responded marginally faster in the morphological condition ($t = -1.747$, $p = .082$).

The effect of ZPrevLRT on LRT ($t = 6.961$, $p < .001$) was significant, and the effect of PrevACC on LRT ($t = -1.897$, $p = .063$) and the effect of ZTrialNum on LRT ($t = -1.965$, $p = .055$) were both marginally significant.

For native Chinese speakers, there was a significant effect of ZLexTALE on the LRT in the unrelated condition ($t = -2.222$, $p < .05$) meaning that participants with higher LexTALE scores responded faster in the unrelated condition, but LexTALE did not affect the priming effects of the form control, opaque, or morphological conditions relative to the unrelated condition.

6.4.2 Morphological processing results in the Chinese group for words with regard to accuracy

Model summary results are presented in Tables 27-28 in Appendix D. As compared to the unrelated condition, native Chinese speakers responded significantly more accurately in the morphological condition (t = 3.683, p < .001), but did not respond significantly more or less accurately in the form control or opaque conditions (although there is a trend of the form condition being less accurate than the unrelated condition and the opaque being more accurate than the unrelated condition as evidenced by the estimates). As compared to the opaque condition, native Chinese participants did not respond more or less accurately in the form condition (although there was a trend of the form condition being less accurate than the opaque condition as evidenced by the estimates), but did respond significantly more accurately in the morphological condition (t = 2.816, p < .01).

The effect of ZPrevLRT on ACC (t = 1.258, p > .05) was not significant for native Chinese speakers such that the likelihood of participants' giving a correct response was not affected by the reaction time of the previous response. The effect of PrevACC on ACC (t = -4.493, p < .001) and the effect of TrialNum on ACC (t = -5.123, p < .001) were significant.

For native Chinese speakers, there was a significant effect of ZLexTALE on the ACC in the unrelated condition (t = 3.026, p < .01) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the form control or opaque conditions relative to the unrelated condition. There was a marginal interaction between morph and ZLexTALE (t = 1.676, p = .094), meaning that the higher the LexTALE score, the marginally larger the facilitatory effect of the morphological condition relative to the unrelated condition.

6.4.3 Discussion: Morphological processing results in the Chinese group for words

To summarize the Chinese results, with regard to reaction time, the Chinese group differed in the priming effects of the form control and opaque conditions. They were marginally more facilitated in the opaque than in the form control condition, and again marginally more facilitated in the morphological than opaque condition. Therefore, the marginally larger facilitatory priming effects found in reaction time in the opaque relative to the form control and the marginally larger facilitatory priming effects found in reaction time in the morphological relative to opaque conditions constitute evidence for an early stage of involvement of both morpho-orthographic decomposition and morpho-semantic information. The Chinese participants were found to be able to decompose based solely on the morpho-orthographic information, and they were also sensitive to the morpho-semantic information at this early stage. Moreover, the marginal facilitatory priming effect in the form control condition with regard to reaction time suggested that the Chinese group were also reliant on pure orthographic information at this stage.

6.5 MORPHOLOGICAL PROCESSING RESULTS IN THE VIETNAMESE GROUP FOR WORDS

6.5.1 Morphological processing results in the Vietnamese group for words with regard to reaction time

Model summary results are presented in Tables 29-30 in Appendix D. As compared to the unrelated condition, native Vietnamese speakers responded significantly faster in the morphological condition ($t = -6.399$, $p < .001$), but did not respond significantly faster or slower in the form control or opaque conditions (although there was a trend of facilitation in both the form and opaque conditions). As compared to the opaque condition, native Vietnamese participants did not respond faster or slower in the form condition (although there was a trend of the form condition being slower than the opaque condition as evidenced by the estimates), but did respond significantly faster in the morphological condition ($t = -2.865$, $p < .01$).

The effect of ZPrevLRT on LRT ($t = 9.363$, $p < .001$) and the effect of ZTrialNum on LRT ($t = -3.928$, $p < .05$) were both significant for native Vietnamese speakers. The effect of PrevACC on LRT ($t = -1.644$, $p > .05$) was not significant such that they were not affected by the correctness of the previous response.

For native Vietnamese speakers, LexTALE did not affect the reaction time in the unrelated condition, and also did not affect the priming effects of the form control, opaque, or morphological conditions relative to the unrelated condition.

6.5.2 Morphological processing results in the Vietnamese group for words with regard to accuracy

Model summary results are presented in Tables 31-32 in Appendix D. With regard to accuracy, as compared to the unrelated condition, native Vietnamese speakers responded significantly more accurately in the morphological condition ($t = 2.821$, $p < .01$), significantly less accurately in the form condition ($t = -2.193$, $p < .05$), but did not respond significantly more or less accurately in the opaque conditions (although there was a trend of the opaque being more accurate than the unrelated as evidenced by the estimates). As compared to the opaque condition, native Vietnamese participants responded significantly less accurately in the form condition ($t =

-2.599, $p < .01$), and responded marginally more accurately in the morphological condition (t = 1.919, $p = .055$).

The effect of ZPrevLRT on ACC was not significant for native Vietnamese speakers such that the likelihood of participants' giving a correct response was not affected by the reaction time of the previous response. The effect of PrevACC on ACC (t = -2.159, $p < .05$) and the effect of TrialNum on ACC (t = -2.230, $p < .05$) were both significant.

For native Vietnamese speakers, there was a significant effect of ZLexTALE on the ACC in the unrelated condition (t = 3.974, $p < .001$) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the form control, opaque, or morphological condition relative to the unrelated condition.

6.5.3 Discussion: Morphological processing results in the Vietnamese group for words

To summarize the Vietnamese results, with regard to reaction time, the Vietnamese group showed only trends of facilitation in the form control and opaque conditions, which was to a certain extent similar to the Chinese group in terms of processing patterns. With regard to accuracy, the Vietnamese group responded significantly less accurately in the form condition, similarly to the native English group. Therefore, they showed effects of orthography in the form control condition alone, like the English group. With regard to accuracy, both Vietnamese and English groups showed inhibitory orthographic priming effects, whereas the Chinese group showed facilitatory priming effects with regard to reaction time. Therefore, the differential orthographic priming effects in the Chinese versus the Vietnamese group suggest L1 influence based on orthography and writing systems, since Vietnamese is, like English, based on an alphabetic writing system with a Latin script, whereas Chinese is logographic. Moreover, they responded less accurately in the form relative to the opaque condition, showing effects of morpho-orthographic decomposition in this early stage, similarly to the Chinese group, and responded marginally more accurately in the morphological relative to the opaque condition, showing involvement of morpho-semantic information.

6.6 MORPHOLOGICAL PROCESSING RESULTS: COMPARING THE LANGUAGE GROUPS

I also combined all language groups to examine the interaction between Condition and L1 on both reaction time and accuracy. The fixed effects in combined model for both reaction time and accuracy for words included Condition, L1, the interaction between Condition and L1, ZLexTALE (centered on all language groups), as well as ZPrevLRT, PrevACC, and ZTrialNum and the covariates of Ortho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N (the other three were removed by findLinearCombos() in the caret package in R in order to avoid multicollinearity causing fixed-effect model matrix to be rank deficient). Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in combined model for both reaction time and accuracy included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were also run with opaque being the reference. Model summary results for reaction time are presented in Tables 33-36 in Appendix D. Model summary results for accuracy are presented in Tables 37-40 in Appendix D.

The statistical analyses including L1 and the interaction between Condition and L1 confirmed and validated the statistical results on each language group.

To summarize the results comparing the language groups in terms of both reaction time and accuracy, the significant priming effects in the morphological condition across all groups regarding both reaction time and accuracy constitute as evidence that all language groups in the current study were sensitive to the primes being presented very briefly in the masked priming procedure. The differential priming effects in the form control condition provided evidence for the differential extent of reliance on orthographic and/or semantic information in different groups during the early stage (50ms) of visual word recognition, and also differences among the language groups with regard to automaticity of lexical access. The finding of Chinese participants' differential behavioral patterns in the opaque versus form control conditions suggested early morpho-orthographic decomposition in the Chinese group. The finding that English or Turkish participants' processing patterns for word targets did not differ in the opaque versus form control conditions failed to provide evidence for early morpho-orthographic decomposition in English or Turkish, but such findings did not rule out the involvement of early morpho-orthographic decomposition in English or Turkish either.

The results in the lexical decision task for word targets directly inform the research question of morphological processing. As mentioned in Jacob and Kırkıcı (2016), the key question in masked priming paradigm studies is "not whether participants can ultimately recognize the word successfully, but which types of information contained in the word are in focus at the particular early stages of word recognition addressed by this method" (p. 235). Therefore, in the interpretation of results, more weight should be given to reaction time than to accuracy. An important logic for the evidence for morphological decomposition is to show that the priming effects of the morphologically related words could not be attributed to solely orthographic or semantic similarities between the prime and the target, as studies in Arabic and other languages have shown (Boudelaa & Marslen-Wilson, 2005). Overall, the Turkish and the Vietnamese groups patterned similarly, whereas the Chinese and the Vietnamese groups patterned together. Therefore, with regard to the research question whether there is an L1 influence on on-line L2 morphological processing, the results confirmed the initial hypotheses. Specifically, Turkish learners of L2 English, from a morphologically rich L1, showed similar processing patterns as the English group. Chinese and Vietnamese learners of L2 English, from morphologically isolating L1s, behaved differently from the English and the Turkish groups.

6.7 MODELS AND RESULTS FOR WORD TARGETS ON EFFECTS OF SEX ON MORPHOLOGICAL PROCESSING RESULTS IN THE COMBINED AS WELL AS EACH LANGUAGE GROUP

Because of the differential female/male ratios across language groups, which could be contributing to cross-language differences in priming patterns, I analyzed the effect of sex on morphological processing in the combined data as well as in each language group.

Linear mixed analyses were conducted on the combined data of all language groups and also separately on each language group to analyze the effect of Sex, in order to examine whether there were sex differences in participants' on-line morphological processing patterns. Sex was dummy coded with two conditions, Female and Male. Analyses were conducted with the reference condition being Female and then Male in order to examine the effects of Condition in each Sex.

6.7.1 Models and results for word targets on effects of Sex on morphological processing results in the combined as well as each language group with regard to reaction time

The fixed effects in all reaction time models included Condition, Sex, the interaction between Condition and Sex, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the reaction time model for the combined, as well as the separate data (English, Chinese, and Vietnamese) included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in the reaction time model for Turkish and Vietnamese included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were run with Male as the reference group, except for Chinese, for which the random effects in the reaction time model included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. In terms of LRT, for the combined data, there was a marginally significant interaction between Condition and Sex ($F(3, 214.6) = 2.325$, $Pr(>F) = .076$). There was no interaction between Condition and Sex for the English ($F(3, 96.7) = 1.985$, $Pr(>F) > .05$), Turkish ($F(3, 45.4) = .200$, $Pr(>F) > .05$), or Vietnamese ($F(3, 35.7) = .669$, $Pr(>F) > .05$) groups. For Chinese, there was a marginal interaction between Condition and Sex ($F(3, 116.9) = 2.489$, $Pr(>F) = .064$).

For the combined data with regard to reaction time (see Table 41 in Appendix D), the priming effects of the form control or morphological conditions relative to the unrelated condition were not affected by Sex. There was, however, a significant interaction between opaque and Sex ($t = 2.321$, $p < .05$), meaning that compared to the females who showed significant facilitation in the opaque condition relative to the unrelated condition ($t = -3.016$, $p < .01$), males showed no facilitation or inhibition ($t = .024$, $p > .05$).

Figure 7-10 shows the mean LRT (log ms) in each condition for each Sex for English, Turkish, Chinese, and Vietnamese, respectively.

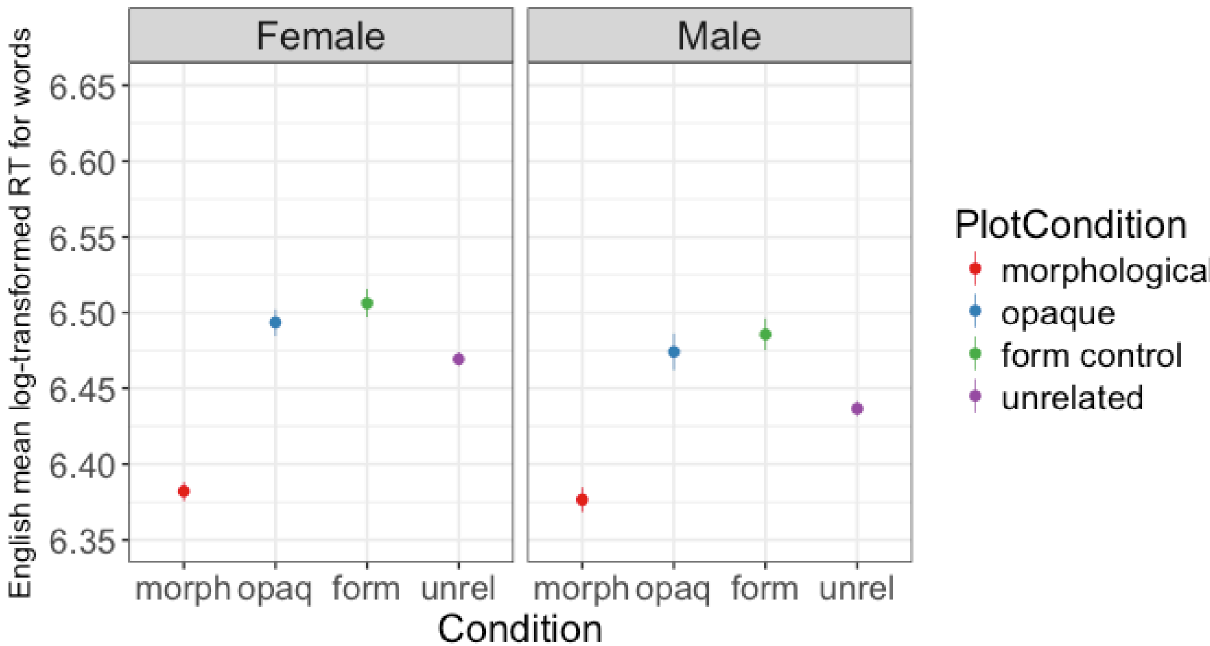

Figure 7. The mean LRT for the English group in each condition for each Sex. Error bars represent ± standard error.

For the native English group with regard to reaction time (see Tables 42-43 in Appendix D), the priming effects of the form control or opaque conditions relative to the unrelated condition were not affected by Sex. There was, however, a significant interaction between morph and Sex ($t = 2.249$, $p < .05$), meaning that compared to the females who showed significant facilitation in the morphological condition relative to the unrelated condition, males showed facilitation to a significantly smaller extent in the morphological relative to the unrelated condition. For females, the form control and opaque conditions were not significantly slower than the unrelated condition (although there was a trend of the form control and opaque conditions being slower than the unrelated condition as evidenced by the estimates). For males, the form control and opaque conditions were significantly slower than the unrelated condition.

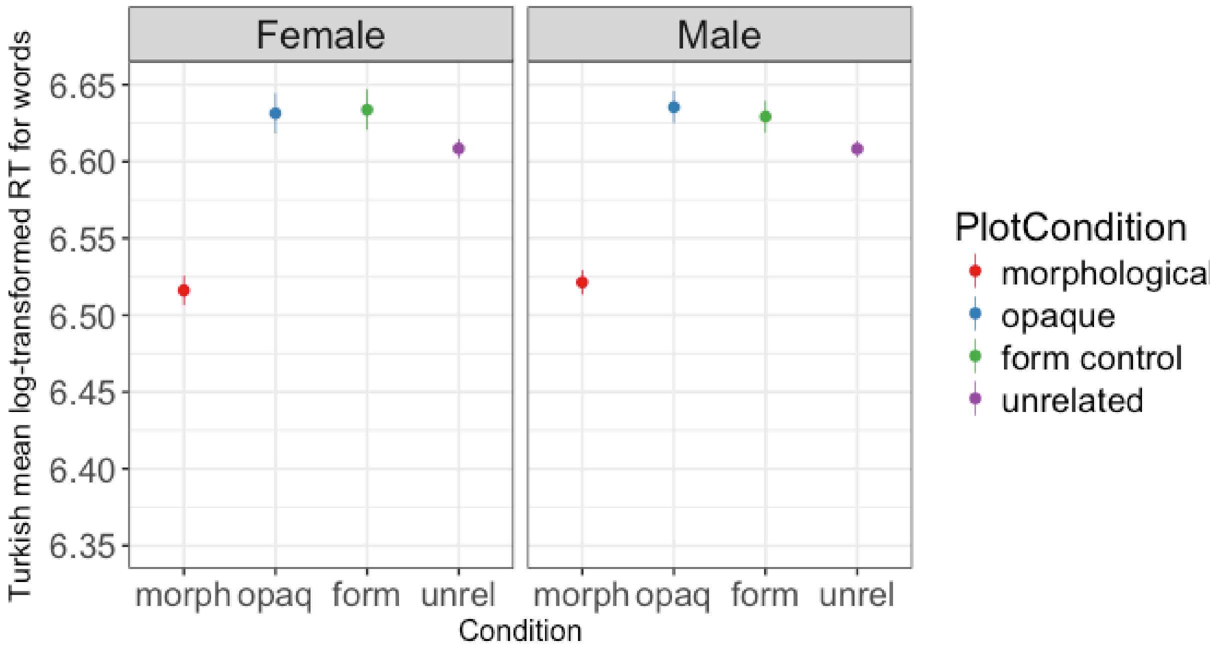

Figure 8. The mean LRT for Turkish in each condition for each Sex. Error bars represent ± standard error.

For the native Turkish group with regard to reaction time (see Tables 44-45 in Appendix D), the priming effects of the form control or opaque or morphological conditions relative to the unrelated condition were not affected by Sex. Both the female and male groups showed no significant difference between the form control and the unrelated condition or between the opaque condition and the unrelated condition.

The overall pattern of processing for the Turkish group (N = 42), i.e., with regard to reaction time, only trends of inhibition for the form control and opaque conditions for both females and males, was similar to the native English females (N = 29) who showed only trends of inhibition for the form control and opaque conditions as well, but not to native English males (N = 21) who showed significant inhibition for both the form control and opaque conditions.

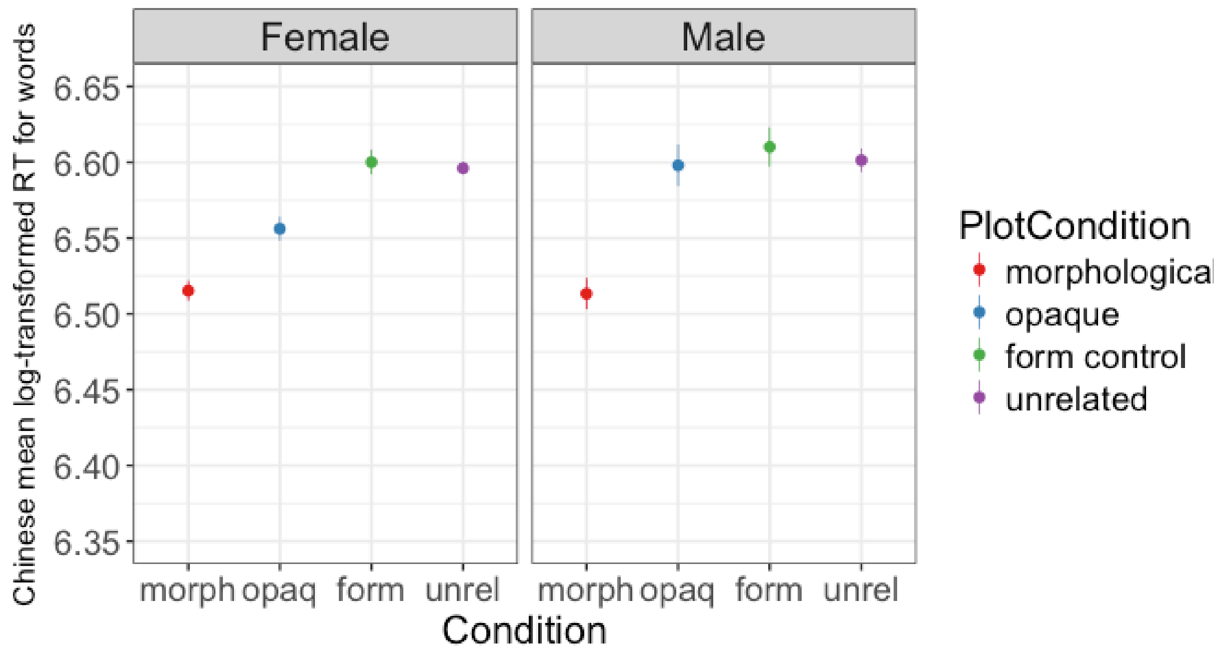

Figure 9. The mean LRT for Chinese in each condition for each Sex. Error bars represent ± standard error.

For the native Chinese group with regard to reaction time (see Tables 46-47 in Appendix D), the priming effects of the form control or morphological conditions relative to the unrelated condition were not affected by Sex. There was, however, a significant interaction between opaque and Sex (t = 2.373, p < .05), meaning that compared to the females who showed significant facilitation in the opaque condition relative to the unrelated condition (t = -4.681, p < .001), males showed facilitation to a significantly smaller extent in the opaque relative to the unrelated condition (t = -.259, p > .05). For females (N = 37), the form control and opaque conditions were significantly faster than the unrelated condition. For males (N=13), the form control and opaque conditions were not significantly faster than the unrelated condition (although there was a trend of the form control and opaque conditions being faster than the unrelated condition as evidenced by the estimates). However, the non-significances for males in the form and opaque conditions could be due to a lack in sample size (cf. 37 females versus 13 males).

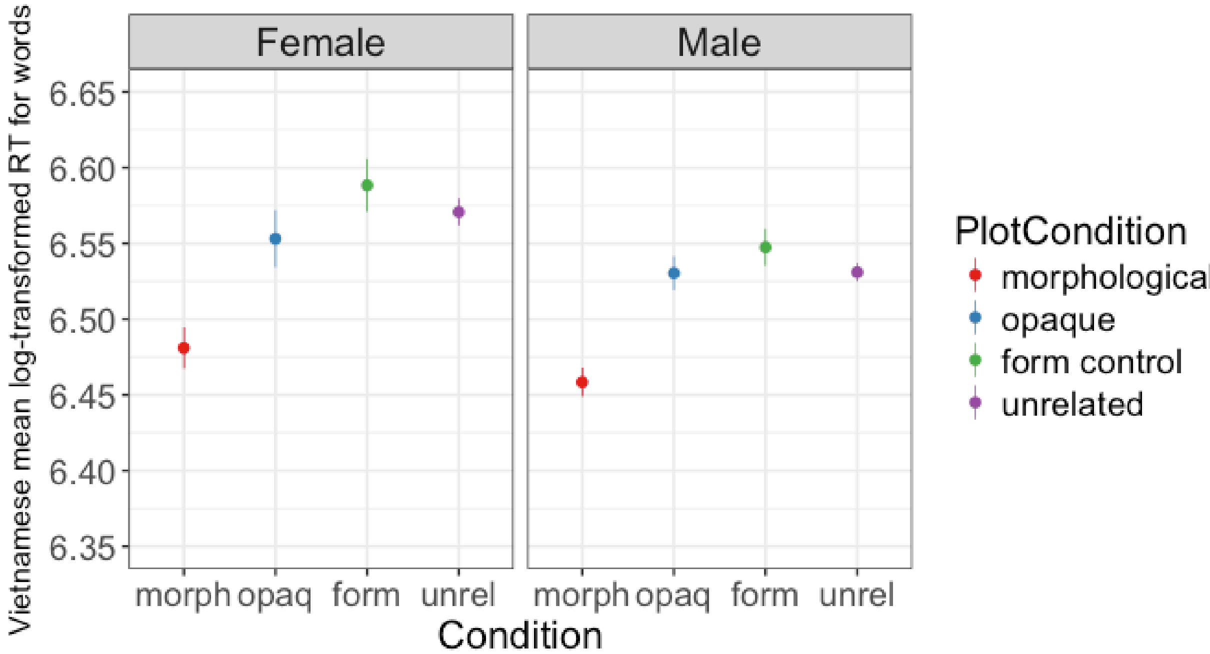

Figure 10. The mean LRT for Vietnamese in each condition for each Sex. Error bars represent ± standard error.

For the native Vietnamese group with regard to reaction time (see Tables 48-49 in Appendix D), the priming effects of the form control or opaque or morphological condition relative to the unrelated condition were not affected by Sex. For both females and males, there were no priming effects of form or opaque conditions relative to the unrelated condition.

6.7.2 Models and results for word targets on effects of Sex on morphological processing results in the combined as well as each language group with regard to accuracy

The fixed effects in all accuracy models included Condition, Sex, the interaction between Condition and Sex, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the accuracy model for the combined data, as well as for each language group (English, Turkish, Chinese, and Vietnamese) included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were run with Male as the reference group.

For the combined data with regard to accuracy (see Table 50 in Appendix D), the priming effects of the form control, opaque, or morphological conditions relative to the unrelated condition were not affected by Sex.

Figure 11-14 show the mean ACC (on a scale of 0-1) in each condition for each Sex for English, Turkish, Chinese, and Vietnamese, respectively.

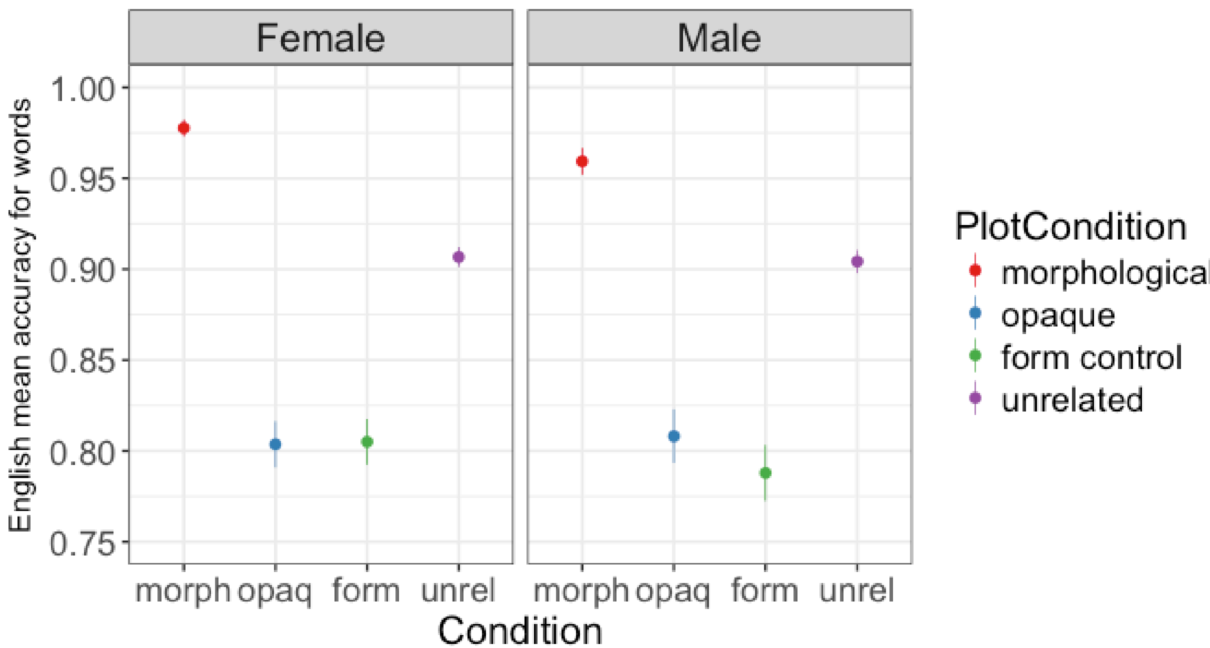

Figure 11. The mean accuracy for the English group in each condition for each Sex. Error bars represent ± standard error.

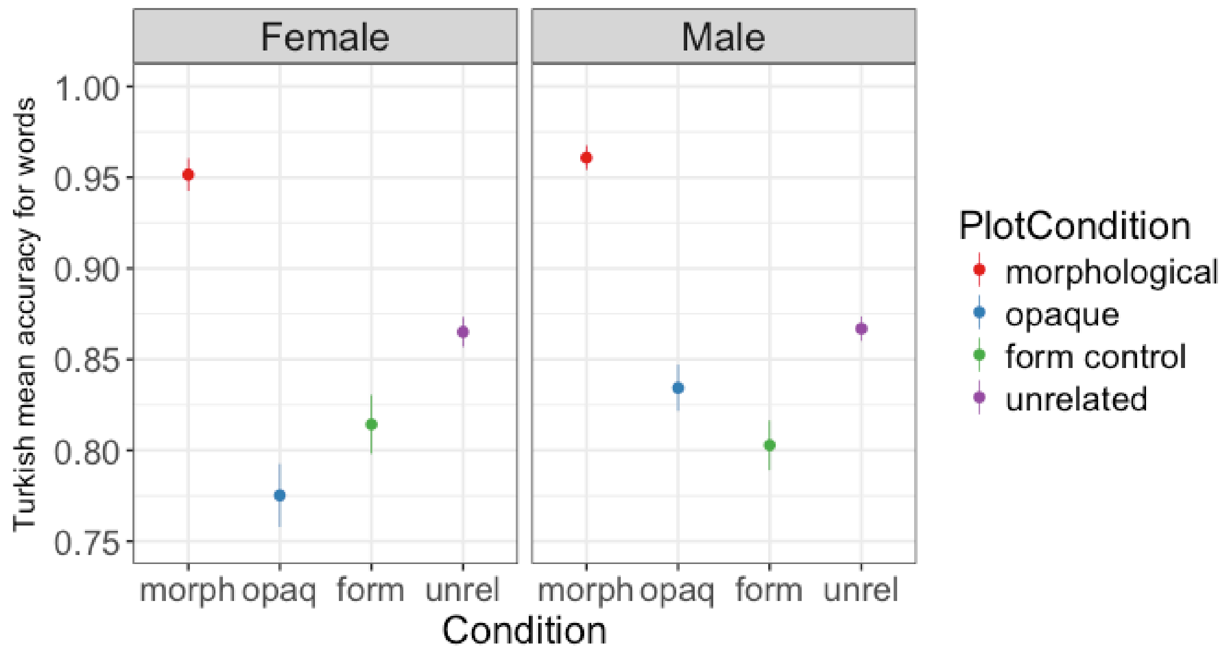

Figure 12. The mean accuracy for Turkish in each condition for each Sex. Error bars represent ± standard error.

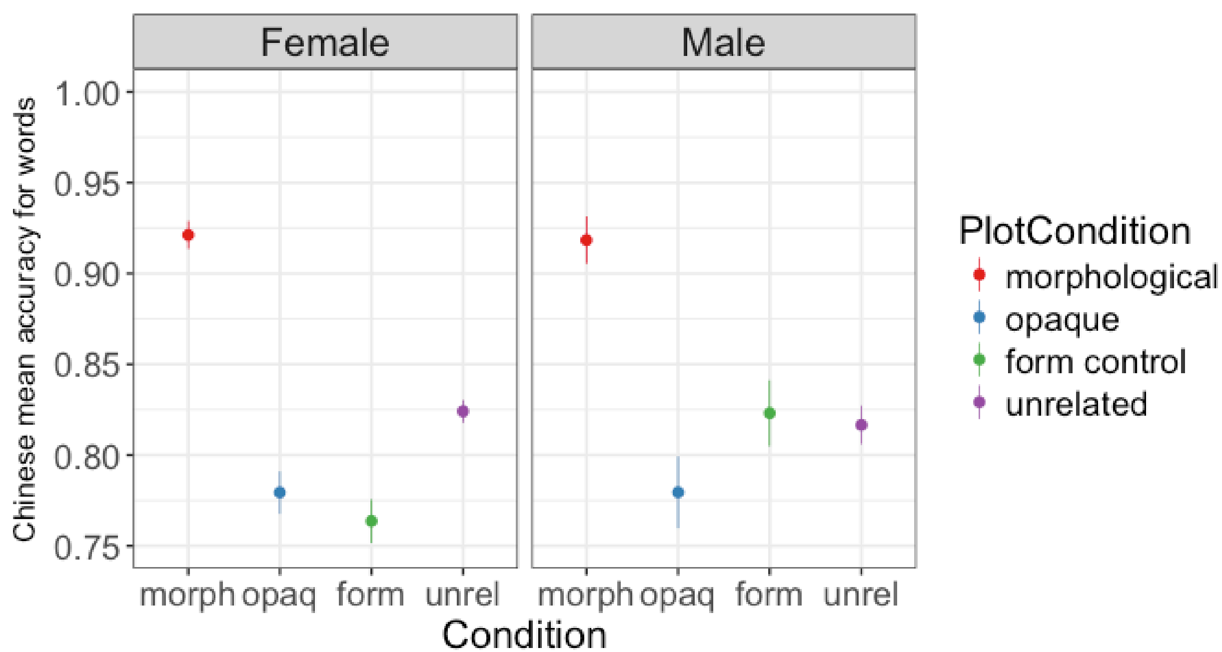

Figure 13. The mean accuracy for Chinese in each condition for each Sex. Error bars represent ± standard error.

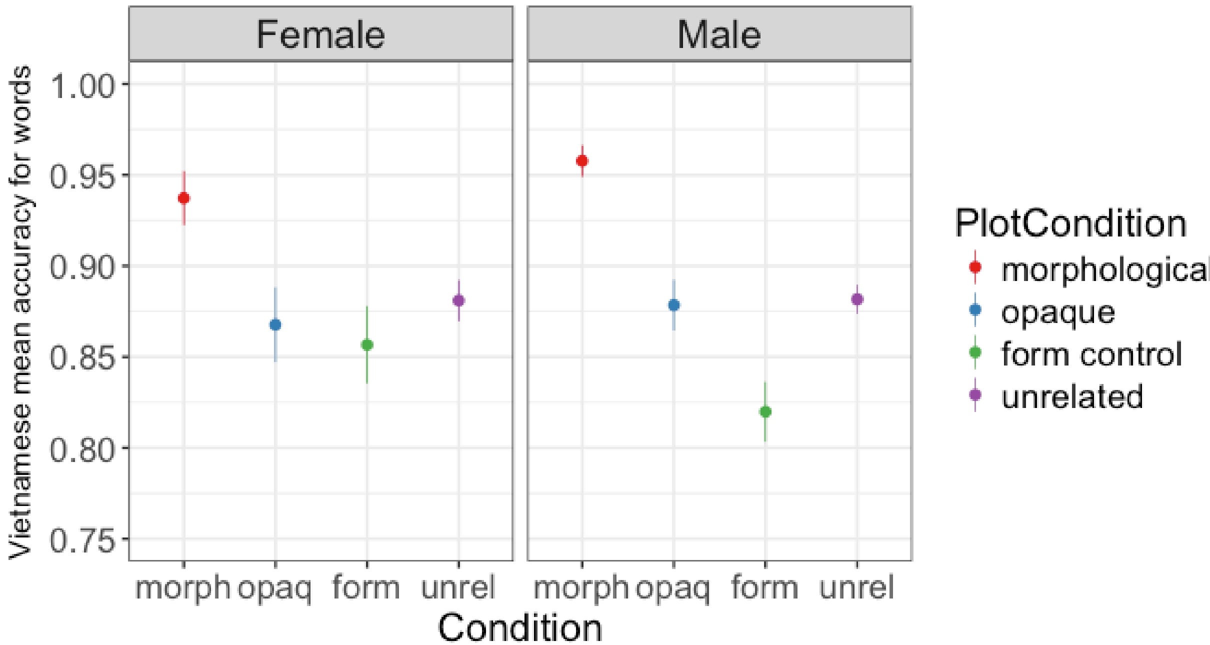

Figure 14. The mean accuracy for Vietnamese in each condition for each Sex. Error bars represent ± standard error.

For the native English group with regard to accuracy (see Tables 51-52 in Appendix D), the priming effects of the form control or opaque condition relative to the unrelated condition were not affected by Sex. There was, however, a significant interaction between morph and Sex (t = -2.007, p < .05), meaning that compared to the females who showed significant facilitation in the morphological condition relative to the unrelated condition (t = 2.844, p < .01), males showed facilitation to a significantly smaller extent in the morphological relative to the unrelated condition (the effect of morph for males actually turned out to be not significant) (t = .539, p > .05).

For the native Turkish group with regard to accuracy (see Tables 53-54 in Appendix D), the priming effects of the form control or morphological condition relative to the unrelated condition were not affected by Sex. There was, however, a significant interaction between opaque and Sex (t = 2.129, p < .05), meaning that compared to the females who showed significant inhibition in the opaque condition relative to the unrelated condition (t = -2.992, p < .01), males showed only a trend of the opaque conditions being less accurate relative to the unrelated condition (the effect of opaque for males actually turned out to be not significant) (t = -.428, p > .05).

For both the native Chinese and the native Vietnamese groups (see Tables 55-56 and Tables 57-58, respectively, in Appendix D) with regard to accuracy, the priming effects of the form control or opaque or morphological conditions relative to the unrelated condition were not affected by Sex.

6.7.3 Discussion: Effects of Sex on morphological processing results for word targets

Overall, with regard to reaction time, females and males significantly differ in the opaque priming effects, such that compared to the females who showed significant facilitation, males showed no facilitation or inhibition. For English, with regard to both reaction time and accuracy, females and males differ significantly in the morphological priming effects such that males showed facilitation to a significantly smaller extent. For Turkish, with regard to accuracy, females and males differ significantly in the opaque priming effects such that females showed larger inhibition. For Chinese, with regard to reaction time, females and males significantly differ in the opaque priming effects, such that compared to the females who showed significant facilitation, males showed facilitation to a significantly smaller extent.

Therefore, generally speaking, females tend to show larger facilitation in the morphological condition but males show larger inhibition in the opaque condition. The sex difference in on-line morphological processing, which has not been explored in the previous literature but attested in the current study, is quite surprising. There is no *prima facie* reason why biological sex should give one sex an advantage over the other, unless there is some sex-based advantage in perceptual ability that the masked priming task taps into.

In order to explore possible sources of these sex differences, we consulted the literature on sex differences in cognitive abilities, which is extensive. Females tend to have perform better than males in verbal fluency, perceptual speed, fine motor skills, memory object location, and arithmetical calculation, and males better than females in mathematics, spatial ability, throwing accuracy, and mechanical reasoning (Kimura, 1999; Payne & Lynn, 2011). Although with conflicting results across studies, females tend to have an advantage on reading ability and comprehension, rate of language development, spelling, and reasoning, and males tend to perform better on verbal analogies, vocabulary, and adult literacy (Boyle, 1987; Ellis et al., 2008; Payne & Lynn, 2011). The literature on sex differences in L1 or L2 learning has suggested females have a stronger module for second language processing than do males after controlling for other factors, e.g., in second language reading comprehension (Payne & Lynn, 2011), and boys to be more impeded by low socio-economic status (SES) than girls (Barbu et al., 2015). In terms of visual acuity, Ishigaki and Miyao (1994) found male superiority than females at most ages in their dynamic visual acuity, but with substantial variability. In terms of field dependence/independence (FD/I), females tend to be field dependent and males independent (Hoffman, 1997). Field independent (FI) people are analytic, confident, and self-reliant, and have higher ability to dis-embed or restructure visual stimuli (cognitive restructuring) and field dependent people are holistic, uncertain, and depend upon others (Chapelle & Green, 1992).

In term of language areas, female and males also differ in the lateralization of language functions with females being more strongly lateralized to the left hemisphere, and females and males also differ in the roles of both anterior and posterior language areas (Kansaku, Yamaura,

& Kitazawa, 2000). Wallentin (2009), on the other hand, reviewed a diverse field of methods for investigating sex differences in language processing and argued against consistent differences between males and females in language proficiency, language lateralization, or language functions in Wada tests, aphasia, and in normal aging. Similarly, the meta-analysis of 165 studies on sex differences in verbal ability by Hyde and Linn (1988) led to (1) their conclusion of no sex differences in different measures of verbal ability such as vocabulary, analogies, reading comprehension, speech production, essay writing, anagrams, and tests of general verbal ability, and moreover, (2) an observation of a slight decline in the magnitude of the gender differences comparing studies published before or after 1973.

If we assume a sex difference in visual acuity and perceptual ability such that males are better at automatic processing of orthography thus relying less on morpho-orthographic decomposition, the smaller morphological priming effects in males as compared to females can thus be explained. Similarly, greater and more automatic orthographic processing of the whole word of opaque primes will thus elicit greater lexical competition with the target, generating greater inhibition in the opaque condition for males than for females.

Sex differences in terms of morphology has never been explored except a study by Hartshorne and Ullman (2006) that examined the overgeneralization rates of 10 girls and 15 boys from the CHILDES database (MacWhinney, 2000). They found girls to overgeneralize strikingly and reliably far more than boys, contrary to their prediction of girls depending more on declarative memory and remembering irregular past-tense forms better than boys, based on previous findings of women and girls being better at verbal memory tasks (Halpern, 2000; Kimura, 1999). Their analyses showed correlation of overgeneralization rates with measures of phonological neighbor size in girls but not boys. Girls tend to produce overgeneralizations based on stored neighboring regulars in associative lexical memory whereas boys are more likely to depend on rule-governed suffixation. The finding that women and girls being better at storage and men and boys being better at rule applications is insufficient to explain the current results of females being more positively primed in the morphological condition. Nevertheless, if we assume males to be better at rule application and morpho-orthographic decomposition during on-line processing, it can, to a certain extent, explain why males being more negatively primed in the opaque condition, since they may have more resources to attend to semantic mismatch.

The current study corroborates the implications of Hartshorne and Ullman (2006) on sex being an important factor on the neuro-cognition of language. As Hartshorne and Ullman (2006) pointed out, sex has been virtually ignored in the literature of language learning, representation, processing and neuro-cognition, and thus calls for future research.

7.0 LEXICAL DECISION RESULTS FOR NON-WORDS AND L1 EFFECTS

The fixed effects in all reaction time models for non-words included Condition, ZLexTALE, the interaction between Condition and ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and ZPrimeOrtho_N, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the reaction time models for Turkish and Vietnamese included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in the reaction time models for English and Chinese included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were run with suffix being the reference condition, except for Turkish, for which the model's random effects included only the random intercepts for participants and targets due to model convergence issues, and for Chinese, for which the model's random effects included only the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets.

Figure 15 shows the mean LRT (log ms) in each condition for each language group for non-words.

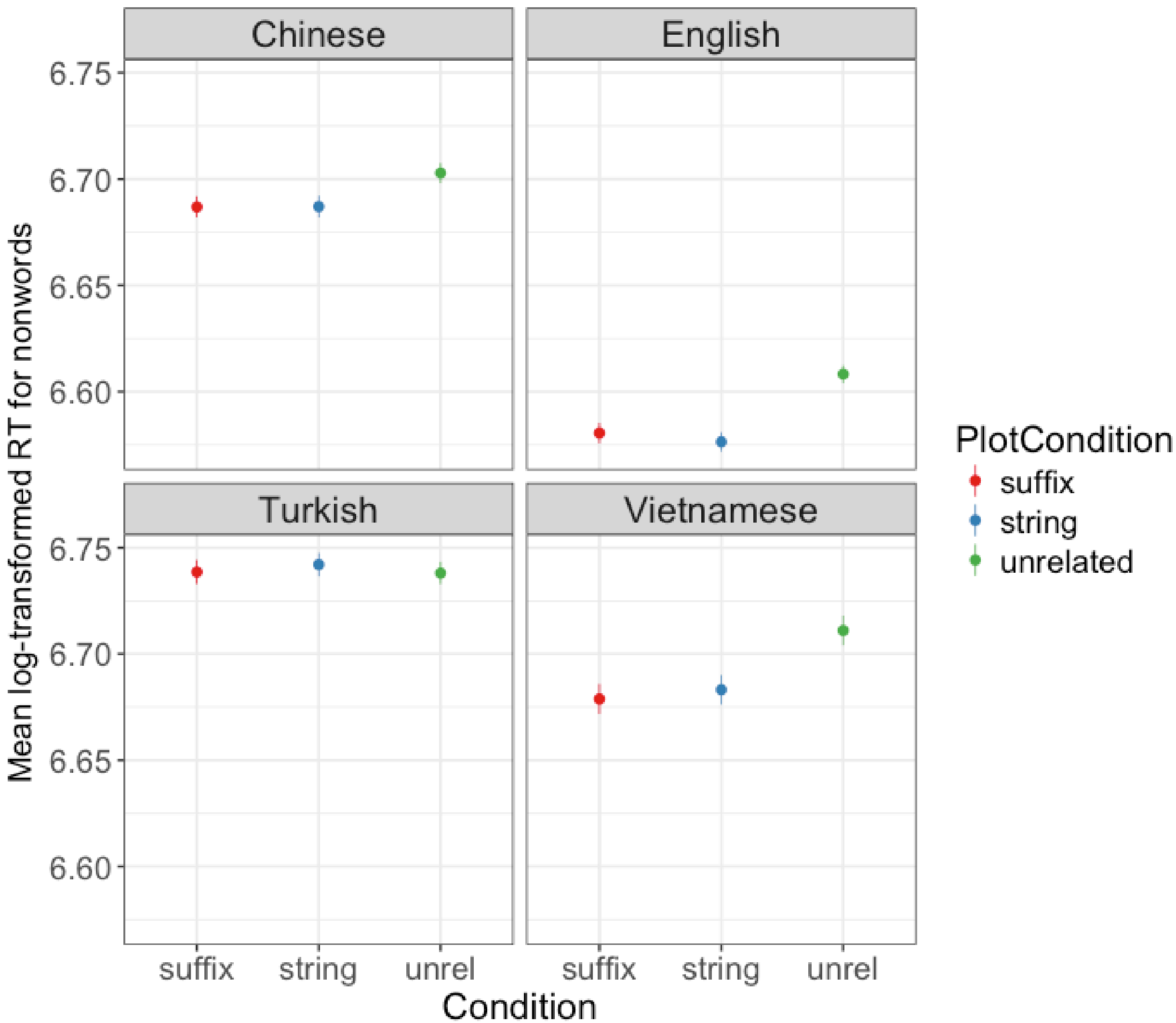

Figure 15. The mean log-transformed reaction times in each condition for each language group for non-words. Error bars represent ± standard error. The conditions were suffix (e.g., blemish-blem), string (e.g., smudge-smud), and unrelated.

The fixed effects in all accuracy models for non-words included Condition, ZLexTALE, the interaction between Condition and ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the accuracy model for all language groups (English, Turkish, Chinese, and Vietnamese) included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The same models were run with the suffix condition being the reference condition. Figure 16 shows the mean accuracy (on a scale of 0-1) in each condition for each language group for non-words.

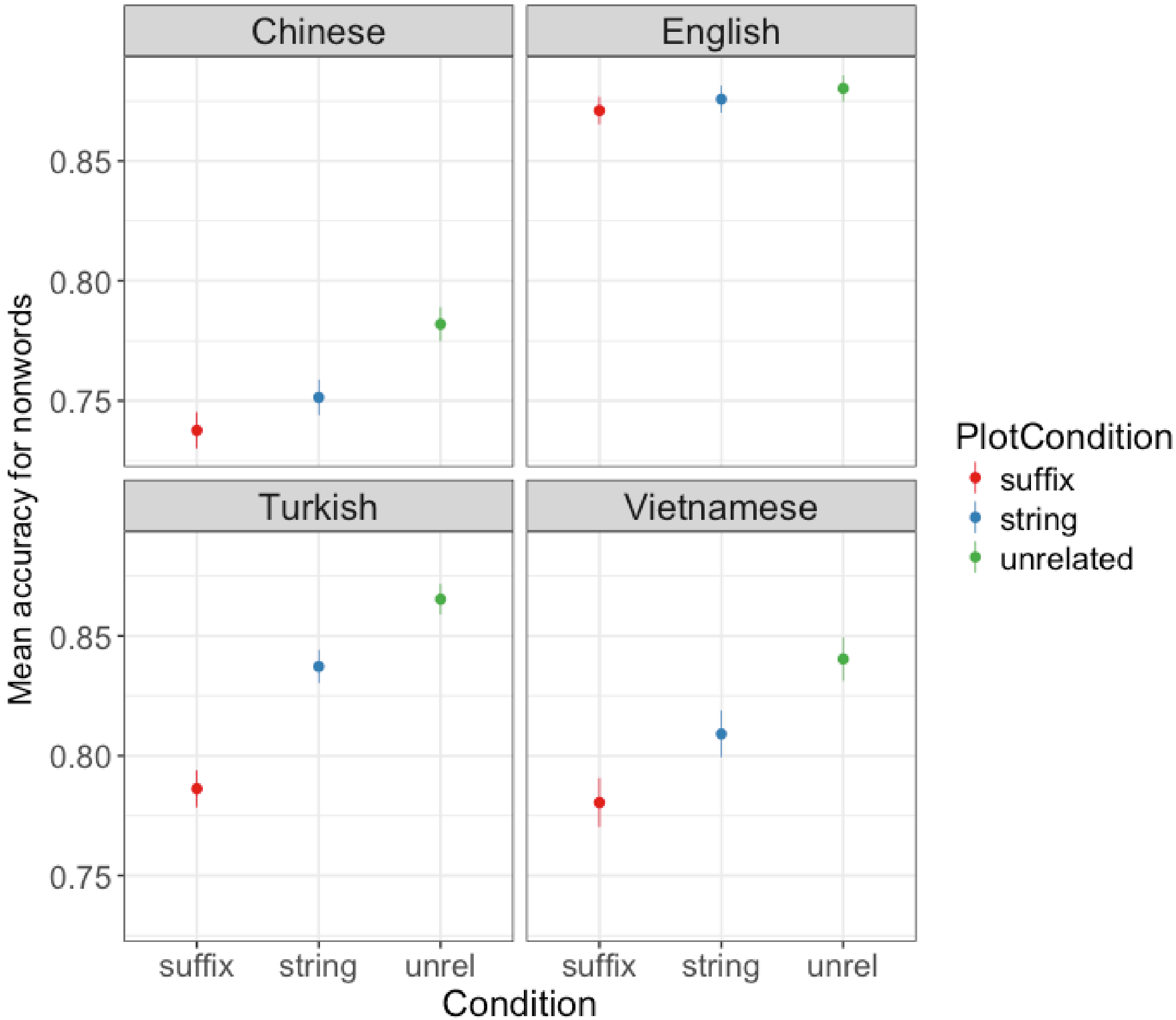

Figure 16. The mean accuracy in each condition for each language group for non-words. Error bars represent ± standard error.

7.1 LEXICAL DECISION RESULTS FOR NON-WORDS FOR THE ENGLISH GROUP

7.1.1 Lexical decision results for non-words for the English group with regard to reaction time

Model summary results are presented in Tables 59-60 in Appendix D. For non-words, as compared to the unrelated condition, native English speakers responded significantly faster in the string condition (t = -2.065, p < .05), and marginally faster in the suffix condition (t = -1.946, p = .053). As compared to the suffix condition, native English participants did not respond faster or slower in the string condition (although there was a trend of the string condition being faster than the suffix condition as evidenced by the estimates). The effect of ZPrevLRT on LRT (t = 10.705, p < .001), the effect of PrevACC on LRT (t = -7.540, p < .001), and the effect of ZTrialNum on LRT (t = -5.762, p < .001) were all significant. LexTALE did not affect the reaction time in the unrelated condition, and did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.1.2 Lexical decision results for non-words for the English group with regard to accuracy

Model summary results are presented in Tables 61-62 in Appendix D. For non-words with regard to accuracy, as compared to the unrelated condition, native English speakers did not respond significantly more or less accurately in the string or suffix conditions. As compared to the suffix condition, native English participants did not respond more or less accurately in the string condition. The effect of ZPrevLRT on ACC ($t = 2.648$, $p < .01$) was significant, but the effect of PrevACC on ACC ($t = 1.066$, $p > .05$) and he effect of TrialNum on ACC ($t = -.866$, $p > .05$) were not significant.

For non-words, for native English speakers, there was a significant effect of ZLexTALE on the ACC in the unrelated condition ($t = 2.814$, $p < .01$) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.1.3 Discussion: Lexical decision results for non-words for the English group

To summarize the English results for non-words, with regard to reaction time, the native English group did not differ in the priming effects of the string and suffix conditions. Interestingly, for the native English group, while inhibitory effects were found in both reaction time and accuracy in the form control and opaque conditions for word targets, facilitatory effects were found in the reaction time in the string and suffix conditions for non-words. The facilitatory priming effects found in the string and suffix conditions for non-words did not constitute evidence for an early stage of decomposition without reference to, or independent of, semantic information. Nevertheless, the facilitatory priming effects in the string and suffix conditions did provide evidence for native English participants' sensitivity to orthography at this early stage.

The facilitatory effects in the string and suffix conditions for non-words combined with the inhibitory effects in the form control and opaque conditions for word targets suggest lexical competition in the form control and opaque conditions for word targets for the English group. The inhibitory effects in the form control and opaque conditions for word targets were due to a combination of facilitatory effects due purely to orthographic overlap, and inhibitory effects due to lexical competition, especially in the lexical semantic level.

7.2 LEXICAL DECISION RESULTS FOR NON-WORDS FOR TURKISH

7.2.1 Lexical decision results for non-words for Turkish with regard to reaction time

Model summary results are presented in Tables 63-64 in Appendix D. For non-words, as compared to the unrelated condition, native Turkish speakers did not respond significantly faster or slower in the string or suffix conditions (although there was a trend of the string and suffix conditions being slower than the unrelated condition as evidenced by the estimates). As compared to the suffix condition, native Turkish participants did not respond faster or slower in the string condition. The effect of ZPrevLRT on LRT (t = 6.193, $p < .001$), the effect of PrevACC on LRT (t = -6.649, $p < .001$), and the effect of ZTrialNum on LRT (t = -5.250, $p < .001$) were all significant. LexTALE did not affect the reaction time in the unrelated condition, and also did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.2.2 Lexical decision results for non-words for Turkish with regard to accuracy

Model summary results are presented in Tables 65-66 in Appendix D. For non-words, as compared to the unrelated condition, native Turkish speakers did not respond significantly more or less accurately in the string condition (although there was a trend of inhibition in the string relative to the unrelated condition as evidence by the estimate), but did respond less accurately in the suffix condition (t = -3.804, p < .001). As compared to the suffix condition, native Turkish participants did respond significantly more accurately in the string condition (t = 2.384, p < .05). The finding of the suffix condition being less accurate than the string condition and the unrelated condition seemed to suggest Turkish participants' extreme sensitivity to the suffixes, and their attempts to strip the "suffix" regardless of the lexicality of the "stem".

The effect of ZPrevLRT on ACC was not significant, but the effect of PrevACC on ACC (t = 3.482, p < .001) and the effect of TrialNum on ACC (t = 5.727, p < .001) were both significant. There was a significant effect of ZLexTALE on the ACC in the unrelated condition (t = 4.228, p < .001) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.2.3 Discussion: Lexical decision results for non-words for Turkish

To summarize the Turkish results for non-words, with regard to reaction time, the Turkish group did not demonstrate significant priming effects of the string and suffix conditions (although there was a trend of the string and suffix conditions being slower than the unrelated condition as evidenced by the estimates). The non-significant priming effects in the string and suffix conditions did not provide evidence for Turkish participants' sensitivity to orthography at this early stage. With regard to accuracy for non-words, the Turkish group did demonstrate significant inhibitory priming effects in the suffix relative to the unrelated condition, and responded more accurately in the string relative to the suffix condition. The significant priming effects in the suffix condition did provide evidence for Turkish participants' sensitivity to orthography at this early stage. Moreover, the differential priming effects in the string relative to the suffix condition suggested an early affix-stripping process based on the “suffix” string, regardless of the lexicality of the “stem”. On traditional generative accounts, those findings suggest that Turkish speakers were more sensitive to affixation than the native English group. The Turkish group, based on their rule-based nature of L1 morphology, apply morphological decompositional rules more readily and more automatic than the English group, who utilized more whole-word storage and processing, based on their morphologically less rich L1.

7.3 LEXICAL DECISION RESULTS FOR NON-WORDS FOR CHINESE

7.3.1 Lexical decision results for non-words for Chinese with regard to reaction time

Model summary results are presented in Tables 67-68 in Appendix D. For non-words, as compared to the unrelated condition, native Chinese speakers did not respond significantly faster or slower in the string or suffix conditions (although there was a trend of the string and suffix conditions being faster than the unrelated condition as evidenced by the estimates). As compared to the suffix condition, native Chinese participants did not respond faster or slower in the string condition. The effect of ZPrevLRT on LRT ($t = 11.738$, $p < .001$), the effect of PrevACC on LRT ($t = -9.180$, $p < .001$), and the effect of ZTrialNum on LRT ($t = -10.967$, $p < .001$) were all significant. LexTALE did not affect the reaction time in the unrelated condition, and also did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.3.2 Lexical decision results for non-words for Chinese with regard to accuracy

Model summary results are presented in Tables 69-70 in Appendix D. For non-words, as compared to the unrelated condition, native Chinese speakers responded marginally significantly less accurately in the string condition ($t = -1.737$, $p = .082$) and significantly less accurately in the suffix condition ($t = -2.032$, $p < .05$). As compared to the suffix condition, native Chinese participants did not respond significantly more or less accurately in the string condition (although there was a trend of the string condition being more accurate than the suffix condition). The effect of ZPrevLRT on ACC ($t = 2.882$, $p < .01$), the effect of PrevACC on ACC ($t = 3.561$, $p < .001$), and the effect of TrialNum on ACC ($t = 5.221$, $p < .001$) were all significant. There was a significant effect of ZLexTALE on the ACC in the unrelated condition ($t = 3.724$, $p < .001$) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, and there were marginal interactions between string and ZLexTALE ($t = -1.748$, $p = .080$), and between suffix and ZLexTALE ($t = -1.724$, $p = .085$), meaning that the higher the LexTALE score, the larger the inhibitory effects of the string or suffix conditions relative to the unrelated condition.

7.3.3 Discussion: Lexical decision results for non-words for Chinese

To summarize the Chinese results for non-words, with regard to reaction time, the Chinese group did not demonstrate significant priming effects of the string and suffix conditions (although there was a trend of the string and suffix conditions being faster than the unrelated condition as evidenced by the estimates). The non-significant priming effects in the string and suffix conditions did not constitute evidence for the Chinese participants' sensitivity to orthography at this early stage. With regard to accuracy, the Chinese group did demonstrate significant inhibitory priming effects in the suffix relative to the unrelated condition and marginal inhibitory priming effects in the string relative to the unrelated condition, and responded more accurately in the string relative to the suffix condition. The significant inhibitory priming effects in the suffix condition and the marginal inhibitory priming effects did provide evidence for Chinese participants' sensitivity to orthography at this early stage. However, the non-differential priming effects in the string relative to the suffix condition did not constitute evidence for "suffix" stripping regardless of the lexicality of the "stem" at this early stage.

7.4 LEXICAL DECISION RESULTS FOR NON-WORDS FOR VIETNAMESE

7.4.1 Lexical decision results for non-words for Vietnamese with regard to reaction time

Model summary results are presented in Tables 71-72 in Appendix D. For non-words, as compared to the unrelated condition, native Vietnamese speakers responded significantly faster in the suffix condition (t = -2.201, p < .05), and marginally faster in the string condition (t = -1.971, p = .052). As compared to the suffix condition, native Vietnamese participants did not respond faster or slower in the string condition (although there was a trend of the string condition being slower than the suffix condition as evidenced by the estimates). The effect of ZPrevLRT on LRT (t = 9.471, p < .001), the effect of PrevACC on LRT (t = -5.520, p < .001), and the effect of ZTrialNum on LRT (t = -12.925, p < .001) were all significant. LexTALE did not affect the reaction time in the unrelated condition, and also did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.4.2 Lexical decision results for non-words for Vietnamese with regard to accuracy

Model summary results are presented in Tables 73-74 in Appendix D. For non-words, as compared to the unrelated condition, native Vietnamese speakers did not respond more or less accurately in the string condition (t = -1.395, $p > .05$) (although there was a trend of the string condition being less accurate than the unrelated condition) but did respond significantly less accurately in the suffix condition (t = -2.220, $p < .05$). As compared to the suffix condition, native Vietnamese participants did not respond significantly more or less accurately in the string condition (although there was a trend of the string condition being more accurate than the suffix condition). The effect of ZPrevLRT on ACC (t = 2.569, $p < .01$), the effect of PrevACC on ACC (t = 4.506, $p < .001$), and the effect of TrialNum on ACC (t = 4.013, $p < .001$) were all significant. There was a marginal effect of ZLexTALE on the ACC in the unrelated condition (t = 1.919, p = .055) meaning that the higher the LexTALE score, the more likely they would give a correct response in the unrelated condition, but LexTALE did not affect the priming effects of the string or suffix conditions relative to the unrelated condition.

7.4.3 Discussion: Lexical decision results for non-words for Vietnamese

To summarize the Vietnamese results for non-words, with regard to reaction time, the Vietnamese group demonstrated significant facilitatory priming effects in the string and suffix conditions. The significant priming effects in the string and suffix conditions constituted evidence for the Vietnamese participants' sensitivity to orthography at this early stage, similarly to the native English group. The facilitatory priming effects found in the string and suffix conditions did not constitute evidence for an early stage of "suffix" stripping regardless of the lexicality of the “stem”. With regard to accuracy for non-words, the Vietnamese group did not demonstrate significant priming effects in the string relative to the unrelated condition but did show significant inhibitory priming effects in the suffix relative to the condition. Moreover, the non-significant differential priming effects in the string relative to the suffix condition did not constitute evidence for an early affix-stripping process based on the “suffix” string, regardless of the lexicality of the “stem”.

7.5 LEXICAL DECISION RESULTS FOR NON-WORDS: COMPARING THE LANGUAGE GROUPS

I also combined all language groups to examine the interaction between Condition and L1 on both reaction time and accuracy. The fixed effects in combined model for reaction time for non-words included Condition, L1, the interaction between Condition and L1, ZLexTALE (centered on all language groups), as well as ZPrevLRT, PrevACC, and ZTrialNum. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The same models were run with suffix being the reference condition. The random effects in combined model for reaction time with the unrelated condition being the reference included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in combined model for reaction time with the suffix condition being the reference included only random intercepts for participants and targets. Model summary results for reaction time are presented in Tables 75-78 in Appendix D. The random effects in combined model for accuracy included random intercepts and random slopes of Condition for participants and random intercepts for targets, and the same model was run with suffix being the reference condition. Model summary results are presented in Tables 79-82 in Appendix D. The statistical analyses including L1 and the interaction between Condition and L1 confirmed and validated the statistical results on each language group.

To summarize the results comparing across language groups on the lexical decisions of non-words, the significant priming that has been found for not only word targets but also non-words suggest sublexical effects in the masked priming paradigm, "by contributing to the construction of an orthographic or a phonological representation of the target, regardless of the target's lexical status" (Masson & Isaak, 1999, p. 399). Moreover, the differential priming results, i.e., the inhibitory effects of the opaque and form control conditions for words and the facilitatory effects of the string and suffix conditions for non-words for English, especially, provided further evidence for a combination of both facilitative and inhibitory mechanisms, i.e., facilitatory effects due purely to orthographic overlap, and inhibitory effects due to lexical competition, especially in the lexical semantic level. Therefore, results of the current study are consistent with the suggestion of Grainger, Colé, and Segui (1991) that the morphological effects in masked priming tasks reflect the combination of both facilitatory and inhibitory mechanisms.

The differential priming effects across language groups, especially with regard to reaction time, suggested differential efficiency and automaticity with regard to sublexical orthographic processing. The English group and the Vietnamese group were able to benefit, in terms of reaction time, from the string and suffix conditions on non-word processing. The Turkish and the Chinese groups demonstrated no priming effects, in terms of reaction time, in the string or suffix conditions, showing less sensitivity to orthography as compared to the English group. Nevertheless, the Turkish results of significant inhibition in the suffix but not the string condition, in terms of accuracy, suggested their larger sensitivity to the suffixes and their attempts on “suffix” stripping regardless of the lexicality of the stem, which suggested L1 influence on morpho-orthographic processing.

Results from the non-words, to a large extent, confirmed my initial hypothesis of the Vietnamese group exhibiting similar orthographic processing patterns to the native English group and the Chinese group behaving differently from the native English group. Moreover, the significant inhibition in the suffix but not the string condition for the Turkish group provided further evidence of L1 influence on morphological processing. In the context of the current study, the Turkish group even outperformed the native English group in their on-line processing of simplex English words with a “suffix” such that the Turkish group, unlike the native English group, automatically strip off the “suffix”. This behavioral pattern for the Turkish group can be explained by their L1’s rich morphology contributing to their automatic affix-stripping processing strategies in on-line visual recognition.

Results from the lexical decision task for word targets and non-words in the current study provided answers for the research question of whether L2 proficiency affects morphological processing patterns in advanced second language learners. With regard to L2 proficiency as measured in the LexTALE test, L2 proficiency generally did not affect morphological processing patterns, in terms of either reaction time or accuracy, contrary to previous studies comparing a low proficiency group and a high proficiency group (Beyersmann et al., 2015; Gor et al., 2017; Gor & Jackson, 2013; Liang & Chen, 2014; Pliatsikas & Marinis, 2012) but consistent with Andrew and Lo (2013). Note, however, the current study involves native speakers and advanced learners of English. As has been mentioned before, within a limited range of L2 proficiency levels, it is not unexpected that the modulation of proficiency on priming effects did not surface. Interpretations regarding the null modulation effects of L2 proficiency on priming effects in advanced second language learners thus need to be strictly restricted to the context of the current study, i.e., for advanced second language learners and native speakers. The current results did not provide evidence against previous studies that involved a larger range of L2 proficiency levels and found modulation of L2 proficiency on morphological priming (Beyersmann et al., 2015; Gor et al., 2017; Gor & Jackson, 2013; Liang & Chen, 2014; Pliatsikas & Marinis, 2012). Moreover, the robust effects of the previous trial' response time, the previous trial's accuracy, and the number of trials into the experiment for both native speakers and second language learners for both word targets and non-words highlighted the importance of including those variables in statistical analyses so as to partial out their effects in both L1 (Kuperman, Schreuder, Bertram, & Baayen, 2009) and L2 processing research.

8.0 MORPHOLOGICAL PROCESSING AND MORPHOLOGICAL AWARENESS

Linear mixed analyses were conducted on the combined data of all language groups and also separately on each language group to analyze the effect of a variable coding participants' morphological awareness, in order to examine participants' morphological awareness affect on-line morphological processing patterns. The mean accuracy scores for each participant in one of the morphological awareness measures, the Relatedness task, were included in model analyses to analyze the effect of off-line awareness (i.e., knowledge of word structure and derivational relationships between words) on on-line morphological processing.

In the combined data analysis, ZMorph is centered around the mean for all language groups, whereas in the separate analyses on each language group, ZMorph is centered around the mean for only the specific language group. The same goes for ZLexTALE.

8.1 MORPHOLOGICAL PROCESSING AND MORPHOLOGICAL AWARENESS WITH REGARD TO REACTION TIME

The fixed effects in all reaction time models included Condition, ZMorph, the interaction between Condition and ZMorph, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, and ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the reaction time model for the combined, as well as the separate data (English, Turkish, and Chinese) included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in the reaction time model for Vietnamese included the random intercepts and random slopes of Condition for participants, and random intercepts for targets.

Overall with regard to reaction time (see Table 83 in Appendix D), morphological awareness did not affect the reaction time in the unrelated condition, and morphological awareness did not affect the priming effects of the form control or morphological conditions, but the significant interaction between opaque and ZMorph (t = 3.373, $p < .001$) suggested that higher morphological awareness contributed to an inhibitory effect of the opaque condition relative to the unrelated condition.

For the English group with regard to reaction time (see Table 84 in Appendix D), morphological awareness did not affect the reaction time in the unrelated condition and also did not affect the priming effects of the form control, opaque, or morphological conditions.

For the Turkish group with regard to reaction time (see Table 85 in Appendix D), morphological awareness did not affect the reaction time in the unrelated condition and also did not affect the priming effects of the morphological condition, but the significant interactions between form and ZMorph (t = 2.669, $p < .01$) and between opaque and ZMorph (t = 2.702, $p < .01$) suggested that higher morphological awareness contributed to a larger inhibition effect of both the form and opaque conditions relative to the unrelated condition.

For the Chinese group with regard to reaction time (see Table 86 in Appendix D), morphological awareness did not affect the reaction time in the unrelated condition and also did not affect the priming effects of the form control, opaque, or morphological conditions.

For the Vietnamese group with regard to reaction time (see Table 87 in Appendix D), morphological awareness did not affect the reaction time in the unrelated condition and also did not affect the priming effects of the form control or morphological conditions, but there was a marginally significant interaction between opaque and ZMorph ($t = 2.017$, $p = .051$), suggesting that higher morphological awareness contributed to an inhibitory effect of the opaque condition relative to the unrelated condition.

8.2 MORPHOLOGICAL PROCESSING AND MORPHOLOGICAL AWARENESS WITH REGARD TO ACCURACY

The fixed effects in all accuracy models included Condition, ZMorph, the interaction between Condition and ZMorph, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, and ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the accuracy model for the combined data, as well as for each language group (English, Turkish, and Chinese) included the random intercepts and random slopes of Condition for participants, and random intercepts for targets. The random effects in the accuracy model for Vietnamese included the random intercepts for participants and targets.

Overall with regard to accuracy (see Table 88 in Appendix D), there was a simple main effect of morphological awareness in the unrelated condition ($t = 4.066$, $p < .001$), with higher morphological awareness inducing higher accuracy in the unrelated condition. There were significant interactions between form and ZMorph ($t = -2.081$, $p < .05$) and opaque and ZMorph ($t = -3.100$, $p < .01$), suggesting that higher morphological awareness contributed to larger inhibitory priming effects in the form and opaque conditions relative to the unrelated condition, but the non-significant interaction between morph and ZMorph ($t = 1.577$, $p > .05$) suggested that morphological awareness did not affect the priming effects in the morphological condition relative to the unrelated condition.

For the native English group with regard to accuracy (see Table 89 in Appendix D), there was a simple main effect of morphological awareness in the unrelated condition ($t = 2.571$, $p < .05$), with higher morphological awareness inducing higher accuracy in the unrelated condition. There were significant interactions between opaque and ZMorph ($t = -1.961$, $p < .05$), suggesting that higher morphological awareness contributed to larger inhibitory priming effects in the opaque condition relative to the unrelated condition, but morphological awareness did not affect the priming effects in the form control or morphological conditions relative to the unrelated condition.

For the native Turkish group with regard to accuracy (see Table 90 in Appendix D), there was a simple main effect of morphological awareness in the unrelated condition ($t = 2.080$, $p < .05$), with higher morphological awareness inducing higher accuracy in the unrelated condition. There were significant interactions between form and ZMorph ($t = -3.217$, $p < .01$) and opaque and ZMorph ($t = -2.216$, $p < .05$), suggesting that higher morphological awareness contributed to larger inhibitory priming effects in the form and opaque condition relative to the unrelated condition, but morphological awareness did not affect the priming effects in the morphological condition relative to the unrelated condition.

For the native Chinese group with regard to accuracy (see Table 91 in Appendix D), morphological awareness did not affect the accuracy in the unrelated condition. There was a marginally significant interaction between opaque and ZMorph (t = -1.754, p = .079), suggesting that higher morphological awareness contributed to a marginally larger inhibitory priming effect in the opaque condition relative to the unrelated condition, but morphological awareness did not affect the priming effects in the form control or morphological conditions relative to the unrelated condition.

For the native Vietnamese group with regard to accuracy (see Table 92 in Appendix D), morphological awareness did not affect accuracy in the unrelated condition, and also did not affect the priming effects in the form control, opaque, and morphological conditions relative to the unrelated condition.

8.3 DISCUSSION: MORPHOLOGICAL PROCESSING AND MORPHOLOGICAL AWARENESS

To summarize, results showed clearly the effect of morphological awareness on morphological processing. With regard to reaction time, overall for all language groups higher morphological awareness contributed to an inhibitory effect of the opaque relative to the unrelated condition. Morphological awareness did not affect the priming effects across conditions in the English or Chinese group. For the Turkish group, higher morphological awareness contributed to larger inhibitory effects of both the form and the opaque conditions relative to the unrelated condition.

For the Vietnamese group, again higher morphological awareness contributed to an inhibitory effect of the opaque relative to the unrelated condition.

The results with regard to accuracy mirror those with regard to reaction time. Overall for all language groups regarding accuracy, higher morphological awareness contributed to larger inhibitory effects of the form and opaque conditions relative to the unrelated condition. For the English group, higher morphological awareness contributed to a larger inhibitory effect of the opaque condition relative to the unrelated condition. For the Turkish group, higher morphological awareness contributed to larger inhibitory effects of both the form and the opaque conditions relative to the unrelated condition. For the Chinese group, higher morphological awareness contributed to a marginally larger inhibitory effect of the opaque condition relative to the unrelated condition. Morphological awareness did not affect the priming effects across conditions in the Vietnamese group.

Contrary to the results of Deng, Shi, Bi, et al. (2016) and Deng, Shi, Dunlap, et al. (2016) and my initial hypothesis, I did not find significant effects of morphological awareness on the priming effects in the morphological condition in the combined data of all language groups or in any language group. The results of inhibitory effects of higher morphological awareness in the opaque or form control conditions are interesting. Higher morphological awareness presumably contributed to faster and less effortful morpho-orthographic decomposition in the opaque or form control conditions within the short time window of the presentation of the prime. Participants with higher morphological awareness may thus be able to attribute more attention and/or working memory resources to the semantic mismatch of the prime and the target in the opaque or form control conditions but not the morphological condition, thereby generating an inhibitory rather than facilitatory, or a larger inhibitory effect of the opaque or form control conditions.

The fact that only the Turkish group demonstrated modulation of morphological awareness on the priming effects of both the opaque and the form control conditions suggested their superior sensitivity to morphemes regardless of the morphological structure of the prime. For the form control conditions, the primes were simplex word forms, consisting of a “base” and a string that never functions as a suffix in the English languages. Nevertheless, the Turkish group seemed to be able to strip the “base” off the simplex word form, as demonstrated by the effect of morphological awareness on the priming effect of the form control condition for both reaction time and accuracy.

9.0 MORPHOLOGICAL PROCESSING AND SUFFIX COMPLEXITY (MEAN CO-RANK)

By including a range of suffixes in the masked priming lexical decision task, I examined whether the suffix ordering hierarchy (mean CO-Ranks for each suffix) affect the priming of morphological or opaque conditions relative to the unrelated condition. Should participants demonstrate a modulation of priming by CO-Rank in early lexical processing, it would be evidence for their sensitivity to suffix characteristics of productivity and thus evidence for an early decomposition process in lexical processing.

Linear mixed analyses were conducted on the combined data of all language groups and also separately on each language group to analyze the effect of suffix productivity/complexity (mean CO-Rank) on morphological processing patterns. The mean CO-Rank score for the suffixes were based on Table 3 in Plag and Baayen (2009). Because in the form control condition, there were no real suffixes, the data would only contain three conditions, the opaque, morphological, and unrelated conditions.

In the combined data analysis, ZLexTALE was centered around the mean for all language groups, whereas in the separate analyses on each language group, ZLexTALE was centered around the mean for only the specific language group. In all data analysis, ZCORank was centered around the mean for all suffixes.

I tested Pearson's product-moment correlations between mean CO-Rank and prime or target length or frequencies in the morphological materials (N = 68), and results showed no correlation of CO-Rank with prime surface frequency CobLog (t = -.212, p > .05), a marginal negative correlation with prime surface frequency LogHal (t = -1.904, p = .061), no correlation with prime length (t = .606, p > .05), a marginal positive correlation with target surface frequency CobLog (t = 1.764, p = .082), no correlation with target surface frequency LogHal (t = -1.465, p > .05), and no correlation with target length (t = -1.149, p > .05). Therefore, for the experimental materials in the morphological condition, there were marginal correlations of CO-Rank with both prime and target surface frequencies.

I also tested Pearson's product-moment correlations between mean CO-Rank and prime or target length or frequencies in the opaque materials (N = 29 due to some of the pseudo-suffixes not in Table 3 of Plag and Baayen (2009) and thus not having a CO-Rank value), and results showed no correlation of CO-Rank with prime surface frequency CobLog (t = -.554, p > .05), no correlation with prime surface frequency LogHal (t = .352, p > .05), a significant positive correlation with prime length (t = 2.896, p < .01), no correlation with target surface frequency CobLog (t = 1.423, p > .05), or target surface frequency LogHal (t = .938, p > .05), or target length (t = -1.284, p > .05). Therefore, for the experimental materials in the opaque condition, there is no correlation of CO-Rank with either prime or target surface frequency.

Therefore, prime length, prime LogHal and target CobLog as covariates would need to be included in the statistical analyses to partial out the variances of those variables.

9.1 MORPHOLOGICAL PROCESSING AND SUFFIX COMPLEXITY (MEAN CO-RANK) WITH REGARD TO REACTION TIME

The fixed effects in all reaction time models included Condition, ZCORank, the interaction between Condition and ZCORank, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum and the covariates of ZPrimeLen, ZPrimeLogHal, ZTargetCobLog, ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the reaction time model for the combined, as well as for Chinese and for Vietnamese included the random intercepts and random slopes of Condition, ZPrevLRT, PrevACC, and ZTrialNum for participants, and random intercepts for targets. The random effects in the reaction time model for English and for Turkish, included the random intercepts and random slopes of Condition for participants, and random intercepts for targets.

Overall with regard to reaction time (see Tables 93-95 in Appendix D), CO-Rank did not affect the reaction time of the unrelated condition, and CO-Rank did not affect the priming effects of the opaque condition relative to the unrelated condition. There was a significant interaction between morph and ZCORank ($t = 2.105$, $p < .05$) suggesting that higher CO-Rank contributed to a smaller facilitation effect of the morphological condition relative to the unrelated condition.

For the native English group with regard to reaction time (see Tables 96-98 in Appendix D), CO-Rank did not affect the reaction time of the unrelated condition, and also did not affect the priming effects of the opaque condition relative to the unrelated condition. There was a significant interaction between morph and ZCORank ($t = 1.977$, $p < .05$) suggesting that higher

CO-Rank contributed to a smaller facilitation effect of the morphological condition relative to the unrelated condition.

For the native Turkish group with regard to reaction time (see Tables 99-101 in Appendix D), CO-Rank did not affect the reaction time of the unrelated condition, and there was a marginally significant interaction between morph and ZCORank (t = 1.896, p = .058), suggesting that higher CO-Rank contributed to marginally smaller facilitatory priming effects of the morphological condition relative to the unrelated condition. There was a significant interaction between opaque and ZCORank (t = 2.405, p < .05), suggesting that higher CO-Rank contributed to a larger inhibition effect of the opaque condition relative to the unrelated condition.

For both the Chinese and the Vietnamese groups with regard to reaction time (see Tables 102-104 and 105-107, respectively, in Appendix D), CO-Rank did not affect the reaction time of the unrelated condition, and also did not affect the priming effects of the opaque or the morphological conditions.

9.2 MORPHOLOGICAL PROCESSING AND SUFFIX COMPLEXITY (MEAN CO-RANK) WITH REGARD TO ACCURACY

The fixed effects in all accuracy models included Condition, ZCORank, the interaction between Condition and ZCORank, ZLexTALE, as well as ZPrevLRT, PrevACC, and ZTrialNum, and the covariates of ZPrimeLen, ZPrimeLogHal, ZTargetCobLog, ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N. Condition was dummy-coded (i.e., treatment-coded), with the reference being the unrelated condition. The random effects in the accuracy model for the combined data, as well as in each language group (English, Turkish, Chinese, and Vietnamese) include the random intercepts and random slopes of Condition for participants, and random intercepts for targets.

Overall with regard to accuracy (see Tables 108-110 in Appendix D), CO-Rank did not affect the accuracy of the unrelated condition, and there was a marginal interaction between opaque and ZCORank (t = 1.762, p = .078), meaning that higher CO-Rank contributed to marginally larger facilitatory priming effects in the opaque condition, but CO-Rank did not affect the priming effects of the morphological conditions.

For the English, Chinese, and Vietnamese groups with regard to accuracy (see Tables 111-113, 117-119, and 120-122, respectively in Appendix D), CO-Rank did not affect the accuracy of the unrelated condition, and also did not affect the priming effects of the opaque or the morphological conditions.

For the native Turkish group with regard to accuracy (see Tables 114-116 in Appendix D), CO-Rank did not affect the accuracy of the unrelated condition and also did not affect the priming effect of the opaque condition relative to the unrelated condition. There was a significant interaction between morph and ZCORank (t = -2.804, p < .01), suggesting that higher CO-Rank contributed to smaller facilitatory effects of the morphological condition relative to the unrelated condition.

9.3 DISCUSSION: MORPHOLOGICAL PROCESSING AND SUFFIX COMPLEXITY (MEAN CO-RANK)

For native English speakers, with regard to reaction time, higher CO-Rank led to a smaller facilitation effect in the morphological condition relative to the unrelated condition. For Turkish speakers, with regard to reaction time, higher CO-Rank led to marginally smaller facilitatory priming effects of the morphological condition and a larger inhibition effect of the opaque condition relative to the unrelated condition, and with regard to accuracy, higher CO-Rank contributed to a smaller facilitatory effect of the morphological condition relative to the unrelated condition.

With regard to both reaction time and accuracy, for both Chinese and Vietnamese speakers, CO-Rank did not affect the priming effects of the opaque or the morphological condition relative to the unrelated condition.

The findings of higher suffix complexity/productivity leading to smaller facilitatory effects in the morphological condition in English and both smaller facilitatory effects in the morphological condition and larger inhibitory effects in the opaque condition in Turkish are interesting. The results are consistent with the proposals by Plag and Baayen (2009) on the need for the supplementation of the role of memory on the model of suffix complexity on lexical decision and word naming behavioral results, with suffixes with low complexity/productivity enjoying the advantages of storage and suffixes with high complexity/productivity enjoying the advantages of efficient parsing. The larger inhibitory effects in the opaque condition for suffixes with higher CO-Rank could be explained by the fact that suffixes with higher CO-Rank are more readily and automatically decomposable, and thus require less effort, with more resources left to attend to sematic checking between the opaque prime and the target. As studies on the benefits and costs of lexical decomposition and semantic integration for compound processing of English compounds (Ji, Gagné, & Spalding, 2011) have found, the meaning composition stage after the initial morphological decomposition (regardless of semantics) stage speeded up transparent processing but slowed down opaque processing as a result of meaning conflict. For suffixes with higher mean CO-Rank in the opaque condition, the meaning conflict thus slowed down processing of the target.

The reasons for smaller facilitatory effects in the morphological condition for suffixes with higher mean CO-Rank for both English and Turkish were not self-evident. If there was indeed a modulation effect of suffix complexity on priming in the morphological condition, intuitively the higher the suffix complexity/productivity, the more readily decomposable the prime, and the larger the morphological priming effect should be. One tentative explanation for the smaller facilitation in the morphological condition could be due to the processing cost associated with re-combining the decomposed morphemes in the early stage, thus inducing slow-downs in later lexical decisions.

The English and Turkish demonstrated sensitivity to the property of suffix complexity, whereas the Chinese and Vietnamese did not. Furthermore, the Turkish group demonstrated sensitivity to suffix complexity in both the morphological and opaque conditions, whereas the English group demonstrated sensitivity to suffix complexity only in the morphological condition. The fact that only the Turkish, but not the English group, demonstrated sensitivity to suffix complexity in the opaque condition provided further evidence for early morpho-orthographic decomposition in the opaque condition in Turkish, and also evidence of L1 influence on on-line morphological processing.

Therefore, results generally confirmed my initial hypothesis that advanced L2 speakers, just like L1 speakers, are sensitive to suffix complexity during on-line L2 morphological processing. Several statistical findings and implications are worthy of note. First, as a matter of fact, the statistical results for the model with all such covariates as ZPrimeLen, ZPrimeLogHal, ZTargetCobLog, ZPrimeOrtho_N, ZPrimePhono_N, ZPrimeBG_Sum, ZPrimeBG_Mean, ZPrimeBG_Freq_By_Pos, ZTargetOrtho_N, ZTargetPhono_N and the model without those covariates are qualitatively extremely similar. For reaction time, the results "without" and "with" the covariates did not differ for the combined data, the Turkish group, the Chinese group, or the Vietnamese group. For the English group, the results "without" the covariates had a marginal (t = 1.836, p = .067) interaction between morph and ZCORank, and the results "with" the covariates had a significant interaction (t = 1.977, p < .05) between morph and ZCORank. For accuracy, the results "without" and "with" the covariates did not differ for the English, Chinese, or Vietnamese groups. For the combined data, the results "without" the covariates had no interaction between opaque and ZCORank (t = 1.313, p > .05), and the results "with" the covariates had a marginal interaction (t = 1.762, p = .078) between opaque and ZCORank. For the Turkish group, the results "without" the covariates had a significant effect of ZCORank in the unrelated condition (t = 2.275, p = .023), but the results "with" the covariates had no effect of ZCORank in the unrelated condition (t = 1.612, p > .05). The qualitatively similar results of the models with or without the covariates suggest that the surprising interaction between suffix complexity and priming effects in the morphological or opaque conditions did not have anything to do with the covariates such as prime length, prime frequency, or target frequency, etc. In other words, the interaction between suffix complexity and priming effects was not contaminated by, or stemmed from, covariates such as prime length, prime frequency, or target frequency, etc. With or without controlling for the covariates, the interactions between productivity and priming effects were always in the same direction.

Second, the effects of higher morphological awareness and higher suffix complexity/productivity go in the same direction for the opaque and form control conditions. The higher the morphological awareness, and/or the higher the suffix complexity/productivity, the larger the inhibitory priming effects in the opaque condition. The results of the modulation effect of morphological awareness and the modulation effect of suffix complexity on priming validate each other in the interpretation of results. The higher the morphological awareness, and/or the higher the suffix complexity/productivity, the more likely and automatic participants are to decompose the transparent or opaque primes during the early stage of visual word recognition. The more likely and automatic they are to employ morpho-orthographic decomposition of the primes, the more resources they have left to attend to the semantic mismatch of the prime and the target in the opaque or form control conditions, leading to larger inhibitory priming effects in the opaque or form control conditions.

Third, the modulation of suffix complexity on morphological priming effects suggest the great need in future research to strictly control the suffix complexity/productivity of the suffixes that researchers choose to include in the morphological and opaque conditions and take the measures of suffix complexity/productivity into account in drawing their conclusions.

10.0 EFFECTS OF ALTERNATION VS NO ALTERNATION ON MORPHOLOGICAL PROCESSING

McCormick et al. (2008) showed that native speakers' morpho-orthographic decomposition process is able to survive the regular orthographic alternations in complex words, e.g., missing 'e' in adorable-ADORE, shared 'e' in lover-LOVE, and duplicated consonant in "dropper-DROP" and that even in the absence of a semantic relationship of the prime and the target (e.g., fetish-fete) the robustness to orthographic disruption is preserved, providing evidence for a form of morphological decomposition insensitive to semantic characteristics of the stimuli (Rastle & Davis, 2008). It remains to be seen whether L2 learners are able to tolerate the surface orthographic or phonological variations within the stem.

I therefore analyzed the effect of whether there was alternation (either orthographic or phonological or both) or not on morphological processing with a simple coding for conditions. AlterCondition was coded with three conditions, including Alter (real suffix, where there are either orthographic or phonological alternations or both), NoAlter (real suffix, where there are neither orthographic alternations nor phonological alternations), and unrelated conditions.

10.1 EFFECTS OF ALTERNATION VS. NO ALTERNATION WITH REGARD TO REACTION TIME

Figure 17 shows the mean log-transformed reaction times (log ms) for each AlterCondition for each language group for words.

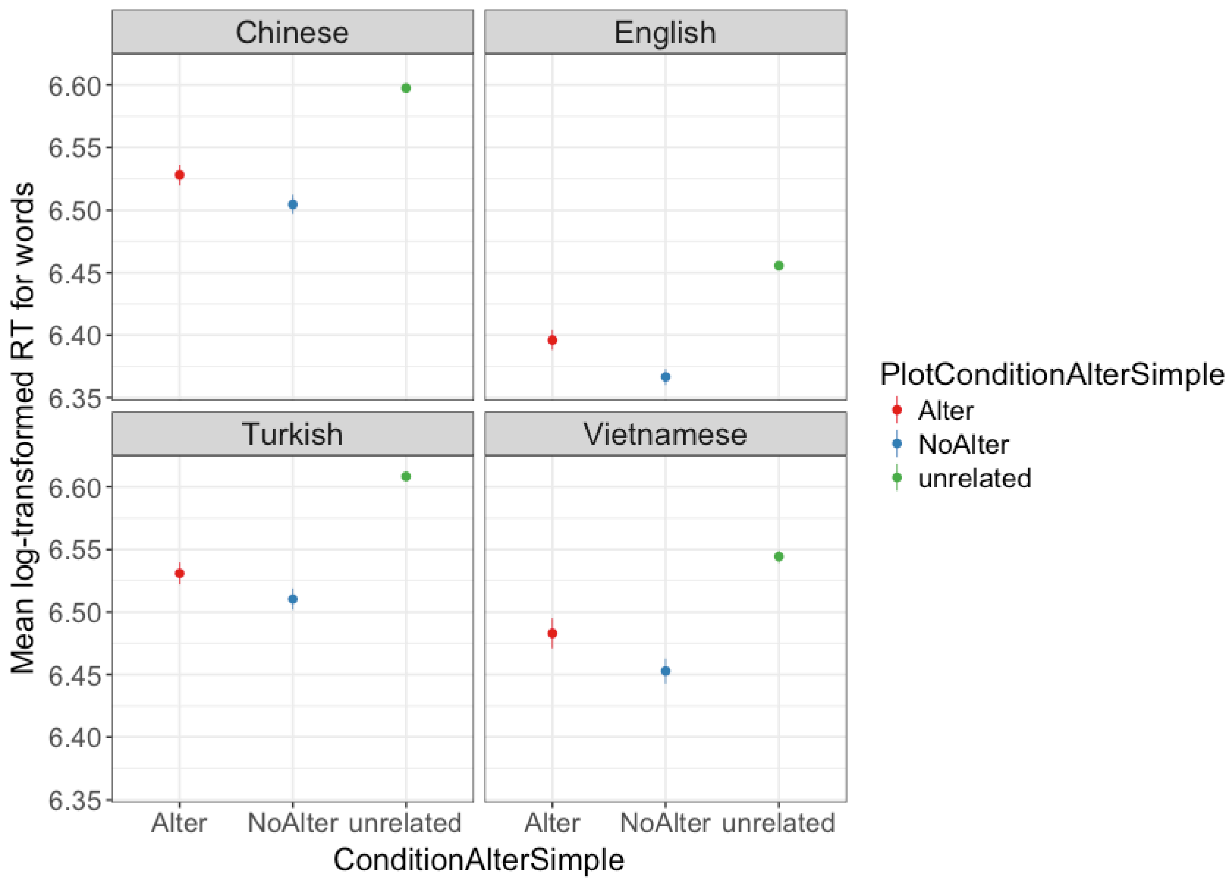

Figure 17. Mean LRT for each AlterCondition for each language group for words. Error bars represent ± standard error.

The fixed effects in the models for LRT for the separate models for each language group included AlterCondition, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZTargetCobLog and ZTargetBG_Freq_By_Pos. AlterCondition was dummy coded with Alter as the reference condition. The random effects for English and Vietnamese included the random intercepts and random slopes of AlterCondition, ZPrevLRT, PrevACC, and ZTrialNum for participants and random intercepts for targets. The random effects for Turkish and Chinese included the random intercepts and random slopes of AlterCondition for participants and random intercepts for targets.

The fixed effects in the models for LRT for the combined model for all language groups included AlterCondition, L1, the interaction between AlterCondition and L1, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZTargetCobLog and ZTargetBG_Freq_By_Pos. AlterCondition was dummy coded with Alter as the reference condition. L1 was dummy coded with English being the reference. The random effects for the combined data included the random intercepts and random slopes of AlterCondition, ZPrevLRT, PrevACC, and ZTrialNum for participants and random intercepts for targets.

For the native English, Turkish, Chinese, or Vietnamese group with reaction time (see Tables 123-126, respectively, in Appendix D), there was no difference between the NoAlter and Alter, meaning that whether there were alternations or not in the morphological condition did not affect reaction time. The Alter condition was significantly faster than the unrelated condition (t = 4.231, $p < .001$), showing a facilitatory priming effect.

Comparing the native English group with the L2 English groups with regard to reaction time (see Table 127 in Appendix D), there were no interactions between NoAlter with either L2 (Chinese, Turkish, or Vietnamese) language group (t = .353, $p > .05$; t = .393, $p > .05$; t = -.286, $p > .05$), meaning that in all language groups, there was no difference between the NoAlter and Alter conditions. There were no interactions between unrelated and Chinese (t = .911, $p > .05$) or between unrelated and Vietnamese (t = .410, $p > .05$), but there was a marginally significant interaction between unrelated and Turkish (t = 1.833, p = .060), suggesting that the difference between Alter and unrelated did not differ in the Chinese or Vietnamese groups as compared to the English group, but the difference between Alter and unrelated was slightly larger in Turkish than in English, i.e., the Turkish group were more facilitated in the Alter condition relative to the unrelated condition than the English group are.

10.2 EFFECTS OF ALTERNATION VS. NO ALTERNATION WITH REGARD TO ACCURACY

Figure 18 shows the mean accuracy (on a scale of 0-1) for each AlterCondition for each language group for words.

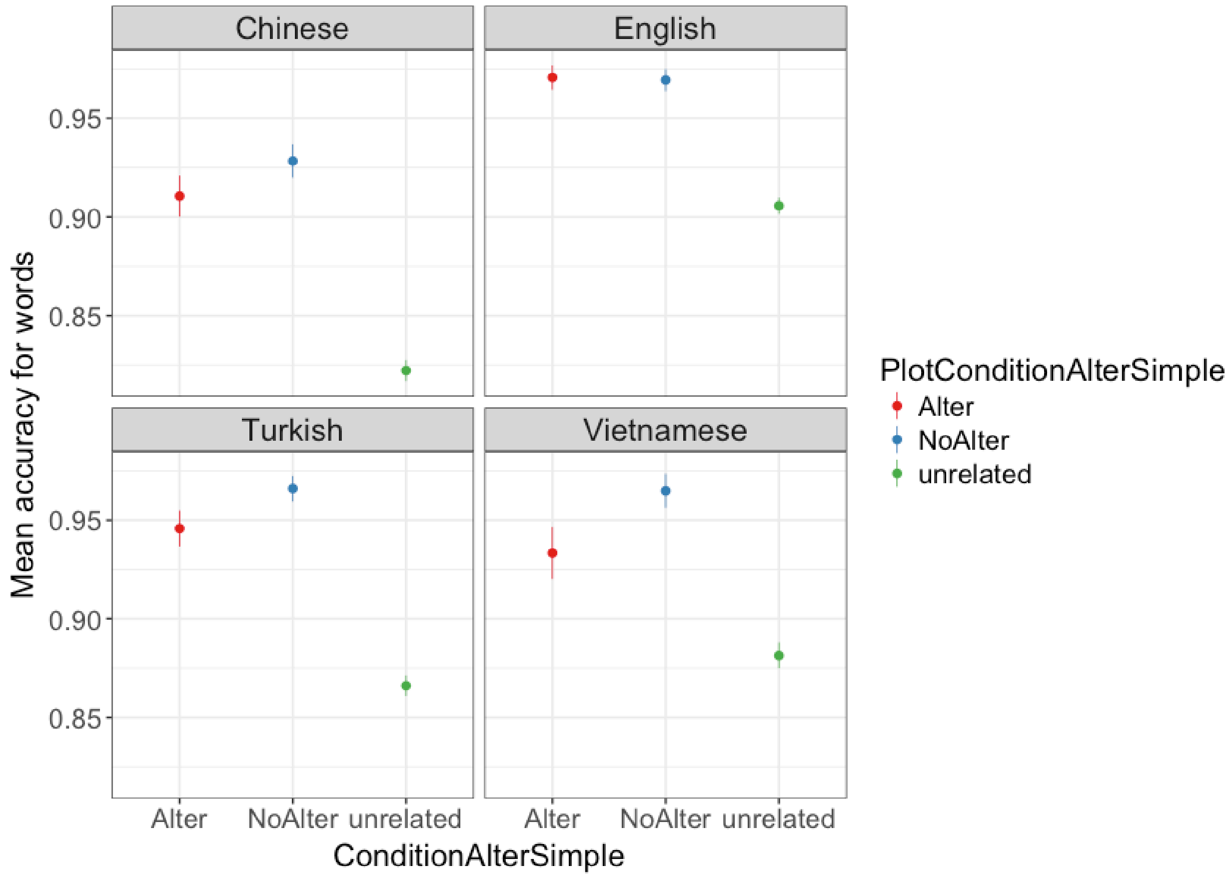

Figure 18. Mean ACC for each AlterCondition for each language group. Error bars represent ± standard error.

The fixed effects in the models for ACC for Turkish and Chinese included AlterCondition, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZTargetCobLog and ZTargetBG_Freq_By_Pos. AlterCondition was dummy coded with Alter as the reference condition. The random effects for English, Turkish, Chinese, and Vietnamese included the random intercepts and random slopes of AlterCondition for participants and random intercepts for targets.

The fixed effects in the models for ACC for the combined model for all language groups included AlterCondition, L1, the interaction between AlterCondition and L1, ZLexTALE, ZPrevLRT, PrevACC, ZTrialNum, and the covariates of ZTargetCobLog and

ZTargetBG_Freq_By_Pos. AlterCondition was dummy coded with Alter as the reference condition. L1 was dummy coded with English being the reference. The random effects for the combined data included the random intercepts for participants and targets.

For the native English group with accuracy (see Table 128 in Appendix D), there was no difference between the NoAlter and Alter (t = -.740, p > .05), meaning that whether there were alternations or not in the morphological condition did not affect accuracy. The Alter condition was marginally more accurate than the unrelated condition (t = -1.897, p = .058), showing a facilitatory priming effect.

For the native Turkish group with accuracy (see Table 129 in Appendix D), there was no difference between the NoAlter and Alter (t = .323, p > .05), meaning that whether there were alternations or not in the morphological condition did not affect accuracy. The Alter condition was marginally more accurate than the unrelated condition (t = -1.712, p = .087), showing a marginal facilitatory priming effect.

For the native Chinese group with accuracy (see Table 130 in Appendix D), there was no difference between the NoAlter and Alter (t = .242, p > .05), meaning that whether there were alternations or not in the morphological condition did not affect accuracy. The Alter condition was significantly more accurate than the unrelated condition (t = -2.236, p < .05), showing a facilitatory priming effect.

For the native Vietnamese group with accuracy (see Table 131 in Appendix D), there was no difference between the NoAlter and Alter (t = 1.147, p > .05), meaning that whether there were alternations or not in the morphological condition did not affect accuracy. The Alter condition was also not significantly more or less accurate than the unrelated condition (t = -1.505, p > .05), showing no significant facilitatory priming effect.

Comparing the native English group with the L2 English groups with regard to accuracy (see Table 132 in Appendix D), there were almost no interactions between the NoAlter or unrelated conditions and either Chinese (t = .986, p > .05; t = 1.306, p > .05) or Turkish (t = 1.514, p > .05; t = .499, p > .05), meaning that the Chinese and Turkish groups followed the same processing pattern as the native English group. There were marginally significant interactions between NoAlter and Vietnamese (t = 1.801, p = .072), and between unrelated and Vietnamese (t = 1.881, p = .060), as evidenced by the negative albeit non-significant estimate of NoAlter (comparing NoAlter and Alter) for English as compared to the positive albeit non-significant estimate of NoAlter (comparing NoAlter and Alter) for Vietnamese, and by the marginally significant difference between Alter and unrelated in English and no such effect in Vietnamese.

10.3 DISCUSSION: EFFECTS OF ALTERNATION VS. NO ALTERNATION

The results confirmed the initial hypothesis that advanced L2 learners of English, just like native speakers, are tolerant of base orthographic/phonological alternations during their on-line morphological decomposition. With regard to both reaction time and accuracy, and for each language group (English, Turkish, Chinese, and Vietnamese), the trials with or without alternations did not differ in the priming effects in the morphological conditions. The results of the English group replicated the findings of McCormick et al. (2008) such that native speakers' morpho-orthographic decomposition process was able to survive the regular orthographic alternations in complex words. The results of the L2 groups have shown, like native speakers, the morpho-orthographic decomposition processes in advanced L2 learners of English were able to survive the orthographic and/or phonological alternations in complex words as well, providing evidence for native-like attainment of knowledge of regular alternations of base allomorphy.

11.0 GENERAL DISCUSSION

11.1 KEY FINDINGS AND DISCUSSION

The current study aimed to examine a range of research questions regarding L2 morphological awareness and L2 morphological processing mainly focusing on possible L1 influence. The research questions that the current dissertation research aimed to examine, along with the results are:

(1) Are there L1 influences on off-line L2 morphological awareness?

Results confirmed the initial hypothesis that there are L1 influences on off-line L2 morphological awareness. Specifically, the Turkish group, from a morphologically rich agglutinative L1, have higher L2 English morphological awareness than the Chinese group or the Vietnamese group, both with an L1 with isolating morphology. In terms of English morphological awareness as measured in a relatedness task, in contrast to the Chinese or Vietnamese groups who performed worse than the English group before accounting for language proficiency, the Turkish group marginally outperformed the English group even before accounting for language proficiency, demonstrating clear L1 influence on morphological awareness, i.e., knowledge of word structure in L2 English.

(2) Does L2 proficiency affect morphological processing patterns in advanced second language learners?

Contrary to the initial hypothesis, L2 proficiency generally did not affect morphological processing patterns in the context of the current study. This is likely due to the selection procedure of recruiting advanced learners in an English-speaking community.

(3) Is there an L1 influence on on-line L2 morphological processing?

Results confirmed the initial hypotheses that there is an L1 influence on on-line L2 morphological processing and that the Chinese and the Vietnamese groups differ in their orthographic processing, due to the differential L1 writing systems (logographic Chinese vs. alphabetic Vietnamese). As regards on-line morphological processing patterns, the Turkish group exhibited priming effects across conditions similarly to the English group, whereas the Chinese and the Vietnamese groups behaved similarly, both differently from the Turkish and English groups. The on-line processing patterns across language groups clearly reflected L1 influence.

(4) Does L2 morphological awareness affect L2 morphological processing?

Results confirmed the initial hypothesis that L2 morphological awareness affects L2 morphological processing. The significant effects of morphological awareness on the priming effects across conditions, together with the results of morphological awareness across language groups, suggest that the differences across language groups with regard to the priming patterns could, at least in part, be attributed to cross-group differences in morphological awareness.

(5) Are L1 and/or L2 speakers sensitive to suffix complexity during on-line L2 morphological processing?

Results confirmed the initial hypothesis that L1 and L2 speakers are both sensitive to suffix complexity during on-line L2 morphological processing. That only the Turkish group, not even the English group, showed sensitivity to suffix complexity in the opaque condition provided further evidence for L1 influence on early morpho-orthographic decomposition.

(6) Are L2 learners of English tolerant of base orthographic/phonological alternations during their on-line morphological decomposition, similarly to native speakers?

Results confirmed the initial hypothesis that L2 learners of English, like native speakers, are tolerant of base orthographic/phonological alternations during their on-line morphological decomposition.

The results of the current study could be explained in terms of the lexical quality hypothesis (Perfetti, 2007; Perfetti & Hart, 2001, 2002). High quality representations support coherent and fast activation of the orthographic, phonological, and semantic information of a lexical entry, as compared to low quality representations. One source of differential processing patterns among different L2 groups with different L1 in the current study could be due to L2 groups having to attributing differential amount of additional processing resources to English orthographic information. Jacob and Kırkıcı (2016) interpreted their finding of the Turkish heritage group (with German being their dominant language) differing in their processing pattern from both the L1 and L2 Turkish groups to the Turkish heritage group's unique way of acquiring written Turkish because they acquire only the German orthography-to-phonology mapping explicitly and therefore, they might need to correct an initially activated German orthography-to-phonology mapping for the correct, later-activated Turkish mapping, therefore relying more on orthography. In the current study, the similarities between the orthography-to-phonology mappings in different L1s (Chinese, Turkish, and Vietnamese) as compared to English differ across language groups, and could very likely be the reason of differential patterns of priming in the form control condition (and/or the opaque condition). Similarly to Jacob and Kırkıcı (2016), the significant orthographic priming (facilitatory or inhibitory) found in the current study cannot be explained by the accounts of Rastle, Davis, and New (2004) or Marslen-Wilson (2007) assuming the operation of morpho-orthographic decomposition specifically on morphological units.

The differential priming effects found in the opaque relative to the form control conditions in the current study, along with the differential sensitivity of opaque versus form control priming effects to morphological awareness and suffix complexity measures allowed the teasing apart of morphological processing and purely orthographic processing. Firstly, as shown in Sections 6.4-6.6, for the word targets, the Chinese group demonstrated larger facilitation in terms of reaction time in the opaque relative to the form control condition, and the Vietnamese group showed more facilitation in the opaque relative to the form control condition. Those differential priming effects in the opaque relative to the form control conditions were thus able to provide evidence for morphological processing in the opaque condition beyond pure orthographic processing due to orthographic overlap as in the form control condition. Secondly, as argued in Section 8.3, all language groups showed significant modulation of morphological awareness on opaque priming, but for the modulation of morphological awareness on form control priming, only the Turkish group showed significant effects. Thirdly, according to results in Sections 9.1-9.3, for the Turkish group, suffix complexity modulated opaque priming but not form priming. Therefore, the differential sensitivity of opaque relative to form control priming to morphological awareness and suffix complexity again constitutes evidence for morphological processing beyond orthographic processing in the opaque condition.

The null modulation effect of orthographic and/or phonological alternations of the stem on morphological priming effects for both L1 and L2 speakers, in view of McCormick et al. (2009) provided evidence for L1 and L2 orthographic underspecification of stems that regularly undergo orthographic or phonological alternations. Nevertheless, especially when considering connectionist models' view of allomorphy to be obsolete and epiphenomenal, the null modulation results do not provide evidence for underspecification of orthography or clear direct access to morphology regardless of orthography.

The results of the current study are consistent with the model proposed by Diependaele, Sandra, and Grainger (2009), who argued for parallel mapping of morphological information into morpho-orthographic and morpho-semantic routes during lexical access, by which effects of morpho-orthographic decomposition of opaque words as well as effects of semantic transparency can be explained. Specifically, according to the results in Sections 6.2-6.7, for word targets, all language groups showed more facilitation in the morphological condition relative to the opaque condition in terms of both reaction time and accuracy, suggesting semantic processing at the early stage of lexical processing. Moreover, as demonstrated in Sections 6.4-6.6, the differential priming effects in the opaque relative to the form control conditions in the Chinese and Vietnamese groups provide evidence for morpho-orthographic decomposition at this early stage. These results together attest to parallel processing of both morpho-orthographic and morpho-semantic information during the early stages of lexical processing.

11.2 SIGNIFICANCE OF THE STUDY

11.2.1 Implications for theories in second language representation and processing

This study is the first to demonstrate clear L1 influence on offline L2 morphological awareness, and also the first to demonstrate clear L1 influence on on-line L2 processing of derivational morphology, due to the relative morphological richness of the L1 and the L2.

This study has implications for theories in second language acquisition, especially the representation and processing of the bilingual lexicon, and speaks to general theories such as the Shallow Structure Hypothesis, Declarative/Procedural Hypothesis. Results of the Chinese and the Turkish groups, especially, provided evidence for early morpho-orthographic decomposition and parallel processing of both morpho-orthographic and morpho-semantic information, as has been suggested for either L1 or L2 morphological processing (Bosch et al., 2016; Feldman, O'Connor, & Del Prado Martin, 2009; Zhang, Liang, Yao, Hu, & Chen, 2016), contrary to claims by the Shallow Structure Hypothesis or the Declarative/Procedural Hypothesis that L2 learners are not able to, or are limited in, decomposition compared to native speakers. Not only were L2 learners able to decompose morphologically complex words in real-time, L2 learners are also sensitive to suffix complexity properties and are tolerant of orthographic/phonological alternations.

The clear L1 influence found in both morphological awareness and morphological processing provided evidence for language transfer models such as the Competition Model (CM) (Macwhinney, 1987, 1992, 1997, 2001, 2005a, 2005b) or the Full Transfer/Full Access (FT/FA) model (Schwartz & Sprouse, 1996) such that L2 participants, specifically the Turkish group, were able to transfer their knowledge of word structure in L1 Turkish during their acquisition and processing of L2 English words. However, while consistent with the CM, the current study focused on L1 influence on L2 morphological processing, and the results of the current study cannot decide between emergentist and rule-based theory, i.e., how morphological structures are represented in the brain. That is, the results of the current study are consistent and compatible with both symbolic generative accounts and connectionist accounts.

However, the findings of the Turkish speakers showing more sensitivity than the native English speakers to morphology can be readily and nicely explained by symbolic accounts of morphology such that since their L1 Turkish has extensive derivation and inflection, extensive L1 exposure to derivations and inflections gives them a predisposition to apply morphological rules and decompose words to a much larger extent than native English speakers, and even much more than native Chinese or Vietnamese speakers with extremely isolating L1 morphology. When encountering L2 English words, with their long-term practice of decomposing words, they are more inclined to decompose complex words in English as well, as compared to native English speakers and L2 learners with L1s of isolating morphology. Moreover, they are more efficient and automatic in this decomposition process to the extent that they could not resist stripping off an "affix" when they see such a string, regardless of the lexicality and legitimacy of the "base", which was why they were found to strip off "affixes" in the condition of simplex primes consisting of a non-word "base" plus an "affix" string.

Connectionist models also predict L1 influence, such as the CM (Macwhinney, 1987, 1992, 1997, 2001, 2005a, 2005b). The CM, first formulated for normal adult and child native speakers attributing development to constructive, data-driven learning and transfer, and universals of cognitive structure, has been generalized to L2 acquisition, mostly focusing on L1 transfer in L2 phonological, syntactic (on-line sentence processing strategies and production abilities), and lexical learning such that L2 rely on the structures and units of the L1. The Competition Model has rarely been considered in the context of L1 influences on L2 acquisition and processing of derivational morphology, for which the current study aims to fill a gap. From the viewpoint of the Competition Model (MacWhinney, 1997), each single lexical item is viewed as a form-to-function mapping through cues in the lexical connectionist networks and L2 morphological processing could be dependent on L2 input-driven learning and L1 transfer due to the view of all mental processing sharing a common and interconnected set of cognitive structures with strong analogy and pattern generalization, such that “all aspects of the first language that can possibly transfer to L2 will transfer” (p. 119) and over time the second language grows out of the parasitic set of grammatical constructs at the initial stages and becomes a full language in its own right. With regard to morphological knowledge, this connectionist view of second language learning will predict transfer effects of morphological awareness from L1 to L2 and less interference from L1 to L2 with the increase in L2 proficiency, with the initial stage’s L2 cue weight settings close to L1 and gradually changing in the direction of the native speakers’ settings. The Competition Model thus predicts that second language learners of L1 with little morphology compared to English will initially ignore, to a certain extent, word structure in word recognition, and gradually weigh more cues of morphological structures of complex English words, whereas second language learners of L1 with extensive morphology compared to English will be initially already able to transfer the strong morphological cues of their L1 to their L2 English word recognition. With the increase in L2 frequency, differential transfer effects due to L1 morphological characteristics could be reduced, with the changing cue weightings towards those of native speakers. Nevertheless, connectionist models have not readily demonstrated such a case of Turkish L2 learners of English being superior to native English speakers in English morphological processing. This is not to suggest that connectionist accounts could not explain such a case of Turkish L2 learners of English being superior to native English speakers in English morphological processing. This is not to suggest that connectionist accounts could not explain such a phenomenon. As a matter of fact, the modeling results of Plaut and Gonnerman (2000) have hinted at this possibility. For Turkish L2 learners of English, due to their dominant L1, have higher degrees of morphological organization of the L1 system, and L2 English acquisition and processing of morphology could very probably benefit from their already high degree of morphological organization of L1.

The current results are perhaps better explained by the proposal of Jackendoff (2002) in that there are no clear-cut conclusions regarding whether learners store all forms or compute all complex structures in terms of rules. In fact, there may be a combination of both, depending on the organizational nature of the language system itself. For a language such as English, there are not an extremely high percentage of complex words with inflections, therefore favoring storage and demonstrating effects of frequency, with not much rule application in word representations. For a morphologically rich language like Turkish, it is un-economical, cumbersome, and may even be impossible to store all the complex and long words with rich derivations and inflections, in which case, dependence on rule applications in lexical representation and processing will reveal its importance.

The current study has also shown differential priming effects across language groups in the orthographic overlap, i.e., form control, condition, and further emphasized the importance in the consideration of L2 learners' efficiency and automaticity of orthographic processing in studies of lexical decisions, especially priming studies. In masked priming studies, primes are usually presented in lowercase and target in uppercase. The motivation for the change in letter case and the superposition of the target and the prime in the same location is to both forward mask the prime with a string of hash signs and backward the prime with the target and to reduce or minimize prime visibility (Pastizzo & Feldman, 2002). Unlike most masked priming studies with targets presented in uppercase and prime in lowercase inducing no awareness of the prime on most of the trials and thus eliminating the possible confound of conscious processing (Forster, 1999), in the current study, for native speakers, the consciousness of the prime is somewhat high (28 out of 50), which could have contributed to the inhibitory effects in the opaque and form control conditions in English, as compared to the usual facilitative or null effects in previous studies with presentation of targets in uppercase (Diependaele et al., 2011; Feldman et al., 2012; Jacob & Kırkıcı, 2016). In the current study, both primes and targets are in lowercase, which could not be minimizing visual overlap to a smaller extent as many previous studies do, and which could be the reason leading to inhibitory effects in the form control conditions. Moreover, the findings of inhibitory priming in the current study, especially for the native English group, provided further support that superior linguistic abilities could sometimes be a detriment to performance (Hartshorne & Ullman, 2006; MacDonald, Just, & Carpenter, 1992). The Chinese and Vietnamese, as compared to the Turkish and English groups, may have different spelling abilities or perceptual acuity or automaticity of orthographic processing, thus inducing differential priming effects in the form control condition. The fact that the opaque and form conditions were inhibitive for English suggest semantic competition for English due to English speakers' higher quality of lexical representations (Perfetti, 2007; Perfetti & Hart, 2001, 2002), but not so much for Chinese. Especially the fact that morphological awareness and suffix complexity modulate the priming effects suggest decomposition for English and Turkish.

The results of the current study thus are consistent with Kirkici and Clahsen (2013) on their argument for subtler rather than superficial or obvious differences between L1 and L2 morphological processing and highlight the need against comparative fallacy (Bley-Vroman, 1983; Dekydtspotter, Schwartz, & Sprouse, 2006). The conclusion regarding the comparison between L1 and L2 morphological processing is not clear-cut similar or dissimilar; rather, the similarities and differences between L1 and L2 morphological processing, and even further, among L2 groups with different L1s, reflect intricacies of various other factors, such as reading profile, reading speed, and automaticity of orthographic processing, etc.

11.2.2 Educational implications

The educational implications for native speakers are that by instruction on morphemes we can improve literacy growth for both hearing and deaf students (Bowers et al., 2010; Carlisle, 2010; Nielsen, Luetke, & Stryker, 2011; Nunes, Bryant, Pretzlik, & Hurry, 2006). Bowers et al. (2010) and Carlisle (2010) both gave a comprehensive review of effects of morphological instruction on the development of literacy skills, including reading, spelling, vocabulary, word meaning, and morphological skills, and confirmed the benefit of morphological instruction for learners, especially less able learners, and most notably on students' understanding of morphemic structure, spelling, and meaning of written words.

In the context of second language acquisition, the educational implications are that the current study has convincingly revealed L1 differences in both morphological awareness and morphological processing. These results support approaches promoting L2 morphological awareness for morphologically isolating languages like Chinese or Vietnamese, by spending more class time on morphological instruction, such that morphological instruction can benefit L2 learners in both their acquisition process and their on-line processing. To incorporate more word study into reading and spelling programs where attention is brought to focus to both form and meaning (Carlisle, 2003) is very likely to benefit L2 acquisition as well. First, L2 instruction on new derived forms could make use of analogy of the specific suffix family, by providing students with other base forms that the same suffix attaches to, and highlighting the orthographic and semantic relationships between the base and the derived forms that are common across all examples of the base forms. During this process, L2 learners could become more aware of morphological relationships of the base and the derived word, and also realize and be more attentive to suffixes within complex word forms, thus improving the lexical quality of the representations by strengthening links between morphology and semantics and between morphology and orthography/phonology of the lexical entry. Second, specific instructions on selectional constraints and ordering requirements of English affixes could also contribute to depth of suffix processing of the complex words.

APPENDIX A

STIMULI FOR THE MASKED PRIMING LEXICAL DECISION TASK

Table 6. List 1 materials in the masked priming lexical decision study.

Condition	SS	Prime	Target	Ortho alternation	Phono alternation
pseudo-stem	ace	surface	surf		
pseudo-stem	adox	paradox	par		
pseudo-stem	alogue	catalogue	cat		
pseudo-stem	at	combat	comb		
pseudo-stem	bo	placebo	place		
pseudo-stem	ce	force	for		
pseudo-stem	ce	pierce	pier		
pseudo-stem	ce	source	sour		
pseudo-stem	ch	branch	bran		
pseudo-stem	ch	search	sear		
pseudo-stem	cott	boycott	boy		
pseudo-stem	ct	direct	dire		
pseudo-stem	ct	extract	extra		

pseudo-stem	e	corpse	corps
pseudo-stem	e	quite	quit
pseudo-stem	e	severe	sever
pseudo-stem	ect	dialect	dial
pseudo-stem	gain	bargain	bar
pseudo-stem	galow	bungalow	bun
pseudo-stem	ge	scourge	scour
pseudo-stem	hesis	parenthesis	parent
pseudo-stem	itude	aptitude	apt
pseudo-stem	kle	twinkle	twin
pseudo-stem	l	easel	ease
pseudo-stem	mn	solemn	sole
pseudo-stem	nie	brownie	brow
pseudo-stem	no	inferno	infer
pseudo-stem	orse	endorse	end
pseudo-stem	ow	fellow	fell
pseudo-stem	ress	buttress	butt
pseudo-stem	rse	diverse	dive
pseudo-stem	tle	bustle	bus
pseudo-stem	uct	product	prod
pseudo-stem	ve	believe	belie
pseudo-suffix	able	amenable	amen
pseudo-suffix	able	capable	cap

pseudo-suffix	age	hostage	host
pseudo-suffix	ate	candidate	candid
pseudo-suffix	ate	innate	inn
pseudo-suffix	ate	literate	liter
pseudo-suffix	ative	putative	put
pseudo-suffix	en	lateen	late
pseudo-suffix	en	pollen	poll
pseudo-suffix	ent	potent	pot
pseudo-suffix	er	brother	broth
pseudo-suffix	er	corner	corn
pseudo-suffix	er	flower	flow
pseudo-suffix	er	halter	halt
pseudo-suffix	er	ponder	pond
pseudo-suffix	er	tender	tend
pseudo-suffix	ible	fallible	fall
pseudo-suffix	ify	justify	just
pseudo-suffix	ion	section	sect
pseudo-suffix	ious	carious	car
pseudo-suffix	ise	promise	prom
pseudo-suffix	ish	perish	per
pseudo-suffix	let	scarlet	scar
pseudo-suffix	ling	dumpling	dump
pseudo-suffix	ly	lively	live

pseudo-suffix	ment	figment	fig		
pseudo-suffix	ment	pigment	pig		
pseudo-suffix	ness	witness	wit		
pseudo-suffix	or	tractor	tract		
pseudo-suffix	ry	country	count		
pseudo-suffix	ry	pantry	pant		
pseudo-suffix	sion	tension	ten		
pseudo-suffix	th	hearth	hear		
pseudo-suffix	y	tally	tall		
real-suffix	age	dosage	dose	Missing 'e'	No
real-suffix	age	postage	post	No	No
real-suffix	aryA	glossary	gloss	No	No
real-suffix	aryA	honorary	honor	No	No
real-suffix	en	loosen	loose	Sharing 'e'	No
real-suffix	en	shorten	short	No	No
real-suffix	er	dropper	drop	Double consonant	No
real-suffix	er	hunter	hunt	No	No
real-suffix	ery	bakery	bake	Missing 'e'	No
real-suffix	ery	cookery	cook	No	No
real-suffix	fulA	handful	hand	No	No
real-suffix	fulA	useful	use	No	Consonant Change
real-suffix	ian	guardian	guard	No	No
real-suffix	ian	librarian	library	Missing 'y'	Vowel change &

					Stress change
real-suffix	ish	bookish	book	No	No
real-suffix	ish	purplish	purple	Missing 'e'	No
real-suffix	ist	artist	art	No	No
real-suffix	ist	rapist	rape	Missing 'e'	No
real-suffix	ive	adoptive	adopt	No	No
real-suffix	ive	formative	form	Adding a	No
real-suffix	less	flawless	flaw	No	No
real-suffix	less	harmless	harm	No	No
real-suffix	lyAV	costly	cost	No	No
real-suffix	lyAV	duly	due	Missing 'e'	No
real-suffix	ment	argument	argue	Missing 'e'	No
real-suffix	ment	payment	pay	No	No
real-suffix	ness	readiness	ready	y to i	No
real-suffix	ness	richness	rich	No	No
real-suffix	ous	joyous	joy	No	No
real-suffix	ous	nervous	nerve	Missing 'e'	No
real-suffix	ship	friendship	friend	No	No
real-suffix	ship	hardship	hard	No	No
real-suffix	th	growth	grow	No	No
real-suffix	th	width	wide	Missing 'e'	Vowel change
unrelated	ace	palace	grim		
unrelated	ach	coach	spin		

unrelated	age	drainage	pill
unrelated	age	shrinkage	mass
unrelated	age	storage	bag
unrelated	age	village	mess
unrelated	age	wreckage	mile
unrelated	ake	shake	mist
unrelated	al	brutal	later
unrelated	al	legal	sand
unrelated	al	typical	rest
unrelated	ary	canary	secret
unrelated	aryA	budgetary	sum
unrelated	aryA	elementary	dub
unrelated	aryA	primary	diet
unrelated	ble	feeble	plate
unrelated	da	panda	bra
unrelated	e	code	them
unrelated	e	fare	glad
unrelated	el	label	colon
unrelated	elope	envelope	ant
unrelated	en	forbidden	sad
unrelated	en	quicken	man
unrelated	en	sweeten	deep
unrelated	en	toughen	list

unrelated	er	admirer	sweat
unrelated	er	builder	moth
unrelated	er	controller	loaf
unrelated	er	dancer	buy
unrelated	er	drummer	fact
unrelated	er	offer	cent
unrelated	er	smoker	win
unrelated	er	toaster	wand
unrelated	ery	bravery	nun
unrelated	ery	trickery	fish
unrelated	ew	askew	cash
unrelated	fulA	doubtful	bull
unrelated	fulA	faithful	pity
unrelated	fulA	mournful	hope
unrelated	g	thing	clan
unrelated	ian	historian	magic
unrelated	ian	physician	cord
unrelated	ian	technician	music
unrelated	io	patio	fat
unrelated	ish	childish	turn
unrelated	ish	girlish	snob
unrelated	ish	pinkish	fool
unrelated	ist	cyclist	ego

unrelated	ist	Sexist	harp
unrelated	it	digit	gen
unrelated	ite	petite	char
unrelated	ive	decisive	pass
unrelated	ive	excessive	act
unrelated	ive	expensive	add
unrelated	k	spank	than
unrelated	l	bowl	draw
unrelated	l	hazel	grave
unrelated	l	pearl	grove
unrelated	less	priceless	care
unrelated	lyAV	apply	dip
unrelated	lyAV	densely	huge
unrelated	lyAV	hourly	true
unrelated	lyAV	orderly	wear
unrelated	ment	amazement	judge
unrelated	ment	announcement	call
unrelated	ment	entertainment	plan
unrelated	n	crown	treat
unrelated	ness	mildness	mad
unrelated	ness	sickness	empty
unrelated	ney	kidney	access
unrelated	ous	continuous	vest

unrelated	ous	ridiculous	long
unrelated	ous	riotous	envy
unrelated	ow	best	will
unrelated	ow	yellow	shall
unrelated	p	clamp	cop
unrelated	ple	dimple	odor
unrelated	ple	ripple	spur
unrelated	r	tear	stud
unrelated	rol	patrol	exam
unrelated	se	expose	port
unrelated	se	prose	ban
unrelated	sel	diesel	prove
unrelated	sh	flush	since
unrelated	ship	citizenship	heal
unrelated	ship	fellowship	town
unrelated	ship	membership	king
unrelated	st	against	bell
unrelated	t	facet	beg
unrelated	t	sight	mode
unrelated	te	demote	pen
unrelated	ure	allure	feat
unrelated	ure	assure	overt
unrelated	ure	frothy	vent

unrelated	ure	mature	cult
unrelated	ure	wealthy	past
unrelated	urse	fuzzy	disco
unrelated	y	freaky	warm
unrelated	y	itchy	men
unrelated	ya	papaya	free
unrelated	ze	booze	star
unrelated	zle	martyr	bamboo

Table 7. List 2 materials in the masked priming lexical decision study.

Condition	SS	Prime	Target	Ortho alternation	Phono alternation
pseudo-stem	ace	grimace	grim		
pseudo-stem	ach	spinach	spin		
pseudo-stem	ake	mistake	mist		
pseudo-stem	au	plateau	plate		
pseudo-stem	cket	bracket	bra		
pseudo-stem	e	glade	glad		
pseudo-stem	e	plane	plan		
pseudo-stem	e	theme	them		
pseudo-stem	el	colonel	colon		
pseudo-stem	elope	antelope	ant		
pseudo-stem	etin	bulletin	bull		
pseudo-stem	ew	cashew	cash		

pseudo-stem	g	clang	clan
pseudo-stem	ige	vestige	vest
pseudo-stem	igue	fatigue	fat
pseudo-stem	ip	turnip	turn
pseudo-stem	k	thank	than
pseudo-stem	l	drawl	draw
pseudo-stem	l	gravel	grave
pseudo-stem	l	grovel	grove
pseudo-stem	loma	diploma	dip
pseudo-stem	ow	shallow	shall
pseudo-stem	ow	willow	will
pseudo-stem	ple	example	exam
pseudo-stem	quet	banquet	ban
pseudo-stem	rait	portrait	port
pseudo-stem	rb	proverb	prove
pseudo-stem	re	sincere	since
pseudo-stem	rn	modern	mode
pseudo-stem	rudge	begrudge	beg
pseudo-stem	urse	discourse	disco
pseudo-stem	ve	starve	star
pseudo-stem	ze	freeze	free
pseudo-stem	zle	bamboozle	bamboo
pseudo-suffix	age	manage	man

pseudo-suffix	age	massage	mass
pseudo-suffix	age	message	mess
pseudo-suffix	age	pillage	pill
pseudo-suffix	al	lateral	later
pseudo-suffix	al	sandal	sand
pseudo-suffix	ary	secretary	secret
pseudo-suffix	en	listen	list
pseudo-suffix	er	center	cent
pseudo-suffix	er	loafer	loaf
pseudo-suffix	er	mother	moth
pseudo-suffix	er	sweater	sweat
pseudo-suffix	er	wander	wand
pseudo-suffix	ial	cordial	cord
pseudo-suffix	ious	copious	cop
pseudo-suffix	ious	dubious	dub
pseudo-suffix	ious	spurious	spur
pseudo-suffix	ious	studious	stud
pseudo-suffix	itive	genitive	gen
pseudo-suffix	ity	charity	char
pseudo-suffix	ive	passive	pass
pseudo-suffix	ory	accessory	access
pseudo-suffix	ory	factory	fact
pseudo-suffix	ous	callous	call

pseudo-suffix	sion	pension	pen		
pseudo-suffix	th	health	heal		
pseudo-suffix	tion	mention	men		
pseudo-suffix	ure	culture	cult		
pseudo-suffix	ure	feature	feat		
pseudo-suffix	ure	overture	overt		
pseudo-suffix	ure	pasture	past		
pseudo-suffix	ure	venture	vent		
pseudo-suffix	y	belly	bell		
pseudo-suffix	y	weary	wear		
real-suffix	age	baggage	bag	Double consonant	No
real-suffix	age	mileage	mile	No	No
real-suffix	aryA	dietary	diet	No	No
real-suffix	aryA	summary	sum	Double consonant	No
real-suffix	en	deepen	deep	No	No
real-suffix	en	sadden	sad	Double consonant	No
real-suffix	er	buyer	buy	No	No
real-suffix	er	winner	win	Sharing 'e'	No
real-suffix	ery	fishery	fish	No	No
real-suffix	ery	nunnery	nun	Double consonant	No
real-suffix	fulA	hopeful	hope	No	No
real-suffix	fulA	pitiful	pity	y to i	No
real-suffix	ian	magician	magic	Missing 'y'	Vowel change &

					Stress change
real-suffix	ian	musician	music	No	Consonant change & Stress change
real-suffix	ish	foolish	fool	No	No
real-suffix	ish	snobbish	snob	Double consonant	No
real-suffix	ist	egotist	ego	Adding t	No
real-suffix	ist	harpist	harp	No	No
real-suffix	ive	active	act	No	No
real-suffix	ive	additive	add	Adding it	Vowel change & Stress change
real-suffix	less	careless	care	No	No
real-suffix	less	restless	rest	No	No
real-suffix	lyAV	hugely	huge	No	No
real-suffix	lyAV	truly	true	Missing 'e'	No
real-suffix	ment	judgment	judge	Missing 'e'	No
real-suffix	ment	treatment	treat	No	No
real-suffix	ness	emptiness	empty	y to i	No
real-suffix	ness	madness	mad	No	No
real-suffix	ous	envious	envy	Missing 'e'	Consonant change
real-suffix	ous	odorous	odor	No	No
real-suffix	ship	kingship	king	No	No
real-suffix	ship	township	town	No	No
real-suffix	th	length	long	No	Vowel change

real-suffix	th	warmth	warm	No	No
unrelated	able	sizable	amen		
unrelated	able	taxable	cap		
unrelated	ace	furnace	surf		
unrelated	ach	stomach	par		
unrelated	age	blockage	dose		
unrelated	age	damage	host		
unrelated	age	voyage	post		
unrelated	al	coastal	hard		
unrelated	al	refusal	corn		
unrelated	alogue	dialogue	cat		
unrelated	ance	acceptance	flow		
unrelated	aryA	evolutionary	ease		
unrelated	aryA	imaginary	gloss		
unrelated	aryA	momentary	honor		
unrelated	at	acrobat	comb		
unrelated	ate	palate	liter		
unrelated	ate	rotate	candid		
unrelated	ation	exploration	ten		
unrelated	b	blurb	put		
unrelated	ce	fleece	place		
unrelated	ce	peace	for		
unrelated	ce	piece	sour		

unrelated	ch	brunch	pier
unrelated	ch	punch	bran
unrelated	ch	thatch	sear
unrelated	dle	paddle	boy
unrelated	e	cube	quit
unrelated	e	pine	corps
unrelated	e	tape	sever
unrelated	ect	affect	dial
unrelated	en	darken	loose
unrelated	en	freshen	poll
unrelated	en	thicken	late
unrelated	en	whiten	short
unrelated	ent	absent	pot
unrelated	er	destroyer	pond
unrelated	er	eraser	hunt
unrelated	er	gardener	tend
unrelated	er	sober	broth
unrelated	er	steamer	drop
unrelated	er	taper	halt
unrelated	ery	mockery	prom
unrelated	ery	nursery	bake
unrelated	ery	slavery	cook
unrelated	fulA	cheerful	hand

unrelated	fulA	regretful	use
unrelated	gain	regain	bar
unrelated	ge	badge	bun
unrelated	he	bathe	parent
unrelated	ian	comedian	library
unrelated	ian	politician	guard
unrelated	ify	ramify	just
unrelated	io	ratio	sect
unrelated	ish	dampish	per
unrelated	ish	punish	book
unrelated	ish	selfish	purple
unrelated	ist	novelist	rape
unrelated	ist	stylist	art
unrelated	ity	nudity	apt
unrelated	ity	obesity	fall
unrelated	ive	attentive	form
unrelated	ive	attractive	brow
unrelated	ive	descriptive	dire
unrelated	ive	evasive	adopt
unrelated	kle	ankle	twin
unrelated	less	effortless	flaw
unrelated	less	stainless	harm
unrelated	let	tablet	scar

unrelated	ly	early	dump
unrelated	lyAV	locally	due
unrelated	lyAV	specially	inn
unrelated	lyAV	weekly	cost
unrelated	ment	adjustment	scour
unrelated	ment	assessment	pig
unrelated	ment	attachment	fig
unrelated	ment	equipment	argue
unrelated	ment	harassment	butt
unrelated	ne	prone	pay
unrelated	ness	deafness	ready
unrelated	ness	neatness	wit
unrelated	ness	slimness	rich
unrelated	on	surgeon	tract
unrelated	ot	bigot	end
unrelated	ot	robot	infer
unrelated	ous	dangerous	joy
unrelated	ous	fibrous	nerve
unrelated	p	hemp	car
unrelated	re	whore	fell
unrelated	ship	authorship	friend
unrelated	ship	scholarship	sole
unrelated	t	comet	pant

unrelated	t	paint	dive
unrelated	t	planet	count
unrelated	th	sixth	grow
unrelated	th	teeth	hear
unrelated	ure	closure	live
unrelated	ure	legislature	extra
unrelated	x	latex	wide
unrelated	y	filthy	prod
unrelated	y	fluffy	bus
unrelated	y	gloomy	tall
unrelated	y	speedy	belie

Table 8. Non-words materials in the masked priming lexical decision study.

Condition	SS	Prime	Target
string	my	academy	acade
string	ce	advance	advan
string	gy	allergy	aller
string	dy	already	alrea
string	na	antenna	anten
string	pt	attempt	attem
string	ue	avenue	aven
string	na	banana	bana
string	ave	bereave	bere

string	om	blossom	bloss
string	ce	bounce	boun
string	bon	bourbon	bour
string	ge	bridge	brid
string	us	cactus	cact
string	ndar	calendar	cale
string	el	caramel	caram
string	ney	chimney	chim
string	ch	church	chur
string	ch	clench	clen
string	ective	collective	coll
string	uct	conduct	cond
string	ble	crumble	crum
string	ew	curfew	curf
string	sit	deposit	depo
string	ert	dessert	dess
string	ination	destination	dest
string	ch	detach	deta
string	urb	disturb	dist
string	ow	follow	foll
string	ge	fridge	frid
string	ce	glance	glan
string	met	gourmet	gour

string	e	hinge	hing
string	ow	hollow	holl
string	se	intense	inten
string	ch	launch	laun
string	ow	mellow	mell
string	rative	narrative	nar
string	e	nope	nop
string	ril	nostril	nost
string	ge	orange	oran
string	icure	pedicure	ped
string	imistic	pessimistic	pess
string	ge	plunge	plun
string	ict	predict	pred
string	bit	rabbit	rab
string	iate	retaliate	retal
string	ual	ritual	rit
string	om	seldom	seld
string	ar	seminar	semin
string	p	shrimp	shrim
string	ch	sketch	sket
string	der	slander	slan
string	der	slender	slen
string	ge	smudge	smud

string	ce	stance	stan
string	ma	stigma	stig
string	k	stink	stin
string	ge	strange	stran
string	ow	swallow	swall
string	ve	swerve	swer
string	ch	switch	swit
string	em	system	syst
string	her	thither	thit
string	dy	trendy	tren
string	oil	turmoil	turm
string	are	welfare	welf
string	erday	yesterday	yest
suffix	on	abandon	aband
suffix	en	abdomen	abdom
suffix	ish	abolish	abol
suffix	al	animal	anim
suffix	ive	arrive	arr
suffix	er	banter	bant
suffix	ish	blemish	blem
suffix	er	border	bord
suffix	en	burden	burd
suffix	le	candle	cand

suffix	al	capital	capit
suffix	ish	cherish	cher
suffix	le	chortle	chort
suffix	ify	clarity	clar
suffix	ate	climate	clim
suffix	er	cluster	clust
suffix	age	courage	cour
suffix	ard	custard	cust
suffix	ing	darling	darl
suffix	ent	dissent	diss
suffix	ey	donkey	donk
suffix	ic	drastic	drast
suffix	ent	eminent	emin
suffix	ion	emotion	emot
suffix	ate	emulate	emul
suffix	ent	evident	evid
suffix	er	feather	feath
suffix	er	filter	filt
suffix	er	finger	fing
suffix	er	foster	fost
suffix	al	frugal	frug
suffix	le	gamble	gamb
suffix	ic	garlic	garl

suffix	ent	garment	garm
suffix	er	gender	gend
suffix	er	ginger	ging
suffix	le	grumble	grumb
suffix	ic	hectic	hect
suffix	one	hormone	horm
suffix	le	humble	humb
suffix	le	hurdle	hurd
suffix	le	hustle	hust
suffix	le	knuckle	knuck
suffix	ate	mandate	mand
suffix	le	mantle	mant
suffix	in	margin	marg
suffix	ic	mystic	myst
suffix	ion	nation	nat
suffix	ty	naughty	naugh
suffix	ar	nectar	nect
suffix	ing	nothing	noth
suffix	ure	nurture	nurt
suffix	ent	opulent	opul
suffix	er	panther	panth
suffix	end	pretend	pret
suffix	le	ramble	ramb

suffix	ify	rectify	rect
suffix	ative	sedative	sed
suffix	ar	stellar	stell
suffix	ile	sterile	ster
suffix	id	stupid	stup
suffix	ent	torment	torm
suffix	ic	tragic	trag
suffix	ity	trinity	trin
suffix	ey	valley	vall
suffix	ory	victory	vict
suffix	er	weather	weath
suffix	er	winter	wint
Unrelated		oily	beal
Unrelated		guilty	bink
Unrelated		fussy	brate
Unrelated		loser	brun
Unrelated		waken	bry
Unrelated		writer	cest
Unrelated		killer	ceter
Unrelated		global	dind
Unrelated		singer	eare
Unrelated		birth	eath
Unrelated		sanity	esate

Unrelated	merger	frint
Unrelated	heater	gake
Unrelated	thorny	gare
Unrelated	harden	gez
Unrelated	scenic	glush
Unrelated	helper	gon
Unrelated	oddity	hent
Unrelated	sugary	hesk
Unrelated	trader	hince
Unrelated	sicken	kest
Unrelated	feeder	kined
Unrelated	speaker	kint
Unrelated	revival	laste
Unrelated	fighter	lert
Unrelated	wrongly	lind
Unrelated	awesome	linew
Unrelated	chaotic	lote
Unrelated	seizure	lut
Unrelated	learner	mape
Unrelated	abusive	marer
Unrelated	clearly	nath
Unrelated	painful	nink
Unrelated	printer	noll

Unrelated	pleasant	nore
Unrelated	organic	pab
Unrelated	exactly	pag
Unrelated	rigidly	pesin
Unrelated	removal	pite
Unrelated	security	pon
Unrelated	lighter	prall
Unrelated	socially	rarm
Unrelated	abruptly	rast
Unrelated	publicly	rell
Unrelated	politely	rin
Unrelated	athletic	rine
Unrelated	scarcity	rone
Unrelated	composer	sar
Unrelated	moisture	sich
Unrelated	betrayal	sind
Unrelated	magnetic	slare
Unrelated	tiresome	sline
Unrelated	virtuous	soin
Unrelated	reliance	sone
Unrelated	fiercely	staw
Unrelated	merciful	stereas
Unrelated	beginner	storst

Unrelated	motorist	tay
Unrelated	humidity	tean
Unrelated	breakage	tet
Unrelated	motivate	thrig
Unrelated	alienate	tix
Unrelated	classify	trelt
Unrelated	lustrous	vare
Unrelated	simplify	vite
Unrelated	rental	wone
Unrelated	brighten	yine
Unrelated	theorize	zat

APPENDIX B

STIMULI FOR THE MORPHOLOGICAL AWARENESS AND ORTHOGRAPHIC AWARENESS TASKS

B.1 DERIVATION TASK

Welcome to this section. In this section, you are asked to complete a sentence with the correct form of a given word.

For example:

Given word: help

My sister is always __.

The correct form should be "helpful". Type in your answer using the keyboard. The word that you type in will show up below the sentence line. You can use Backspace to edit. After you finish typing, press the Enter key.

Table 9. Materials for the derivation task.

#	Suffix	Given word	Sentence	CorrectResponse
1	able	profit	Selling lemonade in summer is __.	profitable
2	able	remark	The speed of the car was __.	remarkable

3	ance	assist	The teacher will give you __.	assistance
4	ance	perform	Tonight is the last __.	performance
5	er	swim	She was a strong __.	swimmer
6	er	wash	Put the laundry in the __.	washer
7	ion/tion	absorb	She chose the sponge for its __.	absorption
8	ion/tion	expand	The company planned an __.	expansion
9	ity	human	The kind man was known for his __.	humanity
10	ous/ious	mystery	The dark glasses made the man look __.	mysterious
11	th	long	They measured the ladder's __.	length
12	th	warm	He chose the jacket for its __.	warmth

B.2 MULTIPLE CHOICE WORD TASK

Welcome to this section. In this section, you will be asked to select one from four choices to complete a given sentence.

For example:

Jone wants to make a good __ on his date.

a. impressive

b. impressionable

c. impression

d. impressively

You should press "c" on the keyboard because "impression" is the only word of the four choices to make a grammatical and meaningful sentence.

Table 10. Materials for the multiple choice word task.

Sentence	a	b	c	d	CR
Age improved his __.	personality	personal	personify	personalize	a
He received __ questioning.	intensive	intensity	intensify	intensification	a
It is impossible to __ people's thoughts.	legislate	legislative	legislature	legislation	a
She's very __ when she is encouraged.	industrious	industry	industrialize	industrialization	a
You have played an __ part in the project.	instrumental	instrumentation	instrumentality	instrument	a
Watch carefully. I will __.	demonstrate	demonstrative	demonstration	demonstrable	a
He's always going to meetings. He's an __.	active	activist	activate	activity	b
Those two dogs are almost __.	identity	identical	identify	identification	b
He likes to __ his desires.	gratification	gratify	gratuity	grateful	b
The __ of their approach prevented	systematic	systematicity	systematize	systematically	b

many errors.					
She is an __ in environmental issues.	actively	activist	activation	activate	b
They planned to __ the entire island.	colonist	colonize	colonial	colonization	b
The country has a __ of about 100,000.	popular	popularity	popularize	population	b
Please don’t be so __.	criticism	criticize	critical	critically	c
A famous doctor performed the __.	operative	operational	operation	operationalize	c
They need to __ their methods.	diversity	diversion	diversify	diversionary	c
His __ behavior destroyed his family.	adultery	adulterate	adulterous	adulterousness	c
You can't __ results from studies done only on rats to humans.	generalization	generality	generalize	generalizable	c
He was too tired to be __.	production	produce	productive	productivity	c
She ignored the	dead	deadly	deadness	deaden	c

feeling of __ in her feet.					
Farmers __ their fields.	fertilizer	fertility	fertilization	fertilize	d
__ birds fly from the north to the south in the fall.	migration	migratory	migrate	migrational	d
Does the city __ the traffic?	regular	regularity	regulation	regulate	d
The cost of __ keeps going up.	electric	electrify	electrical	electricity	d
They should __ the dry room.	humidity	humid	humidifier	humidify	d
The sunrise was so __ yesterday morning.	glorify	glorification	gloriousness	glorious	d

B.3 MULTIPLE CHOICE NON-WORD TASK

Welcome to this section. This section is similar to the one you have just completed, except that in this section, the four answer choices are not real words. They are nonsense words. Nevertheless, one of the four choices makes a good sentence. The other three do not. Read each sentence and decide which choice is the best one to fill in the blank.

Table 11. Materials for the multiple choice non-word task.

Sentence	a	b	c	d	CR
You can't even begin to __.	equamanize	equamanizable	equamanity	equamanive	a
He was not very__.	crepentive	crepentification	crepenticism	crepentify	a
He is a well-known __.	circumtarious	circumtarist	circumtarify	circumtarize	a
Too much __ is bad.	malburnity	malburnify	malburnicious	malburnable	a
They __ their house every year.	genilify	genility	genilification	geniliar	a
She met her first __.	benedumptist	benedumptify	benedumptize	benedumptuous	a
The new tool can __ things quickly.	transurbate	transurbativity	transurbatist	transurbative	a
In spite of his __, he did a good job.	dispribize	dispribation	dispribational	dispribify	b
Desert	commalianization	commalious	commalianism	commalianize	b

animals are not normally __.					
They hope to __ them.	niromosity	niromify	niromous	niromative	b
I do not like __ people.	froodify	froodful	frooden	froodness	b
The place was very __.	loquarify	loquarial	loquarialize	loquarialism	b
He is __.	torbatify	torbative	torbativize	torbature	b
You must __ them quickly.	premanicism	premanicize	premanicity	premanic	b
They __ the data in the office.	curfamic	curfamation	curfamate	curfamity	c
He is so __.	dictopithify	dictopithification	dictopithial	dictopithity	c
Please try to be as __ as possible.	prolenalism	prolenalize	prolenious	prolenify	c
We should __ that money by the end of the year.	laptification	laptian	laptify	laptable	c

They were stopped by a sudden __.	postramify	postramic	postramity	postramicize	c
Everyone hated her __.	spectitious	spectitionalize	spectition	spectitive	c
The car is too __.	birendment	birendalize	birendify	birendal	d
All those models are too __.	lemptify	lemptness	lemptity	lemptive	d
He wants to __ while he still can.	moration	morative	morational	morate	d
Please __ these forms.	rumptist	rumptious	rumptian	rumptize	d
Everyone dislikes the old __.	vergalize	vergalicious	vergalify	vergalist	d
I like his __.	sufilize	sufilial	sufilify	sufilation	d

B.4 RELATEDNESS TASK

In this section, you are asked to decide whether two words are related. Press "f" if you think they are not related. Press "j" if you think they are related.

For example, if you see a word pair:

happy happiness

You should press "j" because "happy" and "happiness" are related. "happiness" comes from "happy".

However, if you see a word pair:

cat catalog

You should press "f" because "cat" and "catalog" are not related. "cat" has nothing to do with "catalog". It is just by accident that the words start with the same letters.

Table 12. Materials for the relatedness task.

Condition	Word1	Word2	CR
I. Neutral: No change in spelling/pronunciation due to derivation	region	regional	j
I. Neutral: No change in spelling/pronunciation due to derivation	allow	allowance	j
I. foil	ill	illegal	f
I. foil	let	letter	f
II. Stress Shift and Vowel Change:	superior	superiority	j
II. Stress Shift and Vowel Change:	history	historic	j
II. foil	general	generosity	f
II. foil	humor	humanity	f
III. Vowel Change	deep	depth	j

III. Vowel Change	supervise	supervision	j
III. foil	major	magic	f
III. foil	ear	earth	f
IV. Consonant Change:	associate	association	j
IV. Consonant Change:	divide	division	j
IV. foil	import	impression	f
IV. foil	insult	insulation	f
V. Silent Letter:	sign	signature	j
V. Silent Letter:	crumb	crumble	j
V. foil	numb	numbers	f
V. foil	comb	combination	f

B.5 SUFFIX ORDERING TASK

In this section, you will decide whether a string of letters is an English word or not. Press "j" if it is an English word. Press "f" if it is not an English word.

Table 13. Materials for the suffix-ordering task.

string of letters	CorrectResponseSuffixOrd
painfulity	f
shamefulize	f
motoristal	f
vocalistive	f

royalistous	f
harmlessity	f
happinessal	f
sicknessic	f
deafnessive	f
brightnessous	f
readinessy	f
adaptableate	f
forgivableful	f
globalable	f
peachfulal	f
cubicable	f
hostilityly	f
theorizeless	f
carelessal	f
politelyive	f
wronglyize	f
continuousful	f
adaptability	j
respectablize	j
admirably	j
dependableness	j
emotionalist	j

normalize	j
typically	j
accidentalness	j
classicist	j
romanticize	j
graphicness	j
artistic	j
touristy	j
activist	j
collectivize	j
passively	j
competitiveness	j
memorizable	j
dangerously	j
nervousness	j
luckily	j
cloudiness	j

B.6 ORTHOGRAPHIC AWARENESS TASK

In this section, you are asked to choose from a pair of non-words the one that looks more like an English word. Press "f" if the left one looks more like an English word. Press "j" if the right one looks more like an English word.

For example, if you see a pair:

ib yb

You should press "f" because "ib" looks more like an English word than "yb".

However, if you see a pair:

ukko ullo

You should press "j" because "ullo" looks more like an English word than "ukko".

Table 14. Materials for the orthographic awareness task.

OrthoLeft	OrthoRight	CorrectResponseOrthoAware
uhha	udda	j
damiff	ddamif	f
bahh	baff	j
jjus	juss	j
eppi	ejji	f
viss	viww	f
vvil	vill	j
yatuff	yyatuf	f
aut	awt	f
daw	dau	f
moyl	moil	j
bei	bey	j
gry	gri	f
chym	chim	j
nuck	ckun	f

ckader	dacker	j
stee	staa	f
haak	heek	j
brii	bree	j
meer	miir	f
sloo	slaa	f
gaat	goot	j
plii	ploo	j
woor	wiir	f
trath	thatr	f
cheefr	freech	j
bofl	flob	j
prush	shupr	f
pitw	twip	j
nilt	ltin	f
ndow	wond	j
larn	rnal	f
ptam	mapt	j
pumb	mbup	f

APPENDIX C

LANGUAGE HISTORY QUESTIONNAIRE

1. Participant ID

____

2. Age

____

3. Sex

____

4. Education

____

5. Native language(s) (If you grew up with more than one language, please specify)

____

6. Country of Birth

____

7. Which country where you currently live: ________________ since: ________________

8. If you have lived or traveled in countries other than your country of residence or country of origin for three or more months, then indicate the name of the country, your length of stay, the language you used, and the frequency of your use of the language for each country.

Country	Length of stay	Language	Frequency of use

9. Indicate the language used by your teachers for instruction at each educational level. If the instructional language switched during any educational level, then also indicate the "Switched to" language.

Language	(Switched to)
Elementary school	
Middle school	
High school	
College/university	
Graduate school	

10. List below **ALL** the languages you know, **from most fluent to least fluent**. Also specify the **age** when you began to learn the language, **how many years** have you been learning it, the

context in which you have learned it, and also **rate** your reading, writing, listening, and speaking abilities in that language on the following scale of 1-7.

1 very poor   2 poor   3 fair   4 functional   5 good   6 very good 7 native-like

Include all languages to which you have been exposed, although you may never have had formal training in them and may not be able to read, speak or write them.

Please remember to list your native language. For example, "English, 0, 20, home and school, 7, 7, 7, 7".

Language	Beginning Age	# of years of learning	Learning context	reading	writing	listening	speaking

11. If you have taken any standardized language proficiency tests (e.g., TOEFL), then indicate the name of the test, the language assessed, and the score you received for each. If you do not remember the exact score, then indicate an "Approximate score" instead.

Test	Language	Score	(Approximate score)

12. In the beginning of the study, you completed a task in which you decided whether a string of English letters was an English word or not. In each trial, first a string of hash signs were shown, and then you were shown a string of English letters. Did you see anything after the presentation of the hash signs and before the presentation of the string of English letters? If you did see something, what was it?

____

13. To ensure the comparability and validity of the study, we would like to ask our participants not to share any information about the content or purpose of the study to other people. Please check yes to confirm that you will not share any information about the content or purpose of the study with other people.

YES

NO

APPENDIX D

MODEL SUMMARY RESULTS

Table 15. Consciousness LRT Model summary for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.495	0.020	61.000	327.501	<2e-16	***
form	0.018	0.012	72.000	1.554	0.125	
opaque	0.016	0.011	126.000	1.454	0.148	
morph	-0.033	0.009	143.000	-3.516	0.001	***
Consciousnessyes	-0.031	0.026	48.000	-1.204	0.235	
ZLexTALE	0.005	0.012	48.000	0.412	0.682	
ZPrevLRT	0.022	0.002	8757.000	9.101	<2e-16	***
PrevACC1	-0.022	0.006	8723.000	-3.440	0.001	***
ZTrialNum	-0.008	0.002	8728.000	-3.878	0.000	***
ZPrimeOrtho_N	0.007	0.004	6646.000	1.541	0.123	
ZPrimePhono_N	-0.007	0.004	4831.000	-1.712	0.087	.
ZPrimeBG_Sum	0.006	0.007	6702.000	0.936	0.349	
ZPrimeBG_Mean	-0.004	0.006	6568.000	-0.554	0.580	

ZPrimeBG_Freq_By_Pos	0.001	0.005	6038.000	0.302	0.763	
ZTargetOrtho_N	-0.021	0.010	180.000	-2.017	0.045	*
ZTargetPhono_N	0.002	0.010	180.000	0.214	0.831	
form:Consciousnessyes	0.001	0.014	48.000	0.071	0.944	
opaque:Consciousnessyes	0.004	0.013	86.000	0.263	0.793	
morph:Consciousnessyes	-0.019	0.012	103.000	-1.634	0.105	

Table 16. The Consciousness ACC model summary for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.456	0.200	17.316	<2e-16	***
form	-0.869	0.185	-4.691	2.72e-06	***
opaque	-0.553	0.173	-3.202	0.001	**
morph	0.600	0.281	2.136	0.033	*
Consciousnessyes	-0.057	0.206	-0.276	0.782	
ZLexTALE	0.241	0.091	2.645	0.008	**
ZPrevLRT	0.096	0.032	2.948	0.003	**
PrevACC1	-0.428	0.117	-3.657	0.000	***
ZTrialNum	-0.119	0.037	-3.239	0.001	**
ZPrimeOrtho_N	0.035	0.072	0.489	0.625	
ZPrimePhono_N	-0.037	0.072	-0.515	0.606	
ZPrimeBG_Sum	0.207	0.124	1.673	0.094	.
ZPrimeBG_Mean	-0.249	0.112	-2.226	0.026	*
ZPrimeBG_Freq_By_Pos	-0.010	0.087	-0.113	0.910	

ZTargetOrtho_N	0.089	0.189	0.470	0.639	
ZTargetPhono_N	0.054	0.187	0.290	0.772	
form:Consciousnessyes	-0.142	0.218	-0.651	0.515	
opaque:Consciousnessyes	-0.379	0.205	-1.847	0.065	.
morph:Consciousnessyes	-0.223	0.325	-0.686	0.493	

Table 17. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for English for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.485	0.013	75.000	492.275	<2e-16	***
form	0.016	0.008	140.000	1.926	0.056	.
opaque	0.018	0.008	190.000	2.207	0.028	*
morph	-0.044	0.007	197.000	-6.434	9.25e-10	***
ZLexTALE	0.001	0.011	48.000	0.136	0.892	
ZPrevLRT	0.046	0.006	52.000	7.337	1.47e-09	***
PrevACC1	-0.022	0.007	53.000	-3.153	0.003	**
ZTrialNum	-0.008	0.003	49.000	-2.162	0.036	*
ZPrimeOrtho_N	0.006	0.004	6735.000	1.401	0.161	
ZPrimePhono_N	-0.006	0.004	4956.000	-1.531	0.126	
ZPrimeBG_Sum	0.007	0.007	6791.000	0.996	0.319	
ZPrimeBG_Mean	-0.003	0.006	6659.000	-0.470	0.638	
ZPrimeBG_Freq_By_Pos	0.001	0.005	6146.000	0.236	0.813	
ZTargetOrtho_N	-0.022	0.010	180.000	-2.171	0.031	*

ZTargetPhono_N	0.004	0.010	180.000	0.365	0.716	
form:ZLexTALE	0.009	0.007	75.000	1.330	0.187	
opaque:ZLexTALE	0.001	0.007	140.000	0.159	0.874	
morph:ZLexTALE	-0.007	0.006	168.000	-1.145	0.254	

Table 18. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for English for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.503	0.016	75.000	399.243	<2e-16	***
form	-0.002	0.011	172.000	-0.171	0.864	
morph	-0.062	0.011	187.000	-5.878	1.87e-08	***
unrelated	-0.018	0.008	190.000	-2.207	0.028	*
ZLexTALE	0.003	0.014	50.000	0.185	0.854	
ZPrevLRT	0.046	0.006	52.000	7.337	1.46e-09	***
PrevACC1	-0.022	0.007	53.000	-3.153	0.003	**
ZTrialNum	-0.008	0.003	49.000	-2.162	0.036	*
ZPrimeOrtho_N	0.006	0.004	6735.000	1.401	0.161	
ZPrimePhono_N	-0.006	0.004	4956.000	-1.531	0.126	
ZPrimeBG_Sum	0.007	0.007	6791.000	0.996	0.319	
ZPrimeBG_Mean	-0.003	0.006	6659.000	-0.470	0.638	
ZPrimeBG_Freq_By_Pos	0.001	0.005	6146.000	0.236	0.813	
ZTargetOrtho_N	-0.022	0.010	180.000	-2.171	0.031	*
ZTargetPhono_N	0.004	0.010	180.000	0.365	0.716	

form:ZLexTALE	0.008	0.008	59.000	0.970	0.336
morph:ZLexTALE	-0.008	0.008	92.000	-0.972	0.334
unrelated:ZLexTALE	-0.001	0.007	140.000	-0.159	0.874

Table 19. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for English for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.424	0.163	20.941	<2e-16	***
form	-0.952	0.140	-6.809	9.83e-12	***
opaque	-0.766	0.131	-5.867	4.44e-09	***
morph	0.507	0.216	2.347	0.019	*
ZLexTALE	0.246	0.095	2.604	0.009	**
ZPrevLRT	0.096	0.032	2.946	0.003	**
PrevACC1	-0.428	0.117	-3.654	0.000	***
ZTrialNum	-0.119	0.037	-3.233	0.001	**
ZPrimeOrtho_N	0.036	0.072	0.497	0.619	
ZPrimePhono_N	-0.038	0.072	-0.521	0.602	
ZPrimeBG_Sum	0.207	0.124	1.671	0.095	.
ZPrimeBG_Mean	-0.249	0.112	-2.226	0.026	*
ZPrimeBG_Freq_By_Pos	-0.010	0.087	-0.113	0.910	
ZTargetOrtho_N	0.089	0.188	0.474	0.636	
ZTargetPhono_N	0.053	0.187	0.286	0.775	
form:ZLexTALE	-0.072	0.106	-0.684	0.494	

opaque:ZLexTALE	-0.074	0.101	-0.735	0.462	
morph:ZLexTALE	0.058	0.149	0.387	0.699	

Table 20. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for English for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.658	0.189	14.050	<2e-16	***
form	-0.186	0.166	-1.123	0.261	
morph	1.273	0.245	5.193	2.07e-07	***
unrelated	0.766	0.131	5.867	4.43e-09	***
ZLexTALE	0.172	0.117	1.472	0.141	
ZPrevLRT	0.096	0.032	2.946	0.003	**
PrevACC1	-0.428	0.117	-3.654	0.000	***
ZTrialNum	-0.119	0.037	-3.233	0.001	**
ZPrimeOrtho_N	0.036	0.072	0.497	0.619	
ZPrimePhono_N	-0.038	0.072	-0.521	0.602	
ZPrimeBG_Sum	0.207	0.124	1.671	0.095	.
ZPrimeBG_Mean	-0.249	0.112	-2.226	0.026	*
ZPrimeBG_Freq_By_Pos	-0.010	0.087	-0.113	0.910	
ZTargetOrtho_N	0.089	0.188	0.474	0.636	
ZTargetPhono_N	0.053	0.187	0.286	0.775	
form:ZLexTALE	0.002	0.106	0.020	0.984	
morph:ZLexTALE	0.132	0.160	0.826	0.409	

unrelated:ZLexTALE	0.074	0.101	0.735	0.462

Table 21. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Turkish for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.632	0.017	68.000	399.110	<2e-16	***
form	0.002	0.011	88.000	0.213	0.832	
opaque	0.003	0.010	96.000	0.297	0.767	
morph	-0.062	0.009	96.000	-6.952	4.37e-10	***
ZLexTALE	-0.009	0.011	35.000	-0.829	0.412	
ZPrevLRT	0.032	0.005	35.000	6.478	1.85e-07	***
PrevACC1	-0.011	0.009	42.000	-1.207	0.234	
ZTrialNum	-0.017	0.006	40.000	-2.932	0.006	**
ZPrimeOrtho_N	-0.005	0.005	6231.000	-1.032	0.302	
ZPrimePhono_N	0.000	0.005	5198.000	0.027	0.979	
ZPrimeBG_Sum	-0.008	0.008	6233.000	-0.962	0.336	
ZPrimeBG_Mean	0.002	0.008	6093.000	0.256	0.798	
ZPrimeBG_Freq_By_Pos	0.007	0.006	5725.000	1.222	0.222	
ZTargetOrtho_N	-0.025	0.013	186.000	-1.941	0.054	.
ZTargetPhono_N	0.005	0.013	186.000	0.422	0.674	
form:ZLexTALE	0.005	0.009	58.000	0.547	0.586	
opaque:ZLexTALE	0.011	0.009	50.000	1.226	0.226	
morph:ZLexTALE	-0.007	0.008	84.000	-0.866	0.389	

Table 22. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Turkish for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.636	0.019	72.000	355.744	<2e-16	***
form	-0.001	0.013	147.000	-0.116	0.908	
morph	-0.068	0.013	109.000	-5.057	1.73e-06	***
unrelated	-0.003	0.010	86.000	-0.344	0.732	
ZLexTALE	-0.001	0.016	40.000	-0.074	0.941	
ZPrevLRT	0.013	0.002	7129.000	5.663	1.54e-08	***
PrevACC1	-0.015	0.007	7112.000	-2.156	0.031	*
ZTrialNum	-0.018	0.003	7110.000	-6.991	2.97e-12	***
ZPrimeOrtho_N	-0.005	0.005	6163.000	-0.941	0.347	
ZPrimePhono_N	0.000	0.005	5086.000	-0.018	0.986	
ZPrimeBG_Sum	-0.007	0.008	6167.000	-0.907	0.364	
ZPrimeBG_Mean	0.000	0.008	6016.000	0.062	0.950	
ZPrimeBG_Freq_By_Pos	0.008	0.006	5628.000	1.436	0.151	
ZTargetOrtho_N	-0.025	0.013	186.000	-1.987	0.048	*
ZTargetPhono_N	0.006	0.013	186.000	0.437	0.663	
form:ZLexTALE	-0.002	0.010	42.000	-0.257	0.799	
morph:ZLexTALE	-0.019	0.011	42.000	-1.738	0.089	.
unrelated:ZLexTALE	-0.012	0.008	40.000	-1.433	0.160	

Table 23. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Turkish for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.032	0.180	16.871	<2e-16	***
form	-0.247	0.153	-1.612	0.107	
opaque	-0.286	0.142	-2.014	0.044	*
morph	0.740	0.209	3.540	0.000	***
ZLexTALE	0.458	0.105	4.340	1.42e-05	***
ZPrevLRT	0.018	0.035	0.508	0.612	
PrevACC1	-0.179	0.106	-1.696	0.090	.
ZTrialNum	-0.128	0.038	-3.372	0.001	***
ZPrimeOrtho_N	0.081	0.076	1.069	0.285	
ZPrimePhono_N	-0.112	0.079	-1.414	0.157	
ZPrimeBG_Sum	0.114	0.122	0.933	0.351	
ZPrimeBG_Mean	-0.138	0.113	-1.229	0.219	
ZPrimeBG_Freq_By_Pos	0.073	0.087	0.839	0.401	
ZTargetOrtho_N	0.332	0.218	1.527	0.127	
ZTargetPhono_N	-0.090	0.214	-0.421	0.674	
form:ZLexTALE	-0.175	0.125	-1.400	0.161	
opaque:ZLexTALE	-0.063	0.124	-0.512	0.609	
morph:ZLexTALE	0.231	0.161	1.436	0.151	

Table 24. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Turkish for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.746	0.203	13.546	<2e-16	***
form	0.038	0.181	0.212	0.832	
morph	1.025	0.239	4.295	1.75e-05	***
unrelated	0.286	0.142	2.014	0.044	*
ZLexTALE	0.394	0.123	3.200	0.001	**
ZPrevLRT	0.018	0.035	0.508	0.612	
PrevACC1	-0.179	0.106	-1.696	0.090	.
ZTrialNum	-0.128	0.038	-3.372	0.001	***
ZPrimeOrtho_N	0.081	0.076	1.069	0.285	
ZPrimePhono_N	-0.112	0.079	-1.414	0.157	
ZPrimeBG_Sum	0.114	0.122	0.933	0.351	
ZPrimeBG_Mean	-0.138	0.113	-1.229	0.219	
ZPrimeBG_Freq_By_Pos	0.073	0.087	0.839	0.401	
ZTargetOrtho_N	0.332	0.218	1.527	0.127	
ZTargetPhono_N	-0.090	0.214	-0.421	0.674	
form:ZLexTALE	-0.112	0.134	-0.839	0.401	
morph:ZLexTALE	0.295	0.170	1.730	0.084	.
unrelated:ZLexTALE	0.063	0.124	0.512	0.609	

Table 25. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Chinese for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.614	0.015	72.000	444.518	<2e-16	***
form	-0.016	0.009	180.000	-1.918	0.057	.
opaque	-0.036	0.009	102.000	-3.960	0.000	***
morph	-0.055	0.007	153.000	-7.398	8.59e-12	***
ZLexTALE	-0.027	0.012	47.000	-2.222	0.031	*
ZPrevLRT	0.043	0.006	48.000	6.961	8.64e-09	***
PrevACC1	-0.013	0.007	52.000	-1.897	0.063	.
ZTrialNum	-0.009	0.005	48.000	-1.965	0.055	.
ZPrimeOrtho_N	-0.002	0.004	6605.000	-0.449	0.653	
ZPrimePhono_N	0.004	0.004	5249.000	0.948	0.343	
ZPrimeBG_Sum	0.006	0.007	6754.000	0.899	0.368	
ZPrimeBG_Mean	-0.010	0.006	6567.000	-1.615	0.106	
ZPrimeBG_Freq_By_Pos	0.002	0.005	6003.000	0.439	0.661	
ZTargetOrtho_N	-0.032	0.011	192.000	-3.044	0.003	**
ZTargetPhono_N	-0.003	0.011	193.000	-0.259	0.796	
form:ZLexTALE	-0.003	0.007	101.000	-0.435	0.665	
opaque:ZLexTALE	-0.005	0.007	61.000	-0.678	0.500	
morph:ZLexTALE	-0.005	0.006	185.000	-0.844	0.400	

Table 26. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Chinese for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.578	0.018	69.000	356.022	<2e-16	***
form	0.019	0.011	294.000	1.700	0.090	.
morph	-0.019	0.011	166.000	-1.747	0.082	.
unrelated	0.036	0.009	102.000	3.960	0.000	***
ZLexTALE	-0.032	0.015	46.000	-2.122	0.039	*
ZPrevLRT	0.043	0.006	48.000	6.961	8.64e-09	***
PrevACC1	-0.013	0.007	52.000	-1.897	0.063	.
ZTrialNum	-0.009	0.005	48.000	-1.965	0.055	.
ZPrimeOrtho_N	-0.002	0.004	6605.000	-0.449	0.653	
ZPrimePhono_N	0.004	0.004	5249.000	0.948	0.343	
ZPrimeBG_Sum	0.006	0.007	6754.000	0.899	0.368	
ZPrimeBG_Mean	-0.010	0.006	6567.000	-1.615	0.106	
ZPrimeBG_Freq_By_Pos	0.002	0.005	6003.000	0.439	0.661	
ZTargetOrtho_N	-0.032	0.011	192.000	-3.044	0.003	**
ZTargetPhono_N	-0.003	0.011	193.000	-0.259	0.796	
form:ZLexTALE	0.002	0.008	216.000	0.234	0.816	
morph:ZLexTALE	0.000	0.008	55.000	-0.041	0.968	
unrelated:ZLexTALE	0.005	0.007	61.000	0.678	0.500	

Table 27. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Chinese for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.249	0.135	16.646	<2e-16	***
form	-0.165	0.111	-1.483	0.138	
opaque	0.018	0.103	0.170	0.865	
morph	0.490	0.133	3.683	0.000	***
ZLexTALE	0.252	0.083	3.026	0.002	**
ZPrevLRT	0.040	0.031	1.258	0.208	
PrevACC1	-0.346	0.077	-4.493	7.01e-06	***
ZTrialNum	-0.155	0.030	-5.123	3.01e-07	***
ZPrimeOrtho_N	0.074	0.060	1.231	0.218	
ZPrimePhono_N	-0.064	0.061	-1.048	0.295	
ZPrimeBG_Sum	-0.014	0.101	-0.135	0.893	
ZPrimeBG_Mean	-0.067	0.093	-0.715	0.475	
ZPrimeBG_Freq_By_Pos	0.040	0.071	0.566	0.571	
ZTargetOrtho_N	0.380	0.168	2.263	0.024	*
ZTargetPhono_N	-0.112	0.166	-0.677	0.498	
form:ZLexTALE	-0.022	0.090	-0.247	0.805	
opaque:ZLexTALE	0.014	0.089	0.156	0.876	
morph:ZLexTALE	0.195	0.116	1.676	0.094	.

Table 28. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Chinese for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.266	0.154	14.696	<2e-16	***
form	-0.183	0.142	-1.282	0.200	
morph	0.472	0.168	2.816	0.005	**
unrelated	-0.018	0.103	-0.170	0.865	
ZLexTALE	0.266	0.097	2.729	0.006	**
ZPrevLRT	0.040	0.031	1.258	0.208	
PrevACC1	-0.346	0.077	-4.493	7.01e-06	***
ZTrialNum	-0.155	0.030	-5.123	3.01e-07	***
ZPrimeOrtho_N	0.074	0.060	1.231	0.218	
ZPrimePhono_N	-0.064	0.061	-1.048	0.295	
ZPrimeBG_Sum	-0.014	0.101	-0.135	0.893	
ZPrimeBG_Mean	-0.067	0.093	-0.715	0.475	
ZPrimeBG_Freq_By_Pos	0.040	0.071	0.566	0.571	
ZTargetOrtho_N	0.380	0.168	2.263	0.024	*
ZTargetPhono_N	-0.112	0.166	-0.677	0.498	
form:ZLexTALE	-0.036	0.110	-0.329	0.742	
morph:ZLexTALE	0.181	0.133	1.363	0.173	
unrelated:ZLexTALE	-0.014	0.089	-0.156	0.876	

Table 29. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Vietnamese for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.563	0.024	27.000	277.898	<2e-16	***
form	-0.004	0.012	47.000	-0.337	0.738	
opaque	-0.017	0.011	53.000	-1.530	0.132	
morph	-0.060	0.009	408.000	-6.399	4.29e-10	***
ZLexTALE	-0.006	0.023	22.000	-0.274	0.787	
ZPrevLRT	0.033	0.004	4130.000	9.363	<2e-16	***
PrevACC1	-0.014	0.008	4131.000	-1.644	0.100	
ZTrialNum	-0.011	0.003	4135.000	-3.928	8.70e-05	***
ZPrimeOrtho_N	0.002	0.006	3531.000	0.314	0.754	
ZPrimePhono_N	-0.008	0.005	2965.000	-1.386	0.166	
ZPrimeBG_Sum	0.009	0.009	3552.000	0.936	0.350	
ZPrimeBG_Mean	0.002	0.009	3492.000	0.223	0.824	
ZPrimeBG_Freq_By_Pos	-0.008	0.006	3178.000	-1.255	0.210	
ZTargetOrtho_N	-0.032	0.012	186.000	-2.695	0.008	**
ZTargetPhono_N	0.007	0.012	187.000	0.561	0.576	
form:ZLexTALE	0.003	0.010	24.000	0.306	0.762	
opaque:ZLexTALE	0.016	0.010	30.000	1.607	0.119	
morph:ZLexTALE	-0.003	0.009	266.000	-0.406	0.685	

Table 30. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Vietnamese for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.545	0.028	28.000	234.806	<2e-16	***
form	0.013	0.015	76.000	0.925	0.358	
morph	-0.043	0.015	66.000	-2.865	0.006	**
unrelated	0.017	0.011	53.000	1.530	0.132	
ZLexTALE	0.010	0.027	22.000	0.375	0.711	
ZPrevLRT	0.033	0.004	4130.000	9.363	<2e-16	***
PrevACC1	-0.014	0.008	4131.000	-1.644	0.100	
ZTrialNum	-0.011	0.003	4135.000	-3.928	8.7e-05	***
ZPrimeOrtho_N	0.002	0.006	3531.000	0.314	0.754	
ZPrimePhono_N	-0.008	0.005	2965.000	-1.386	0.166	
ZPrimeBG_Sum	0.009	0.009	3552.000	0.936	0.350	
ZPrimeBG_Mean	0.002	0.009	3492.000	0.223	0.824	
ZPrimeBG_Freq_By_Pos	-0.008	0.006	3178.000	-1.255	0.210	
ZTargetOrtho_N	-0.032	0.012	186.000	-2.695	0.008	**
ZTargetPhono_N	0.007	0.012	187.000	0.561	0.576	
form:ZLexTALE	-0.013	0.011	26.000	-1.151	0.260	
morph:ZLexTALE	-0.020	0.012	29.000	-1.591	0.123	
unrelated:ZLexTALE	-0.016	0.010	30.000	-1.607	0.119	

Table 31. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Vietnamese for words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.067	0.187	16.410	<2e-16	***
form	-0.415	0.189	-2.193	0.028	*
opaque	0.247	0.183	1.346	0.178	
morph	1.071	0.379	2.821	0.005	**
ZLexTALE	0.402	0.101	3.974	7.08e-05	***
ZPrevLRT	0.064	0.053	1.204	0.229	
PrevACC1	-0.343	0.159	-2.159	0.031	*
ZTrialNum	-0.122	0.055	-2.230	0.026	*
ZPrimeOrtho_N	-0.129	0.109	-1.190	0.234	
ZPrimePhono_N	0.006	0.125	0.045	0.964	
ZPrimeBG_Sum	0.136	0.171	0.793	0.428	
ZPrimeBG_Mean	-0.141	0.156	-0.900	0.368	
ZPrimeBG_Freq_By_Pos	-0.123	0.120	-1.029	0.304	
ZTargetOrtho_N	0.494	0.212	2.332	0.020	*
ZTargetPhono_N	-0.132	0.206	-0.640	0.522	
form:ZLexTALE	-0.036	0.150	-0.241	0.810	
opaque:ZLexTALE	0.081	0.149	0.543	0.587	
morph:ZLexTALE	0.441	0.285	1.548	0.122	

Table 32. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Vietnamese for words with opaque being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.314	0.248	13.388	<2e-16	***
form	-0.661	0.254	-2.599	0.009	**
morph	0.824	0.429	1.919	0.055	.
unrelated	-0.247	0.183	-1.346	0.178	
ZLexTALE	0.483	0.158	3.051	0.002	**
ZPrevLRT	0.064	0.053	1.204	0.229	
PrevACC1	-0.343	0.159	-2.159	0.031	*
ZTrialNum	-0.122	0.055	-2.230	0.026	*
ZPrimeOrtho_N	-0.129	0.109	-1.190	0.234	
ZPrimePhono_N	0.006	0.125	0.045	0.964	
ZPrimeBG_Sum	0.136	0.171	0.793	0.428	
ZPrimeBG_Mean	-0.141	0.156	-0.900	0.368	
ZPrimeBG_Freq_By_Pos	-0.123	0.120	-1.029	0.304	
ZTargetOrtho_N	0.494	0.212	2.332	0.020	*
ZTargetPhono_N	-0.132	0.206	-0.640	0.522	
form:ZLexTALE	-0.117	0.192	-0.609	0.543	
morph:ZLexTALE	0.360	0.320	1.125	0.261	
unrelated:ZLexTALE	-0.081	0.149	-0.543	0.587	

Table 33. LRT model summary for the combined data for all language groups for words with unrelated being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.496	0.018	218.000	367.256	<2e-16	***
form	0.018	0.008	253.000	2.259	0.025	*
opaque	0.014	0.008	213.000	1.808	0.072	.
morph	-0.040	0.006	758.000	-6.344	3.85e-10	***
Chinese	0.109	0.025	164.000	4.352	2.37e-05	***
Turkish	0.129	0.023	162.000	5.559	1.09e-07	***
Vietnamese	0.068	0.026	161.000	2.656	0.009	**
ZLexTALE	-0.020	0.010	160.000	-2.061	0.041	*
ZPrevLRT	0.019	0.001	28760.000	15.480	<2e-16	***
PrevACC1	-0.016	0.003	28660.000	-4.971	6.70e-07	***
ZTrialNum	-0.011	0.001	28640.000	-9.613	<2e-16	***
ZPrimeOrtho_N	0.001	0.003	25960.000	0.208	0.836	
ZPrimePhono_N	-0.003	0.002	22520.000	-1.056	0.291	
ZPrimeBG_Sum	0.005	0.004	26050.000	1.351	0.177	
ZPrimeBG_Mean	-0.008	0.004	25690.000	-2.040	0.041	*
ZPrimeBG_Freq_By_Pos	0.004	0.003	24530.000	1.368	0.171	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.659	0.009	**
ZTargetPhono_N	0.004	0.011	195.000	0.362	0.718	
form:Chinese	-0.042	0.010	184.000	-4.060	7.26e-05	***
opaque:Chinese	-0.054	0.010	164.000	-5.293	3.81e-07	***

morph:Chinese	-0.008	0.009	618.000	-0.948	0.344	
form:Turkish	-0.021	0.011	179.000	-1.928	0.055	.
opaque:Turkish	-0.004	0.011	159.000	-0.407	0.685	
morph:Turkish	-0.018	0.009	597.000	-2.045	0.041	*
form:Vietnamese	-0.026	0.013	174.000	-2.009	0.046	*
opaque:Vietnamese	-0.040	0.012	149.000	-3.235	0.002	**
morph:Vietnamese	-0.007	0.011	596.000	-0.693	0.488	

Table 34. LRT model summary for the combined data for all language groups for words with unrelated being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.605	0.017	226.000	397.409	<2e-16	***
form	-0.024	0.008	264.000	-3.008	0.003	**
opaque	-0.040	0.008	229.000	-5.113	6.70e-07	***
morph	-0.048	0.007	834.000	-7.428	2.72e-13	***
English	-0.109	0.025	164.000	-4.352	2.37e-05	***
Turkish	0.020	0.020	161.000	0.967	0.335	
Vietnamese	-0.041	0.025	161.000	-1.659	0.099	.
ZLexTALE	-0.020	0.010	160.000	-2.061	0.041	*
ZPrevLRT	0.019	0.001	28760.000	15.480	<2e-16	***
PrevACC1	-0.016	0.003	28660.000	-4.971	6.70e-07	***
ZTrialNum	-0.011	0.001	28640.000	-9.613	<2e-16	***
ZPrimeOrtho_N	0.001	0.003	25960.000	0.208	0.836	

ZPrimePhono_N	-0.003	0.002	22520.000	-1.056	0.291	
ZPrimeBG_Sum	0.005	0.004	26050.000	1.351	0.177	
ZPrimeBG_Mean	-0.008	0.004	25690.000	-2.040	0.041	*
ZPrimeBG_Freq_By_Pos	0.004	0.003	24530.000	1.368	0.171	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.659	0.009	**
ZTargetPhono_N	0.004	0.011	195.000	0.362	0.718	
form:English	0.042	0.010	184.000	4.060	7.26e-05	***
opaque:English	0.054	0.010	164.000	5.293	3.81e-07	***
morph:English	0.008	0.009	618.000	0.948	0.344	
form:Turkish	0.021	0.011	184.000	1.964	0.051	.
opaque:Turkish	0.050	0.011	164.000	4.652	6.73e-06	***
morph:Turkish	-0.010	0.009	629.000	-1.116	0.265	
form:Vietnamese	0.017	0.013	178.000	1.301	0.195	
opaque:Vietnamese	0.014	0.012	153.000	1.126	0.262	
morph:Vietnamese	0.001	0.011	619.000	0.076	0.940	

Table 35. LRT model summary for the combined data for all language groups for words with opaque being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.510	0.020	237.000	327.518	<2e-16	***
form	0.004	0.009	321.000	0.449	0.654	
morph	-0.054	0.010	273.000	-5.560	6.41e-08	***
unrelated	-0.014	0.008	213.000	-1.808	0.072	.

Chinese	0.055	0.028	187.000	1.966	0.051	.
Turkish	0.124	0.026	177.000	4.691	5.44e-06	***
Vietnamese	0.028	0.030	167.000	0.943	0.347	
ZLexTALE	-0.020	0.010	160.000	-2.061	0.041	*
ZPrevLRT	0.019	0.001	28760.000	15.480	<2e-16	***
PrevACC1	-0.016	0.003	28660.000	-4.971	6.70e-07	***
ZTrialNum	-0.011	0.001	28640.000	-9.613	<2e-16	***
ZPrimeOrtho_N	0.001	0.003	25960.000	0.208	0.836	
ZPrimePhono_N	-0.003	0.002	22520.000	-1.056	0.291	
ZPrimeBG_Sum	0.005	0.004	26050.000	1.351	0.177	
ZPrimeBG_Mean	-0.008	0.004	25690.000	-2.040	0.041	*
ZPrimeBG_Freq_By_Pos	0.004	0.003	24530.000	1.368	0.171	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.659	0.008	**
ZTargetPhono_N	0.004	0.011	195.000	0.362	0.718	
form:Chinese	0.012	0.011	189.000	1.017	0.310	
morph:Chinese	0.046	0.013	185.000	3.661	0.000	***
unrelated:Chinese	0.054	0.010	164.000	5.293	3.81e-07	***
form:Turkish	-0.017	0.012	182.000	-1.401	0.163	
morph:Turkish	-0.014	0.013	180.000	-1.063	0.289	
unrelated:Turkish	0.004	0.011	159.000	0.407	0.685	
form:Vietnamese	0.014	0.014	170.000	1.037	0.301	
morph:Vietnamese	0.033	0.015	173.000	2.135	0.034	*
unrelated:Vietnamese	0.040	0.012	149.000	3.235	0.001	**

Table 36. LRT model summary for the combined data for all language groups for words with opaque being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.565	0.019	234.000	346.323	<2e-16	***
form	0.016	0.009	337.000	1.689	0.092	.
morph	-0.008	0.010	287.000	-0.857	0.392	
unrelated	0.040	0.008	229.000	5.113	6.70e-07	***
English	-0.055	0.028	187.000	-1.966	0.051	.
Turkish	0.069	0.024	162.000	2.869	0.005	**
Vietnamese	-0.027	0.029	162.000	-0.928	0.355	
ZLexTALE	-0.020	0.010	160.000	-2.061	0.041	*
ZPrevLRT	0.019	0.001	28760.000	15.480	<2e-16	***
PrevACC1	-0.016	0.003	28660.000	-4.971	6.70e-07	***
ZTrialNum	-0.011	0.001	28640.000	-9.613	<2e-16	***
ZPrimeOrtho_N	0.001	0.003	25960.000	0.208	0.836	
ZPrimePhono_N	-0.003	0.002	22520.000	-1.056	0.291	
ZPrimeBG_Sum	0.005	0.004	26050.000	1.351	0.177	
ZPrimeBG_Mean	-0.008	0.004	25690.000	-2.040	0.041	*
ZPrimeBG_Freq_By_Pos	0.004	0.003	24530.000	1.368	0.171	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.659	0.008	**
ZTargetPhono_N	0.004	0.011	195.000	0.362	0.718	
form:English	-0.012	0.011	189.000	-1.017	0.310	

morph:English	-0.046	0.013	185.000	-3.661	0.000	***
unrelated:English	-0.054	0.010	164.000	-5.293	3.81e-07	***
form:Turkish	-0.028	0.012	187.000	-2.369	0.019	*
morph:Turkish	-0.060	0.013	184.000	-4.555	9.49e-06	***
unrelated:Turkish	-0.050	0.011	164.000	-4.652	6.73e-06	***
form:Vietnamese	0.003	0.014	173.000	0.194	0.846	
morph:Vietnamese	-0.013	0.015	176.000	-0.858	0.392	
unrelated:Vietnamese	-0.014	0.012	153.000	-1.126	0.262	

Table 37. Accuracy model summary for the combined data for all language groups for words with unrelated being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.912	0.147	19.796	<2e-16	***
form	-0.929	0.109	-8.558	<2e-16	***
opaque	-0.741	0.100	-7.394	1.42e-13	***
morph	0.498	0.175	2.849	0.004	**
Chinese	-0.407	0.153	-2.654	0.008	**
Turkish	-0.083	0.146	-0.568	0.570	
Vietnamese	0.037	0.163	0.229	0.819	
ZLexTALE	0.388	0.057	6.802	1.03e-11	***
ZPrevLRT	0.057	0.018	3.236	0.001	**
PrevACC1	-0.320	0.051	-6.242	4.33e-10	***
ZTrialNum	-0.135	0.018	-7.336	2.20e-13	***

ZPrimeOrtho_N	0.037	0.037	0.987	0.323	
ZPrimePhono_N	-0.064	0.039	-1.634	0.102	
ZPrimeBG_Sum	0.073	0.063	1.155	0.248	
ZPrimeBG_Mean	-0.112	0.058	-1.944	0.052	.
ZPrimeBG_Freq_By_Pos	0.003	0.044	0.062	0.951	
ZTargetOrtho_N	0.314	0.161	1.952	0.051	.
ZTargetPhono_N	-0.093	0.160	-0.580	0.562	
form:Chinese	0.866	0.133	6.528	6.66e-11	***
opaque:Chinese	0.794	0.126	6.312	2.76e-10	***
morph:Chinese	-0.216	0.196	-1.101	0.271	
form:Turkish	0.645	0.143	4.512	6.42e-06	***
opaque:Turkish	0.594	0.135	4.386	1.15e-05	***
morph:Turkish	0.131	0.221	0.594	0.552	
form:Vietnamese	0.670	0.172	3.890	0.000	***
opaque:Vietnamese	1.028	0.171	5.998	1.99e-09	***
morph:Vietnamese	-0.235	0.252	-0.936	0.350	

Table 38. Accuracy model summary for the combined data for all language groups for words with unrelated being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.505	0.138	18.123	<2e-16	***
form	-0.062	0.101	-0.612	0.541	
opaque	0.054	0.093	0.577	0.564	

morph	0.283	0.123	2.300	0.021	*
English	0.407	0.153	2.655	0.008	**
Turkish	0.324	0.126	2.584	0.010	**
Vietnamese	0.444	0.153	2.910	0.004	**
ZLexTALE	0.388	0.057	6.802	1.03e-11	***
ZPrevLRT	0.057	0.018	3.236	0.001	**
PrevACC1	-0.320	0.051	-6.242	4.33e-10	***
ZRealExperiment.Sample	-0.135	0.018	-7.336	2.20e-13	***
ZPrimeOrtho_N	0.037	0.037	0.987	0.323	
ZPrimePhono_N	-0.064	0.039	-1.634	0.102	
ZPrimeBG_Sum	0.073	0.063	1.155	0.248	
ZPrimeBG_Mean	-0.112	0.058	-1.944	0.052	.
ZPrimeBG_Freq_By_Pos	0.003	0.044	0.061	0.951	
ZTargetOrtho_N	0.314	0.161	1.952	0.051	.
ZTargetPhono_N	-0.093	0.159	-0.580	0.562	
form:English	-0.866	0.133	-6.529	6.61e-11	***
opaque:English	-0.794	0.126	-6.313	2.73e-10	***
morph:English	0.216	0.196	1.101	0.271	
form:Turkish	-0.222	0.138	-1.610	0.107	
opaque:Turkish	-0.200	0.130	-1.545	0.122	
morph:Turkish	0.347	0.188	1.844	0.065	.
form:Vietnamese	-0.196	0.168	-1.167	0.243	
opaque:Vietnamese	0.234	0.167	1.401	0.161	

morph:Vietnamese	-0.020	0.223	-0.088	0.930	

Table 39. Accuracy model summary for the combined data for all language groups for words with opaque being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.171	0.158	13.748	<2e-16	***
form	-0.188	0.124	-1.515	0.130	
morph	1.239	0.189	6.572	4.98e-11	***
unrelated	0.741	0.100	7.394	1.43e-13	***
Chinese	0.387	0.169	2.284	0.022	*
Turkish	0.511	0.164	3.109	0.002	**
Vietnamese	1.065	0.195	5.463	4.69e-08	***
ZLexTALE	0.388	0.057	6.801	1.04e-11	***
ZPrevLRT	0.057	0.018	3.236	0.001	**
PrevACC1	-0.320	0.051	-6.242	4.33e-10	***
ZTrialNum	-0.135	0.018	-7.336	2.20e-13	***
ZPrimeOrtho_N	0.037	0.037	0.987	0.323	
ZPrimePhono_N	-0.064	0.039	-1.634	0.102	
ZPrimeBG_Sum	0.073	0.063	1.155	0.248	
ZPrimeBG_Mean	-0.112	0.058	-1.944	0.052	.
ZPrimeBG_Freq_By_Pos	0.003	0.044	0.062	0.951	
ZTargetOrtho_N	0.314	0.161	1.952	0.051	.
ZTargetPhono_N	-0.093	0.160	-0.580	0.562	

form:Chinese	0.072	0.149	0.486	0.627	
morph:Chinese	-1.010	0.209	-4.824	1.41e-06	***
unrelated:Chinese	-0.794	0.126	-6.311	2.77e-10	***
form:Turkish	0.051	0.160	0.318	0.750	
morph:Turkish	-0.462	0.235	-1.971	0.049	*
unrelated:Turkish	-0.594	0.135	-4.385	1.16e-05	***
form:Vietnamese	-0.358	0.200	-1.786	0.074	.
morph:Vietnamese	-1.263	0.274	-4.614	3.95e-06	***
unrelated:Vietnamese	-1.028	0.171	-5.999	1.99e-09	***

Table 40. Accuracy model summary for the combined data for all language groups for words with opaque being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.558	0.153	16.701	<2e-16	***
form	-0.116	0.121	-0.952	0.341	
morph	0.229	0.145	1.580	0.114	
unrelated	-0.054	0.093	-0.577	0.564	
English	-0.387	0.169	-2.285	0.022	*
Turkish	0.124	0.150	0.828	0.408	
Vietnamese	0.678	0.189	3.589	0.000	***
ZLexTALE	0.388	0.057	6.802	1.03e-11	***
ZPrevLRT	0.057	0.018	3.236	0.001	**
PrevACC1	-0.320	0.051	-6.242	4.33e-10	***

ZTrialNum	-0.135	0.018	-7.336	2.20e-13	***
ZPrimeOrtho_N	0.037	0.037	0.987	0.323	
ZPrimePhono_N	-0.064	0.039	-1.634	0.102	
ZPrimeBG_Sum	0.073	0.063	1.155	0.248	
ZPrimeBG_Mean	-0.112	0.058	-1.944	0.052	.
ZPrimeBG_Freq_By_Pos	0.003	0.044	0.062	0.951	
ZTargetOrtho_N	0.314	0.161	1.952	0.051	.
ZTargetPhono_N	-0.093	0.160	-0.580	0.562	
form:English	-0.072	0.149	-0.487	0.626	
morph:English	1.010	0.209	4.825	1.40e-06	***
unrelated:English	0.794	0.126	6.313	2.73e-10	***
form:Turkish	-0.021	0.158	-0.136	0.892	
morph:Turkish	0.548	0.206	2.661	0.008	**
unrelated:Turkish	0.200	0.130	1.544	0.123	
form:Vietnamese	-0.430	0.199	-2.161	0.031	*
morph:Vietnamese	-0.254	0.250	-1.016	0.309	
unrelated:Vietnamese	-0.234	0.167	-1.401	0.161	

Table 41. The sex model summary for the LRT for the combined data of all language groups with Female as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.572	0.013	275.000	499.408	<2e-16	***
form	-0.008	0.006	340.000	-1.326	0.186	

opaque	-0.020	0.006	255.000	-3.016	0.003	**
morph	-0.052	0.005	801.000	-10.533	<2e-16	***
SexMale	0.004	0.017	162.000	0.253	0.801	
ZLexTALE	-0.011	0.008	162.000	-1.347	0.180	
ZPrevLRT	0.042	0.003	166.000	12.975	<2e-16	***
PrevACC1	-0.014	0.004	159.000	-3.656	0.000	***
ZTrialNum	-0.011	0.002	162.000	-4.339	2.51e-05	***
ZPrimeOrtho_N	0.000	0.003	26020.000	-0.130	0.897	
ZPrimePhono_N	-0.003	0.002	22790.000	-1.042	0.298	
ZPrimeBG_Sum	0.004	0.004	26100.000	1.086	0.277	
ZPrimeBG_Mean	-0.007	0.004	25760.000	-1.784	0.074	.
ZPrimeBG_Freq_By_Pos	0.004	0.003	24680.000	1.391	0.164	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.656	0.009	**
ZTargetPhono_N	0.004	0.011	195.000	0.351	0.726	
form:SexMale	0.007	0.008	191.000	0.876	0.382	
opaque:SexMale	0.020	0.009	160.000	2.321	0.022	*
morph:SexMale	0.010	0.007	556.000	1.473	0.141	

Table 42. The sex model summary for the LRT for English with Female as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.496	0.016	67.000	402.545	<2e-16	***
form	0.009	0.010	126.000	0.902	0.369	
opaque	0.014	0.010	174.000	1.426	0.156	

morph	-0.055	0.008	201.000	-6.563	4.39e-10	***
SexMale	-0.025	0.022	46.000	-1.128	0.265	
ZLexTALE	-0.003	0.010	47.000	-0.250	0.804	
ZPrevLRT	0.046	0.006	52.000	7.247	2.07e-09	***
PrevACC1	-0.022	0.007	55.000	-3.131	0.003	**
ZTrialNum	-0.007	0.003	49.000	-2.157	0.036	*
ZPrimeOrtho_N	0.006	0.004	6740.000	1.424	0.154	
ZPrimePhono_N	-0.006	0.004	4960.000	-1.532	0.126	
ZPrimeBG_Sum	0.007	0.007	6796.000	1.016	0.310	
ZPrimeBG_Mean	-0.003	0.006	6662.000	-0.500	0.617	
ZPrimeBG_Freq_By_Pos	0.001	0.005	6153.000	0.229	0.819	
ZTargetOrtho_N	-0.022	0.010	180.000	-2.160	0.032	*
ZTargetPhono_N	0.004	0.010	180.000	0.355	0.723	
form:SexMale	0.018	0.013	86.000	1.333	0.186	
opaque:SexMale	0.009	0.013	126.000	0.720	0.473	
morph:SexMale	0.026	0.012	170.000	2.249	0.026	*

Table 43. The sex model summary for the LRT for English with Male as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.471	0.018	64.000	352.514	<2e-16	***
form	0.027	0.011	121.000	2.329	0.022	*
opaque	0.023	0.011	162.000	2.110	0.036	*
morph	-0.029	0.010	197.000	-2.994	0.003	**

SexFemale	0.025	0.022	46.000	1.128	0.265	
ZLexTALE	-0.003	0.010	47.000	-0.250	0.804	
ZPrevLRT	0.046	0.006	52.000	7.247	2.07e-09	***
PrevACC1	-0.022	0.007	55.000	-3.131	0.003	**
ZTrialNum	-0.007	0.003	49.000	-2.157	0.036	*
ZPrimeOrtho_N	0.006	0.004	6740.000	1.424	0.154	
ZPrimePhono_N	-0.006	0.004	4960.000	-1.532	0.126	
ZPrimeBG_Sum	0.007	0.007	6796.000	1.016	0.310	
ZPrimeBG_Mean	-0.003	0.006	6662.000	-0.500	0.617	
ZPrimeBG_Freq_By_Pos	0.001	0.005	6153.000	0.229	0.819	
ZTargetOrtho_N	-0.022	0.010	180.000	-2.160	0.032	*
ZTargetPhono_N	0.004	0.010	180.000	0.355	0.723	
form:SexFemale	-0.018	0.013	86.000	-1.333	0.186	
opaque:SexFemale	-0.009	0.013	126.000	-0.720	0.473	
morph:SexFemale	-0.026	0.012	170.000	-2.249	0.026	*

Table 44. The sex model summary for the LRT for Turkish with Female as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.631	0.026	48.000	255.523	<2e-16	***
form	0.002	0.015	58.000	0.146	0.885	
opaque	0.011	0.014	55.000	0.738	0.464	
morph	-0.067	0.012	85.000	-5.385	6.36e-07	***
SexMale	0.002	0.032	39.000	0.058	0.954	

ZLexTALE	-0.013	0.015	39.000	-0.824	0.415	
ZPrevLRT	0.013	0.002	7128.000	5.633	1.83e-08	***
PrevACC1	-0.015	0.007	7112.000	-2.135	0.033	*
ZTrialNum	-0.018	0.003	7107.000	-7.007	2.65e-12	***
ZPrimeOrtho_N	-0.005	0.005	6165.000	-0.937	0.349	
ZPrimePhono_N	0.000	0.005	5092.000	-0.029	0.977	
ZPrimeBG_Sum	-0.007	0.008	6169.000	-0.903	0.367	
ZPrimeBG_Mean	0.000	0.008	6020.000	0.043	0.966	
ZPrimeBG_Freq_By_Pos	0.008	0.006	5631.000	1.436	0.151	
ZTargetOrtho_N	-0.025	0.013	186.000	-1.990	0.048	*
ZTargetPhono_N	0.006	0.013	186.000	0.438	0.662	
form:SexMale	0.000	0.018	41.000	-0.015	0.988	
opaque:SexMale	-0.011	0.017	38.000	-0.656	0.516	
morph:SexMale	0.004	0.015	65.000	0.245	0.808	

Table 45. The sex model summary for the LRT for Turkish with Male as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.633	0.022	53.000	303.872	<2e-16	***
form	0.002	0.013	68.000	0.149	0.882	
opaque	0.000	0.012	59.000	-0.040	0.968	
morph	-0.063	0.011	95.000	-5.988	3.74e-08	***
SexFemale	-0.002	0.032	39.000	-0.058	0.954	
ZLexTALE	-0.013	0.015	39.000	-0.824	0.415	

ZPrevLRT	0.013	0.002	7128.000	5.633	1.83e-08	***
PrevACC1	-0.015	0.007	7112.000	-2.135	0.033	*
ZTrialNum	-0.018	0.003	7107.000	-7.007	2.65e-12	***
ZPrimeOrtho_N	-0.005	0.005	6165.000	-0.937	0.349	
ZPrimePhono_N	0.000	0.005	5092.000	-0.029	0.977	
ZPrimeBG_Sum	-0.007	0.008	6169.000	-0.903	0.367	
ZPrimeBG_Mean	0.000	0.008	6020.000	0.043	0.966	
ZPrimeBG_Freq_By_Pos	0.008	0.006	5631.000	1.436	0.151	
ZTargetOrtho_N	-0.025	0.013	186.000	-1.990	0.048	*
ZTargetPhono_N	0.006	0.013	186.000	0.438	0.662	
form:SexFemale	0.000	0.018	41.000	0.015	0.988	
opaque:SexFemale	0.011	0.017	38.000	0.656	0.516	
morph:SexFemale	-0.004	0.015	65.000	-0.245	0.808	

Table 46. The sex model summary for the LRT for Chinese with Female as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.611	0.017	70.000	397.484	<2e-16	***
form	-0.020	0.010	173.000	-2.076	0.039	*
opaque	-0.046	0.010	144.000	-4.681	6.53e-06	***
morph	-0.053	0.008	171.000	-6.487	9.12e-10	***
SexMale	0.013	0.028	46.000	0.458	0.649	
ZLexTALE	-0.027	0.012	46.000	-2.218	0.032	*
ZPrevLRT	0.043	0.006	48.000	6.940	9.26e-09	***

PrevACC1	-0.013	0.007	52.000	-1.900	0.063	.
ZTrialNum	-0.009	0.005	48.000	-1.968	0.055	.
ZPrimeOrtho_N	-0.002	0.004	6614.000	-0.454	0.649	
ZPrimePhono_N	0.004	0.004	5251.000	0.924	0.355	
ZPrimeBG_Sum	0.006	0.007	6754.000	0.865	0.387	
ZPrimeBG_Mean	-0.010	0.006	6564.000	-1.557	0.120	
ZPrimeBG_Freq_By_Pos	0.002	0.005	6006.000	0.442	0.658	
ZTargetOrtho_N	-0.032	0.011	192.000	-3.042	0.003	**
ZTargetPhono_N	-0.003	0.011	193.000	-0.257	0.797	
form:SexMale	0.012	0.015	121.000	0.776	0.439	
opaque:SexMale	0.037	0.016	143.000	2.373	0.019	*
morph:SexMale	-0.008	0.014	171.000	-0.583	0.560	

Table 47. The sex model summary for the LRT for Chinese with Male as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.622	0.028	53.000	237.238	<2e-16	***
form	-0.006	0.015	69.000	-0.386	0.700	
opaque	-0.004	0.015	64.000	-0.259	0.797	
morph	-0.058	0.013	86.000	-4.481	2.28e-05	***
SexFemale	-0.012	0.032	47.000	-0.389	0.699	
ZLexTALE	-0.024	0.013	46.000	-1.763	0.084	.
ZPrevLRT	0.019	0.002	8144.000	8.834	<2e-16	***
PrevACC1	-0.016	0.005	8156.000	-3.048	0.002	**

ZTrialNum	-0.010	0.002	8151.000	-4.649	3.39e-06	***
ZPrimeOrtho_N	-0.001	0.004	6530.000	-0.243	0.808	
ZPrimePhono_N	0.005	0.004	5135.000	1.115	0.265	
ZPrimeBG_Sum	0.008	0.007	6669.000	1.128	0.259	
ZPrimeBG_Mean	-0.011	0.007	6485.000	-1.748	0.081	.
ZPrimeBG_Freq_By_Pos	0.003	0.005	5904.000	0.526	0.599	
ZTargetOrtho_N	-0.034	0.011	192.000	-3.161	0.002	**
ZTargetPhono_N	-0.001	0.011	193.000	-0.105	0.916	
form:SexFemale	-0.012	0.017	55.000	-0.742	0.461	
opaque:SexFemale	-0.038	0.017	51.000	-2.230	0.030	*
morph:SexFemale	0.003	0.015	72.000	0.222	0.825	

Table 48. The sex model summary for the LRT for Vietnamese with Female as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.578	0.041	23.000	161.633	<2e-16	***
form	0.004	0.018	28.000	0.222	0.826	
opaque	-0.026	0.019	32.000	-1.372	0.180	
morph	-0.070	0.015	302.000	-4.737	3.34e-06	***
SexMale	-0.023	0.049	21.000	-0.468	0.644	
ZLexTALE	-0.015	0.022	21.000	-0.704	0.489	
ZPrevLRT	0.034	0.004	4125.000	9.409	<2e-16	***
PrevACC1	-0.013	0.008	4132.000	-1.583	0.113	
ZTrialNum	-0.011	0.003	4135.000	-3.888	0.000	***

ZPrimeOrtho_N	0.002	0.006	3533.000	0.314	0.754	
ZPrimePhono_N	-0.008	0.005	2972.000	-1.374	0.170	
ZPrimeBG_Sum	0.009	0.009	3555.000	0.933	0.351	
ZPrimeBG_Mean	0.002	0.009	3496.000	0.236	0.813	
ZPrimeBG_Freq_By_Pos	-0.008	0.006	3183.000	-1.255	0.209	
ZTargetOrtho_N	-0.032	0.012	186.000	-2.696	0.008	**
ZTargetPhono_N	0.007	0.012	187.000	0.569	0.570	
form:SexMale	-0.012	0.021	21.000	-0.596	0.557	
opaque:SexMale	0.013	0.022	26.000	0.592	0.559	
morph:SexMale	0.015	0.017	245.000	0.863	0.389	

Table 49. The sex model summary for the LRT for Vietnamese with Male as the reference group.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.555	0.029	24.000	225.314	<2e-16	***
form	-0.008	0.014	37.000	-0.610	0.545	
opaque	-0.013	0.014	39.000	-0.923	0.362	
morph	-0.056	0.011	362.000	-5.046	7.15e-07	***
SexFemale	0.023	0.049	21.000	0.468	0.644	
ZLexTALE	-0.015	0.022	21.000	-0.704	0.489	
ZPrevLRT	0.034	0.004	4125.000	9.409	<2e-16	***
PrevACC1	-0.013	0.008	4132.000	-1.583	0.113	
ZTrialNum	-0.011	0.003	4135.000	-3.888	0.000	***
ZPrimeOrtho_N	0.002	0.006	3533.000	0.314	0.754	

ZPrimePhono_N	-0.008	0.005	2972.000	-1.374	0.170	
ZPrimeBG_Sum	0.009	0.009	3555.000	0.933	0.351	
ZPrimeBG_Mean	0.002	0.009	3496.000	0.236	0.813	
ZPrimeBG_Freq_By_Pos	-0.008	0.006	3183.000	-1.255	0.209	
ZTargetOrtho_N	-0.032	0.012	186.000	-2.696	0.008	**
ZTargetPhono_N	0.007	0.012	187.000	0.569	0.570	
form:SexFemale	0.012	0.021	21.000	0.596	0.557	
opaque:SexFemale	-0.013	0.022	26.000	-0.592	0.559	
morph:SexFemale	-0.015	0.017	245.000	-0.863	0.389	

Table 50. The sex model summary for ACC for the combined data of all language groups with Female as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.749	0.130	21.193	<2e-16	***
form	-0.391	0.092	-4.258	2.06e-05	***
opaque	-0.287	0.085	-3.379	0.001	***
morph	0.416	0.118	3.516	0.000	***
SexMale	0.053	0.116	0.459	0.646	
ZLexTALE	0.257	0.048	5.374	7.69e-08	***
ZPrevLRT	0.052	0.018	2.944	0.003	**
PrevACC1	-0.309	0.051	-6.036	1.58e-09	***
ZTrialNum	-0.135	0.018	-7.306	2.76e-13	***
ZPrimeOrtho_N	0.037	0.037	0.992	0.321	

ZPrimePhono_N	-0.064	0.039	-1.632	0.103	
ZPrimeBG_Sum	0.074	0.063	1.184	0.236	
ZPrimeBG_Mean	-0.113	0.058	-1.961	0.050	*
ZPrimeBG_Freq_By_Pos	0.002	0.044	0.049	0.961	
ZTargetOrtho_N	0.313	0.161	1.950	0.051	.
ZTargetPhono_N	-0.092	0.159	-0.575	0.565	
form:SexMale	-0.055	0.118	-0.468	0.640	
opaque:SexMale	0.176	0.116	1.519	0.129	
morph:SexMale	0.056	0.148	0.379	0.705	

Table 51. The sex model summary for ACC for English with Female as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.473	0.183	18.947	<2e-16	***
form	-0.939	0.169	-5.561	2.69e-08	***
opaque	-0.815	0.158	-5.157	2.52e-07	***
morph	0.766	0.269	2.844	0.004	**
SexMale	-0.121	0.193	-0.623	0.533	
ZLexTALE	0.217	0.084	2.584	0.010	**
ZPrevLRT	0.095	0.032	2.936	0.003	**
PrevACC1	-0.431	0.117	-3.680	0.000	***
ZTrialNum	-0.120	0.037	-3.243	0.001	**
ZPrimeOrtho_N	0.035	0.072	0.491	0.623	
ZPrimePhono_N	-0.038	0.072	-0.522	0.602	

ZPrimeBG_Sum	0.204	0.124	1.652	0.098	.
ZPrimeBG_Mean	-0.248	0.112	-2.217	0.027	*
ZPrimeBG_Freq_By_Pos	-0.009	0.087	-0.099	0.921	
ZTargetOrtho_N	0.089	0.189	0.470	0.638	
ZTargetPhono_N	0.055	0.187	0.293	0.769	
form:SexMale	-0.020	0.220	-0.090	0.928	
opaque:SexMale	0.130	0.210	0.617	0.537	
morph:SexMale	-0.633	0.315	-2.007	0.045	*

Table 52. The sex model summary for ACC for English with Male as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.352	0.197	17.030	<2e-16	***
form	-0.959	0.188	-5.103	3.35e-07	***
opaque	-0.685	0.177	-3.867	0.000	***
morph	0.133	0.247	0.539	0.590	
SexFemale	0.121	0.193	0.623	0.533	
ZLexTALE	0.217	0.084	2.584	0.010	**
ZPrevLRT	0.095	0.032	2.936	0.003	**
PrevACC1	-0.431	0.117	-3.680	0.000	***
ZTrialNum	-0.120	0.037	-3.243	0.001	**
ZPrimeOrtho_N	0.035	0.072	0.491	0.623	
ZPrimePhono_N	-0.038	0.072	-0.522	0.602	
ZPrimeBG_Sum	0.204	0.124	1.652	0.098	.

ZPrimeBG_Mean	-0.248	0.112	-2.217	0.027	*
ZPrimeBG_Freq_By_Pos	-0.009	0.087	-0.099	0.921	
ZTargetOrtho_N	0.089	0.189	0.470	0.638	
ZTargetPhono_N	0.055	0.187	0.293	0.769	
form:SexFemale	0.020	0.220	0.090	0.928	
opaque:SexFemale	-0.130	0.210	-0.618	0.537	
morph:SexFemale	0.633	0.315	2.007	0.045	*

Table 53. The sex model summary for ACC for Turkish with Female as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.083	0.221	13.967	<2e-16	***
form	-0.104	0.218	-0.478	0.633	
opaque	-0.573	0.191	-2.992	0.003	**
morph	0.486	0.259	1.875	0.061	.
SexMale	-0.094	0.214	-0.437	0.662	
ZLexTALE	0.394	0.098	3.999	6.37e-05	***
ZPrevLRT	0.019	0.035	0.552	0.581	
PrevACC1	-0.184	0.106	-1.739	0.082	.
ZTrialNum	-0.127	0.038	-3.338	0.001	***
ZPrimeOrtho_N	0.081	0.076	1.060	0.289	
ZPrimePhono_N	-0.110	0.079	-1.390	0.165	
ZPrimeBG_Sum	0.114	0.122	0.933	0.351	
ZPrimeBG_Mean	-0.138	0.113	-1.226	0.220	

ZPrimeBG_Freq_By_Pos	0.075	0.088	0.854	0.393	
ZTargetOrtho_N	0.333	0.217	1.531	0.126	
ZTargetPhono_N	-0.089	0.213	-0.417	0.677	
form:SexMale	-0.221	0.256	-0.862	0.389	
opaque:SexMale	0.500	0.235	2.129	0.033	*
morph:SexMale	0.294	0.312	0.944	0.345	

Table 54. The sex model summary for ACC for Turkish with Male as the reference group.

Fixed effects:	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.990	0.199	15.017	<2e-16	***
form	-0.325	0.186	-1.749	0.080	.
opaque	-0.073	0.170	-0.428	0.669	
morph	0.780	0.245	3.179	0.001	**
SexFemale	0.094	0.214	0.437	0.662	
ZLexTALE	0.394	0.098	3.999	6.37e-05	***
ZPrevLRT	0.019	0.035	0.552	0.581	
PrevACC1	-0.184	0.106	-1.739	0.082	.
ZTrialNum	-0.127	0.038	-3.338	0.001	***
ZPrimeOrtho_N	0.081	0.076	1.060	0.289	
ZPrimePhono_N	-0.110	0.079	-1.390	0.165	
ZPrimeBG_Sum	0.114	0.122	0.933	0.351	
ZPrimeBG_Mean	-0.138	0.113	-1.226	0.220	
ZPrimeBG_Freq_By_Pos	0.075	0.088	0.854	0.393	

ZTargetOrtho_N	0.333	0.217	1.531	0.126	
ZTargetPhono_N	-0.089	0.213	-0.417	0.677	
form:SexFemale	0.221	0.256	0.862	0.389	
opaque:SexFemale	-0.500	0.235	-2.129	0.033	*
morph:SexFemale	-0.294	0.312	-0.944	0.345	

Table 55. The sex model summary for ACC for Chinese with Female as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.275	0.143	15.899	<2e-16	***
form	-0.225	0.120	-1.876	0.061	.
opaque	0.009	0.114	0.076	0.940	
morph	0.423	0.143	2.962	0.003	**
SexMale	-0.105	0.186	-0.567	0.571	
ZLexTALE	0.266	0.072	3.679	0.000	***
ZPrevLRT	0.038	0.031	1.203	0.229	
PrevACC1	-0.344	0.077	-4.474	7.69e-06	***
ZTrialNum	-0.156	0.030	-5.157	2.51e-07	***
ZPrimeOrtho_N	0.074	0.060	1.231	0.218	
ZPrimePhono_N	-0.064	0.061	-1.045	0.296	
ZPrimeBG_Sum	-0.013	0.101	-0.128	0.898	
ZPrimeBG_Mean	-0.068	0.093	-0.732	0.464	
ZPrimeBG_Freq_By_Pos	0.040	0.071	0.560	0.575	
ZTargetOrtho_N	0.379	0.168	2.258	0.024	*

ZTargetPhono_N	-0.111	0.166	-0.668	0.504	
form:SexMale	0.265	0.197	1.342	0.180	
opaque:SexMale	0.031	0.192	0.163	0.871	
morph:SexMale	0.103	0.242	0.425	0.671	

Table 56. The sex model summary for ACC for Chinese with Male as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.170	0.192	11.276	<2e-16	***
form	0.040	0.187	0.213	0.832	
opaque	0.040	0.177	0.226	0.821	
morph	0.525	0.223	2.358	0.018	*
SexFemale	0.105	0.186	0.567	0.571	
ZLexTALE	0.266	0.072	3.679	0.000	***
ZPrevLRT	0.038	0.031	1.203	0.229	
PrevACC1	-0.344	0.077	-4.474	7.69e-06	***
ZTrialNum	-0.156	0.030	-5.157	2.51e-07	***
ZPrimeOrtho_N	0.074	0.060	1.231	0.218	
ZPrimePhono_N	-0.064	0.061	-1.045	0.296	
ZPrimeBG_Sum	-0.013	0.101	-0.128	0.898	
ZPrimeBG_Mean	-0.068	0.093	-0.732	0.464	
ZPrimeBG_Freq_By_Pos	0.040	0.071	0.560	0.575	
ZTargetOrtho_N	0.379	0.168	2.258	0.024	*
ZTargetPhono_N	-0.111	0.166	-0.668	0.504	

form:SexFemale	-0.265	0.197	-1.342	0.180	
opaque:SexFemale	-0.031	0.192	-0.163	0.871	
morph:SexFemale	-0.103	0.242	-0.425	0.671	

Table 57. The sex model summary for ACC for Vietnamese with Female as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.226	0.238	13.581	<2e-16	***
form	-0.348	0.286	-1.214	0.225	
opaque	0.143	0.278	0.515	0.607	
morph	0.721	0.547	1.317	0.188	
SexMale	-0.235	0.217	-1.082	0.279	
ZLexTALE	0.428	0.093	4.583	4.58e-06	***
ZPrevLRT	0.066	0.053	1.244	0.213	
PrevACC1	-0.335	0.159	-2.108	0.035	*
ZTrialNum	-0.121	0.055	-2.209	0.027	*
ZPrimeOrtho_N	-0.128	0.109	-1.174	0.241	
ZPrimePhono_N	0.004	0.125	0.034	0.973	
ZPrimeBG_Sum	0.138	0.171	0.807	0.420	
ZPrimeBG_Mean	-0.144	0.157	-0.921	0.357	
ZPrimeBG_Freq_By_Pos	-0.123	0.119	-1.029	0.303	
ZTargetOrtho_N	0.495	0.212	2.331	0.020	*
ZTargetPhono_N	-0.134	0.206	-0.650	0.515	
form:SexMale	-0.084	0.316	-0.266	0.791	

opaque:SexMale	0.137	0.323	0.425	0.671	
morph:SexMale	0.431	0.632	0.682	0.495	

Table 58. The sex model summary for ACC for Vietnamese with Male as the reference group.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.992	0.198	15.108	<2e-16	***
form	-0.432	0.214	-2.017	0.044	*
opaque	0.280	0.216	1.299	0.194	
morph	1.151	0.456	2.528	0.012	*
Sex1	0.235	0.217	1.082	0.280	
ZLexTALE	0.428	0.093	4.583	4.58e-06	***
ZPrevLRT	0.066	0.053	1.244	0.213	
PrevACC1	-0.335	0.159	-2.108	0.035	*
ZTrialNum	-0.121	0.055	-2.209	0.027	*
ZPrimeOrtho_N	-0.128	0.109	-1.174	0.241	
ZPrimePhono_N	0.004	0.125	0.034	0.973	
ZPrimeBG_Sum	0.138	0.171	0.807	0.420	
ZPrimeBG_Mean	-0.144	0.157	-0.921	0.357	
ZPrimeBG_Freq_By_Pos	-0.123	0.119	-1.029	0.303	
ZTargetOrtho_N	0.495	0.212	2.331	0.020	*
ZTargetPhono_N	-0.134	0.206	-0.650	0.516	
form:Sex1	0.084	0.316	0.266	0.791	
opaque:Sex1	-0.137	0.323	-0.425	0.671	

morph:Sex1	-0.431	0.632	-0.681	0.496

Table 59. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for English for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.636	0.017	76.000	384.451	<2e-16	***
string	-0.026	0.012	169.000	-2.065	0.040	*
suffix	-0.025	0.013	167.000	-1.946	0.053	.
ZLexTALE	0.004	0.015	48.000	0.264	0.793	
ZPrevLRT	0.025	0.002	8731.000	10.705	<2e-16	***
PrevACC1	-0.052	0.007	8715.000	-7.540	5.15e-14	***
ZTrialNum	-0.013	0.002	8697.000	-5.762	8.58e-09	***
ZPrimeOrtho_N	0.008	0.006	188.000	1.280	0.202	
ZPrimeBG_Mean	-0.016	0.007	189.000	-2.478	0.014	*
ZPrimeBG_Freq_By_Pos	0.014	0.007	190.000	2.153	0.033	*
string:ZLexTALE	0.002	0.006	49.000	0.241	0.810	
suffix:ZLexTALE	-0.002	0.007	47.000	-0.249	0.805	

Table 60. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for English for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.612	0.019	73.000	354.592	<2e-16	***
string	-0.001	0.012	165.000	-0.079	0.937	
Unrelated	0.025	0.013	167.000	1.946	0.053	.

ZLexTALE	0.002	0.017	48.000	0.142	0.887	
ZPrevLRT	0.025	0.002	8731.000	10.705	<2e-16	***
PrevACC1	-0.052	0.007	8715.000	-7.540	5.15e-14	***
ZTrialNum	-0.013	0.002	8697.000	-5.762	8.58e-09	***
ZPrimeOrtho_N	0.008	0.006	188.000	1.280	0.202	
ZPrimeBG_Mean	-0.016	0.007	189.000	-2.478	0.014	*
ZPrimeBG_Freq_By_Pos	0.014	0.007	190.000	2.153	0.033	*
string:ZLexTALE	0.003	0.006	45.000	0.555	0.582	
Unrelated:ZLexTALE	0.002	0.007	47.000	0.249	0.805	

Table 61. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for English for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.376	0.162	14.639	<2e-16	***
string	0.034	0.203	0.166	0.868	
suffix	-0.053	0.211	-0.249	0.803	
ZLexTALE	0.259	0.092	2.814	0.005	**
ZPrevLRT	0.072	0.027	2.648	0.008	**
PrevACC1	0.101	0.095	1.066	0.286	
ZTrialNum	-0.028	0.032	-0.866	0.386	
ZPrimeOrtho_N	-0.125	0.106	-1.175	0.240	
ZPrimeBG_Mean	0.216	0.110	1.961	0.050	*
ZPrimeBG_Freq_By_Pos	-0.182	0.110	-1.649	0.099	.

string:ZLexTALE	0.114	0.086	1.328	0.184	
suffix:ZLexTALE	0.085	0.105	0.807	0.420	

Table 62. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for English for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.324	0.166	13.991	<2e-16	***
string	0.086	0.205	0.420	0.674	
Unrelated	0.053	0.211	0.249	0.803	
ZLexTALE	0.343	0.093	3.692	0.000	***
ZPrevLRT	0.072	0.027	2.648	0.008	**
PrevACC1	0.101	0.095	1.066	0.286	
ZTrialNum	-0.028	0.032	-0.866	0.386	
ZPrimeOrtho_N	-0.125	0.106	-1.175	0.240	
ZPrimeBG_Mean	0.216	0.110	1.961	0.050	*
ZPrimeBG_Freq_By_Pos	-0.182	0.110	-1.649	0.099	.
string:ZLexTALE	0.030	0.085	0.348	0.728	
Unrelated:ZLexTALE	-0.085	0.105	-0.807	0.420	

Table 63. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Turkish for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.772	0.020	57.290	344.082	<2e-16	***
string	0.016	0.014	135.190	1.100	0.273	

suffix	0.005	0.014	148.930	0.354	0.724	
ZLexTALE	-0.010	0.016	39.790	-0.625	0.536	
ZPrevLRT	0.041	0.007	34.950	6.193	4.34e-07	***
PrevACC1	-0.079	0.012	39.530	-6.649	6.13e-08	***
ZTrialNum	-0.042	0.008	39.380	-5.250	5.53e-06	***
ZPrimeOrtho_N	0.013	0.007	193.590	1.869	0.063	.
ZPrimeBG_Mean	-0.011	0.007	190.790	-1.534	0.127	
ZPrimeBG_Freq_By_Pos	0.018	0.007	186.570	2.546	0.012	*
string:ZLexTALE	-0.008	0.009	42.750	-0.945	0.350	
suffix:ZLexTALE	-0.004	0.008	46.430	-0.444	0.659	

Table 64. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Turkish for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.779	0.020	65.000	335.791	<2e-16	***
string	0.008	0.013	190.000	0.633	0.528	
Unrelated	-0.007	0.013	189.000	-0.548	0.584	
ZLexTALE	-0.013	0.019	45.000	-0.694	0.492	
ZPrevLRT	0.021	0.003	6894.000	8.590	<2e-16	***
PrevACC1	-0.086	0.008	6903.000	-10.800	<2e-16	***
ZTrialNum	-0.039	0.003	6901.000	-14.460	<2e-16	***
ZPrimeOrtho_N	0.015	0.007	193.000	2.102	0.037	*
ZPrimeBG_Mean	-0.011	0.007	190.000	-1.483	0.140	

ZPrimeBG_Freq_By_Pos	0.017	0.007	186.000	2.375	0.019	*
string:ZLexTALE	-0.007	0.007	6837.000	-1.058	0.290	
Unrelated:ZLexTALE	0.004	0.007	6838.000	0.584	0.559	

Table 65. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Turkish for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.288	0.182	12.598	<2e-16	***
string	-0.313	0.209	-1.494	0.135	
suffix	-0.760	0.200	-3.804	0.000	***
ZLexTALE	0.572	0.135	4.228	2.36e-05	***
ZPrevLRT	0.026	0.026	0.972	0.331	
PrevACC1	0.298	0.086	3.482	0.000	***
ZTrialNum	0.188	0.033	5.727	1.02e-08	***
ZPrimeOrtho_N	-0.266	0.095	-2.788	0.005	**
ZPrimeBG_Mean	0.103	0.099	1.039	0.299	
ZPrimeBG_Freq_By_Pos	-0.026	0.101	-0.262	0.793	
string:ZLexTALE	-0.053	0.126	-0.421	0.674	
suffix:ZLexTALE	-0.092	0.110	-0.837	0.402	

Table 66. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Turkish for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.529	0.167	9.157	<2e-16	***

string	0.447	0.187	2.384	0.017	*
Unrelated	0.760	0.200	3.804	0.000	***
ZLexTALE	0.480	0.115	4.177	2.95e-05	***
ZPrevLRT	0.026	0.026	0.972	0.331	
PrevACC1	0.298	0.086	3.482	0.000	***
ZTrialNum	0.188	0.033	5.727	1.02e-08	***
ZPrimeOrtho_N	-0.266	0.095	-2.788	0.005	**
ZPrimeBG_Mean	0.103	0.099	1.039	0.299	
ZPrimeBG_Freq_By_Pos	-0.026	0.101	-0.262	0.793	
string:ZLexTALE	0.039	0.083	0.469	0.639	
Unrelated:ZLexTALE	0.092	0.110	0.837	0.402	

Table 67. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Chinese for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.725	0.019	66.000	363.237	<2e-16	***
string	-0.015	0.012	172.000	-1.269	0.206	
suffix	-0.013	0.012	156.000	-1.079	0.282	
ZLexTALE	-0.011	0.017	48.000	-0.631	0.531	
ZPrevLRT	0.032	0.003	7571.000	11.738	<2e-16	***
PrevACC1	-0.056	0.006	7542.000	-9.180	<2e-16	***
ZTrialNum	-0.027	0.002	7534.000	-10.967	<2e-16	***
ZPrimeOrtho_N	0.008	0.006	203.000	1.246	0.214	

ZPrimeBG_Mean	-0.017	0.006	198.000	-2.616	0.010	**
ZPrimeBG_Freq_By_Pos	0.020	0.006	197.000	3.170	0.002	**
string:ZLexTALE	-0.002	0.006	83.000	-0.342	0.733	
suffix:ZLexTALE	-0.003	0.007	50.000	-0.449	0.655	

Table 68. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Chinese for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.708	0.017	70.240	402.802	<2e-16	***
string	-0.001	0.012	185.700	-0.083	0.934	
Unrelated	0.014	0.012	158.800	1.167	0.245	
ZLexTALE	-0.014	0.015	47.310	-0.911	0.367	
ZPrevLRT	0.055	0.006	49.600	8.689	1.56e-11	***
PrevACC1	-0.050	0.006	132.500	-7.732	2.37e-12	***
ZTrialNum	-0.025	0.005	47.670	-5.008	7.95e-06	***
ZPrimeOrtho_N	0.008	0.006	201.400	1.260	0.209	
ZPrimeBG_Mean	-0.016	0.006	196.400	-2.590	0.010	*
ZPrimeBG_Freq_By_Pos	0.019	0.006	196.200	3.024	0.003	**
string:ZLexTALE	0.000	0.006	188.600	0.051	0.959	
Unrelated:ZLexTALE	0.002	0.007	52.770	0.268	0.790	

Table 69. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Chinese for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)

(Intercept)	1.459	0.133	10.953	<2e-16	***
string	-0.281	0.162	-1.737	0.082	.
suffix	-0.331	0.163	-2.032	0.042	*
ZLexTALE	0.304	0.082	3.724	0.000	***
ZPrevLRT	0.075	0.026	2.882	0.004	**
PrevACC1	0.216	0.061	3.561	0.000	***
ZTrialNum	0.132	0.025	5.221	1.78e-07	***
ZPrimeOrtho_N	-0.293	0.085	-3.463	0.001	***
ZPrimeBG_Mean	0.242	0.088	2.760	0.006	**
ZPrimeBG_Freq_By_Pos	-0.156	0.088	-1.764	0.078	.
string:ZLexTALE	-0.117	0.067	-1.748	0.080	.
suffix:ZLexTALE	-0.119	0.069	-1.724	0.085	.

Table 70. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Chinese for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.128	0.130	8.687	<2e-16	***
string	0.051	0.161	0.315	0.753	
Unrelated	0.331	0.163	2.032	0.042	*
ZLexTALE	0.185	0.073	2.536	0.011	*
ZPrevLRT	0.075	0.026	2.882	0.004	**
PrevACC1	0.216	0.061	3.561	0.000	***
ZTrialNum	0.132	0.025	5.221	1.78e-07	***

ZPrimeOrtho_N	-0.293	0.085	-3.463	0.001	***
ZPrimeBG_Mean	0.242	0.088	2.760	0.006	**
ZPrimeBG_Freq_By_Pos	-0.156	0.088	-1.763	0.078	.
string:ZLexTALE	0.001	0.061	0.024	0.980	
Unrelated:ZLexTALE	0.119	0.069	1.724	0.085	.

Table 71. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Vietnamese for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.734	0.027	27.000	253.831	<2e-16	***
string	-0.028	0.014	75.000	-1.971	0.052	.
suffix	-0.031	0.014	109.000	-2.201	0.030	*
ZLexTALE	0.005	0.026	22.000	0.201	0.843	
ZPrevLRT	0.040	0.004	3852.000	9.471	<2e-16	***
PrevACC1	-0.052	0.009	3839.000	-5.520	3.62e-08	***
ZTrialNum	-0.043	0.003	3825.000	-12.925	<2e-16	***
ZPrimeOrtho_N	0.007	0.007	186.000	0.998	0.320	
ZPrimeBG_Mean	-0.020	0.007	186.000	-2.721	0.007	**
ZPrimeBG_Freq_By_Pos	0.024	0.007	192.000	3.190	0.002	**
string:ZLexTALE	-0.002	0.010	24.000	-0.225	0.824	
suffix:ZLexTALE	0.001	0.009	40.000	0.087	0.931	

Table 72. The estimate, standard error, *t* value, and *p* value for the fixed effects in the lmer model summary for Target.LRT for Vietnamese for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.709	0.028	25.930	235.488	<2e-16	***
string	0.002	0.013	151.900	0.149	0.882	
Unrelated	0.027	0.013	99.650	1.994	0.049	*
ZLexTALE	0.013	0.023	23.090	0.558	0.582	
ZPrevLRT	0.067	0.010	23.960	6.433	1.19e-06	***
PrevACC1	-0.046	0.010	26.120	-4.634	8.75e-05	***
ZTrialNum	-0.039	0.007	22.820	-5.583	1.14e-05	***
ZPrimeOrtho_N	0.009	0.007	186.200	1.341	0.181	
ZPrimeBG_Mean	-0.019	0.007	185.800	-2.727	0.007	**
ZPrimeBG_Freq_By_Pos	0.022	0.007	191.800	3.028	0.003	**
string:ZLexTALE	-0.005	0.008	125.900	-0.554	0.581	
Unrelated:ZLexTALE	-0.001	0.009	35.340	-0.081	0.936	

Table 73. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Vietnamese for non-words with unrelated being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.805	0.162	11.124	<2e-16	***
string	-0.271	0.194	-1.395	0.163	
suffix	-0.432	0.195	-2.220	0.026	*
ZLexTALE	0.200	0.104	1.919	0.055	.
ZPrevLRT	0.112	0.044	2.569	0.010	*

PrevACC1	0.462	0.103	4.506	6.60e-06	***
ZTrialNum	0.161	0.040	4.013	5.99e-05	***
ZPrimeOrtho_N	-0.203	0.103	-1.977	0.048	*
ZPrimeBG_Mean	0.350	0.106	3.301	0.001	***
ZPrimeBG_Freq_By_Pos	-0.329	0.105	-3.120	0.002	**
string:ZLexTALE	0.002	0.095	0.022	0.982	
suffix:ZLexTALE	0.074	0.095	0.783	0.434	

Table 74. The estimate, standard error, *z* value, and *p* value for the fixed effects in the glmer model summary for Target.ACC for Vietnamese for non-words with suffix being the reference condition.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.374	0.165	8.320	<2e-16	***
string	0.161	0.195	0.826	0.409	
Unrelated	0.432	0.195	2.220	0.026	*
ZLexTALE	0.275	0.108	2.545	0.011	*
ZPrevLRT	0.112	0.044	2.569	0.010	*
PrevACC1	0.462	0.103	4.506	6.60e-06	***
ZTrialNum	0.161	0.040	4.013	5.99e-05	***
ZPrimeOrtho_N	-0.203	0.103	-1.977	0.048	*
ZPrimeBG_Mean	0.350	0.106	3.301	0.001	***
ZPrimeBG_Freq_By_Pos	-0.329	0.105	-3.120	0.002	**
string:ZLexTALE	-0.072	0.095	-0.762	0.446	
Unrelated:ZLexTALE	-0.074	0.095	-0.782	0.434	

Table 75. LRT model summary for the combined data for all language groups for non-words with unrelated being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.653	0.020	212.580	335.489	<2e-16	***
string	-0.024	0.012	282.940	-2.040	0.042	*
suffix	-0.027	0.012	278.720	-2.310	0.022	*
Chinese	0.071	0.028	162.230	2.540	0.012	*
Turkish	0.098	0.026	159.370	3.765	0.000	***
Vietnamese	0.091	0.029	161.600	3.151	0.002	**
ZLexTale	-0.008	0.011	159.350	-0.771	0.442	
ZPrevLRT	0.049	0.003	165.780	14.896	<2e-16	***
PrevACC1	-0.056	0.004	159.660	-12.883	<2e-16	***
ZTrialNum	-0.028	0.003	160.430	-8.785	2.22e-15	***
ZPrimeOrtho_N	0.009	0.005	195.670	1.743	0.083	.
ZPrimeBG_Mean	-0.015	0.006	195.000	-2.727	0.007	**
ZPrimeBG_Freq_By_Pos	0.017	0.006	194.940	3.101	0.002	**
string:Chinese	0.008	0.010	170.010	0.786	0.433	
suffix:Chinese	0.011	0.009	175.040	1.157	0.249	
string:Turkish	0.038	0.010	157.980	3.820	0.000	***
suffix:Turkish	0.033	0.010	164.530	3.457	0.001	***
string:Vietnamese	-0.002	0.012	163.510	-0.158	0.875	
suffix:Vietnamese	0.002	0.012	170.010	0.204	0.838	

Table 76. LRT model summary for the combined data for all language groups for non-words with unrelated being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.724	0.019	216.570	363.087	<2e-16	***
string	-0.016	0.012	301.880	-1.367	0.173	
suffix	-0.016	0.012	298.740	-1.350	0.178	
English	-0.071	0.028	162.230	-2.540	0.012	*
Turkish	0.026	0.023	156.770	1.142	0.255	
Vietnamese	0.019	0.028	160.300	0.696	0.487	
ZLexTALE	-0.008	0.011	159.360	-0.771	0.442	
ZPrevLRT	0.049	0.003	165.780	14.896	<2e-16	***
PrevACC1	-0.056	0.004	159.660	-12.883	<2e-16	***
ZTrialNum	-0.028	0.003	160.430	-8.785	2.22e-15	***
ZPrimeOrtho_N	0.009	0.005	195.670	1.743	0.083	.
ZPrimeBG_Mean	-0.015	0.006	195.000	-2.727	0.007	**
ZPrimeBG_Freq_By_Pos	0.017	0.006	194.940	3.101	0.002	**
string:English	-0.008	0.010	170.010	-0.786	0.433	
suffix:English	-0.011	0.009	175.040	-1.157	0.249	
string:Turkish	0.030	0.010	172.070	2.990	0.003	**
suffix:Turkish	0.023	0.010	180.950	2.279	0.024	*
string:Vietnamese	-0.009	0.012	173.460	-0.786	0.433	
suffix:Vietnamese	-0.008	0.012	181.610	-0.722	0.471	

Table 77. LRT model summary for the combined data for all language groups for non-words with suffix being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.623	0.021	210.000	309.172	<2e-16	***
string	0.001	0.011	279.000	0.055	0.957	
Unrelated	0.026	0.011	280.000	2.303	0.022	*
Chinese	0.087	0.031	169.000	2.798	0.006	**
Turkish	0.145	0.029	170.000	5.077	9.97e-07	***
Vietnamese	0.087	0.032	172.000	2.741	0.007	**
ZLexTALE	-0.009	0.012	161.000	-0.752	0.453	
ZPrevLRT	0.027	0.001	27380.000	19.882	<2e-16	***
PrevACC1	-0.063	0.004	27300.000	-17.083	<2e-16	***
ZTrialNum	-0.028	0.001	27300.000	-21.677	<2e-16	***
ZPrimeOrtho_N	0.010	0.005	195.000	1.791	0.075	.
ZPrimeBG_Mean	-0.015	0.006	195.000	-2.718	0.007	**
ZPrimeBG_Freq_By_Pos	0.018	0.006	195.000	3.167	0.002	**
string:Chinese	-0.002	0.008	27280.000	-0.205	0.838	
Unrelated:Chinese	-0.012	0.008	27280.000	-1.420	0.156	
string:Turkish	0.005	0.008	27270.000	0.568	0.570	
Unrelated:Turkish	-0.033	0.008	27270.000	-3.910	9.27e-05	***
string:Vietnamese	0.001	0.010	27260.000	0.074	0.941	
Unrelated:Vietnamese	0.003	0.010	27270.000	0.276	0.783	

Table 78. LRT model summary for the combined data for all language groups for non-words with suffix being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.709	0.020	220.000	333.709	<2e-16	***
string	-0.001	0.011	304.000	-0.093	0.926	
Unrelated	0.014	0.011	303.000	1.242	0.215	
English	-0.087	0.031	169.000	-2.798	0.006	**
Turkish	0.059	0.025	175.000	2.313	0.022	*
Vietnamese	0.000	0.030	174.000	0.007	0.995	
ZLexTALE	-0.009	0.012	161.000	-0.752	0.453	
ZPrevLRT	0.027	0.001	27380.000	19.882	<2e-16	***
PrevACC1	-0.063	0.004	27300.000	-17.083	<2e-16	***
ZTrialNum	-0.028	0.001	27300.000	-21.677	<2e-16	***
ZPrimeOrtho_N	0.010	0.005	195.000	1.791	0.075	.
ZPrimeBG_Mean	-0.015	0.006	195.000	-2.718	0.007	**
ZPrimeBG_Freq_By_Pos	0.018	0.006	195.000	3.167	0.002	**
string:English	0.002	0.008	27280.000	0.205	0.838	
Unrelated:English	0.012	0.008	27280.000	1.420	0.156	
string:Turkish	0.006	0.009	27280.000	0.740	0.459	
Unrelated:Turkish	-0.021	0.009	27280.000	-2.441	0.015	*
string:Vietnamese	0.002	0.010	27270.000	0.234	0.815	
Unrelated:Vietnamese	0.014	0.010	27270.000	1.400	0.162	

Table 79. Accuracy model summary for the combined data for all language groups for non-words with unrelated being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.869	0.150	12.447	<2e-16	***
string	-0.111	0.169	-0.656	0.512	
suffix	-0.125	0.172	-0.729	0.466	
Chinese	-0.117	0.161	-0.728	0.467	
Turkish	0.435	0.158	2.759	0.006	**
Vietnamese	0.021	0.173	0.123	0.902	
ZLexTALE	0.427	0.056	7.556	4.16e-14	***
ZPrevLRT	0.063	0.014	4.480	7.47e-06	***
PrevACC1	0.253	0.040	6.376	1.82e-10	***
ZTrialNum	0.114	0.015	7.387	1.50e-13	***
ZPrimeOrtho_N	-0.234	0.080	-2.944	0.003	**
ZPrimeBG_Mean	0.215	0.082	2.619	0.009	**
ZPrimeBG_Freq_By_Pos	-0.155	0.083	-1.874	0.061	.
string:Chinese	-0.159	0.116	-1.373	0.170	
suffix:Chinese	-0.203	0.121	-1.680	0.093	.
string:Turkish	-0.220	0.129	-1.705	0.088	.
suffix:Turkish	-0.596	0.132	-4.515	6.34e-06	***
string:Vietnamese	-0.201	0.145	-1.386	0.166	
suffix:Vietnamese	-0.356	0.150	-2.381	0.017	*

Table 80. Accuracy model summary for the combined data for all language groups for non-words with unrelated being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.752	0.142	12.376	<2e-16	***
string	-0.270	0.161	-1.675	0.094	.
suffix	-0.328	0.164	-2.001	0.045	*
English	0.117	0.161	0.728	0.467	
Turkish	0.552	0.140	3.944	8.02e-05	***
Vietnamese	0.139	0.165	0.842	0.400	
ZLexTALE	0.427	0.056	7.555	4.17e-14	***
ZPrevLRT	0.063	0.014	4.480	7.47e-06	***
PrevACC1	0.253	0.040	6.376	1.82e-10	***
ZTrialNum	0.114	0.015	7.387	1.50e-13	***
ZPrimeOrtho_N	-0.234	0.080	-2.944	0.003	**
ZPrimeBG_Mean	0.215	0.082	2.619	0.009	**
ZPrimeBG_Freq_By_Pos	-0.155	0.083	-1.874	0.061	.
string:English	0.159	0.116	1.372	0.170	
suffix:English	0.203	0.121	1.679	0.093	.
string:Turkish	-0.061	0.120	-0.509	0.611	
suffix:Turkish	-0.394	0.123	-3.195	0.001	**
string:Vietnamese	-0.042	0.137	-0.306	0.759	
suffix:Vietnamese	-0.154	0.142	-1.085	0.278	

Table 81. Accuracy model summary for the combined data for all language groups for non-words with suffix being the reference condition with English being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.744	0.148	11.804	<2e-16	***
string	0.014	0.166	0.084	0.933	
Unrelated	0.125	0.172	0.729	0.466	
Chinese	-0.320	0.154	-2.078	0.038	*
Turkish	-0.161	0.147	-1.099	0.272	
Vietnamese	-0.335	0.161	-2.076	0.038	*
ZLexTALE	0.427	0.056	7.558	4.08e-14	***
ZPrevLRT	0.063	0.014	4.480	7.47e-06	***
PrevACC1	0.253	0.040	6.376	1.82e-10	***
ZTrialNum	0.114	0.015	7.387	1.50e-13	***
ZPrimeOrtho_N	-0.234	0.080	-2.945	0.003	**
ZPrimeBG_Mean	0.215	0.082	2.619	0.009	**
ZPrimeBG_Freq_By_Pos	-0.155	0.083	-1.874	0.061	.
string:Chinese	0.043	0.100	0.435	0.663	
Unrelated:Chinese	0.203	0.121	1.681	0.093	.
string:Turkish	0.376	0.109	3.440	0.001	***
Unrelated:Turkish	0.596	0.132	4.517	6.28e-06	***
string:Vietnamese	0.155	0.123	1.268	0.205	
Unrelated:Vietnamese	0.356	0.150	2.381	0.017	*

Table 82. Accuracy model summary for the combined data for all language groups for non-words with suffix being the reference condition with Chinese being the reference.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	1.425	0.139	10.218	<2e-16	***
string	0.057	0.157	0.365	0.715	
Unrelated	0.328	0.164	2.001	0.045	*
English	0.320	0.154	2.077	0.038	*
Turkish	0.159	0.127	1.244	0.213	
Vietnamese	-0.015	0.152	-0.101	0.920	
ZLexTALE	0.427	0.056	7.556	4.17e-14	***
ZPrevLRT	0.063	0.014	4.480	7.47e-06	***
PrevACC1	0.253	0.040	6.376	1.82e-10	***
ZTrialNum	0.114	0.015	7.387	1.50e-13	***
ZPrimeOrtho_N	-0.234	0.080	-2.944	0.003	**
ZPrimeBG_Mean	0.215	0.082	2.619	0.009	**
ZPrimeBG_Freq_By_Pos	-0.155	0.083	-1.875	0.061	.
string:English	-0.043	0.100	-0.435	0.664	
Unrelated:English	-0.203	0.121	-1.680	0.093	.
string:Turkish	0.332	0.098	3.378	0.001	***
Unrelated:Turkish	0.394	0.123	3.196	0.001	**
string:Vietnamese	0.112	0.113	0.995	0.320	
Unrelated:Vietnamese	0.154	0.142	1.086	0.278	

Table 83. Morphological awareness model summary for the LRT for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.574	0.010	330.000	639.982	<2e-16	***
form	-0.005	0.005	468.000	-1.015	0.311	
opaque	-0.011	0.005	326.000	-2.084	0.038	*
morph	-0.048	0.004	947.000	-12.132	<2e-16	***
ZMorph	0.002	0.008	161.000	0.201	0.841	
ZLexTALE	-0.048	0.007	163.000	-6.512	8.72e-10	***
ZPrevLRT	0.042	0.003	167.000	12.985	<2e-16	***
PrevACC1	-0.014	0.004	159.000	-3.525	0.001	***
ZTrialNum	-0.011	0.002	162.000	-4.311	2.81e-05	***
ZPrimeOrtho_N	0.000	0.003	26020.000	-0.150	0.881	
ZPrimePhono_N	-0.003	0.002	22780.000	-1.033	0.302	
ZPrimeBG_Sum	0.004	0.004	26100.000	1.087	0.277	
ZPrimeBG_Mean	-0.007	0.004	25760.000	-1.783	0.075	.
ZPrimeBG_Freq_By_Pos	0.004	0.003	24680.000	1.390	0.165	
ZTargetOrtho_N	-0.028	0.011	195.000	-2.660	0.008	**
ZTargetPhono_N	0.004	0.011	195.000	0.357	0.722	
form:ZMorph	0.006	0.004	202.000	1.477	0.141	
opaque:ZMorph	0.014	0.004	153.000	3.373	0.001	***
morph:ZMorph	-0.005	0.003	535.000	-1.404	0.161	

Table 84. Morphological awareness model summary for the LRT for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.485	0.013	72.000	486.594	<2e-16	***
form	0.016	0.008	135.000	1.957	0.052	.
opaque	0.018	0.008	210.000	2.223	0.027	*
morph	-0.044	0.007	187.000	-6.403	1.20e-09	***
ZMorph	-0.003	0.011	46.000	-0.252	0.802	
ZLexTALE	-0.002	0.011	47.000	-0.226	0.822	
ZPrevLRT	0.046	0.006	52.000	7.328	1.53e-09	***
PrevACC1	-0.022	0.007	56.000	-3.120	0.003	**
ZTrialNum	-0.007	0.003	49.000	-2.141	0.037	*
ZPrimeOrtho_N	0.006	0.004	6738.000	1.420	0.156	
ZPrimePhono_N	-0.006	0.004	4957.000	-1.545	0.122	
ZPrimeBG_Sum	0.007	0.007	6794.000	1.007	0.314	
ZPrimeBG_Mean	-0.003	0.006	6661.000	-0.473	0.636	
ZPrimeBG_Freq_By_Pos	0.001	0.005	6149.000	0.223	0.824	
ZTargetOrtho_N	-0.022	0.010	180.000	-2.152	0.033	*
ZTargetPhono_N	0.004	0.010	180.000	0.346	0.729	
form:ZMorph	-0.006	0.007	82.000	-0.881	0.381	
opaque:ZMorph	0.004	0.006	145.000	0.692	0.490	
morph:ZMorph	-0.006	0.006	141.000	-1.023	0.308	

Table 85. Morphological awareness model summary for the LRT for Turkish.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.632	0.017	67.000	399.308	<2e-16	***
form	0.002	0.011	110.000	0.209	0.835	
opaque	0.003	0.010	100.000	0.327	0.745	
morph	-0.062	0.009	86.000	-6.891	8.55e-10	***
ZMorph	-0.019	0.013	44.000	-1.452	0.154	
ZLexTALE	-0.005	0.012	37.000	-0.369	0.714	
ZPrevLRT	0.031	0.005	35.000	6.493	1.83e-07	***
PrevACC1	-0.011	0.009	40.000	-1.211	0.233	
ZTrialNum	-0.018	0.006	40.000	-2.940	0.005	**
ZPrimeOrtho_N	-0.005	0.005	6240.000	-1.048	0.295	
ZPrimePhono_N	0.000	0.005	5212.000	0.019	0.985	
ZPrimeBG_Sum	-0.008	0.008	6242.000	-0.978	0.328	
ZPrimeBG_Mean	0.002	0.008	6104.000	0.242	0.809	
ZPrimeBG_Freq_By_Pos	0.007	0.006	5735.000	1.247	0.212	
ZTargetOrtho_N	-0.025	0.013	186.000	-1.953	0.052	.
ZTargetPhono_N	0.005	0.013	186.000	0.428	0.669	
form:ZMorph	0.022	0.008	70.000	2.669	0.009	**
opaque:ZMorph	0.023	0.008	61.000	2.702	0.009	**
morph:ZMorph	-0.002	0.008	73.000	-0.243	0.809	

Table 86. Morphological awareness model summary for the LRT for Chinese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.614	0.015	69.000	440.911	<2e-16	***
form	-0.016	0.009	182.000	-1.920	0.056	.
opaque	-0.036	0.009	107.000	-4.009	0.000	***
morph	-0.055	0.007	167.000	-7.498	3.64e-12	***
ZMorph	-0.002	0.012	47.000	-0.156	0.877	
ZLexTALE	-0.025	0.012	46.000	-2.098	0.041	*
ZPrevLRT	0.043	0.006	48.000	6.972	8.29e-09	***
PrevACC1	-0.013	0.007	52.000	-1.886	0.065	.
ZTrialNum	-0.009	0.005	48.000	-1.956	0.056	.
ZPrimeOrtho_N	-0.002	0.004	6606.000	-0.448	0.654	
ZPrimePhono_N	0.004	0.004	5248.000	0.949	0.343	
ZPrimeBG_Sum	0.006	0.007	6755.000	0.895	0.371	
ZPrimeBG_Mean	-0.010	0.006	6568.000	-1.611	0.107	
ZPrimeBG_Freq_By_Pos	0.002	0.005	6003.000	0.445	0.657	
ZTargetOrtho_N	-0.032	0.011	192.000	-3.044	0.003	**
ZTargetPhono_N	-0.003	0.011	193.000	-0.259	0.796	
form:ZMorph	-0.004	0.007	113.000	-0.557	0.579	
opaque:ZMorph	0.003	0.007	64.000	0.476	0.636	
morph:ZMorph	-0.004	0.006	197.000	-0.690	0.491	

Table 87. Morphological awareness model summary for the LRT for Vietnamese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.563	0.024	26.000	273.738	<2e-16	***
form	-0.004	0.012	48.000	-0.337	0.737	
opaque	-0.017	0.011	67.000	-1.539	0.128	
morph	-0.061	0.009	356.000	-6.399	4.93e-10	***
ZMorph	0.018	0.031	23.000	0.565	0.577	
ZLexTALE	-0.021	0.030	21.000	-0.718	0.480	
ZPrevLRT	0.033	0.004	4151.000	9.325	<2e-16	***
PrevACC1	-0.014	0.008	4131.000	-1.663	0.096	.
ZTrialNum	-0.011	0.003	4135.000	-3.928	8.72e-05	***
ZPrimeOrtho_N	0.002	0.006	3539.000	0.311	0.756	
ZPrimePhono_N	-0.008	0.005	2967.000	-1.386	0.166	
ZPrimeBG_Sum	0.009	0.009	3561.000	0.943	0.346	
ZPrimeBG_Mean	0.002	0.009	3494.000	0.217	0.828	
ZPrimeBG_Freq_By_Pos	-0.008	0.006	3185.000	-1.258	0.209	
ZTargetOrtho_N	-0.032	0.012	186.000	-2.698	0.008	**
ZTargetPhono_N	0.007	0.012	187.000	0.563	0.574	
form:ZMorph	0.002	0.010	23.000	0.210	0.836	
opaque:ZMorph	0.020	0.010	35.000	2.017	0.051	.
morph:ZMorph	0.000	0.008	212.000	-0.044	0.965	

Table 88. Morphological awareness model summary for accuracy for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.765	0.114	24.198	<2e-16	***
form	-0.392	0.075	-5.222	1.77e-07	***
opaque	-0.193	0.067	-2.876	0.004	**
morph	0.415	0.098	4.255	2.09e-05	***
ZMorph	0.192	0.047	4.066	4.77e-05	***
ZLexTALE	0.350	0.048	7.260	3.88e-13	***
ZPrevLRT	0.057	0.018	3.239	0.001	**
PrevACC1	-0.316	0.051	-6.162	7.20e-10	***
ZTrialNum	-0.136	0.018	-7.389	1.48e-13	***
ZPrimeOrtho_N	0.037	0.037	0.990	0.322	
ZPrimePhono_N	-0.065	0.039	-1.648	0.099	.
ZPrimeBG_Sum	0.070	0.063	1.121	0.262	
ZPrimeBG_Mean	-0.110	0.058	-1.907	0.056	.
ZPrimeBG_Freq_By_Pos	0.003	0.044	0.078	0.938	
ZTargetOrtho_N	0.314	0.161	1.954	0.051	.
ZTargetPhono_N	-0.093	0.160	-0.580	0.562	
form:ZMorph	-0.118	0.057	-2.081	0.037	*
opaque:ZMorph	-0.174	0.056	-3.100	0.002	**
morph:ZMorph	0.096	0.061	1.577	0.115	

Table 89. Morphological awareness model summary for accuracy for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.423	0.161	21.319	<2e-16	***
form	-0.945	0.139	-6.816	9.36e-12	***
opaque	-0.761	0.128	-5.940	2.86e-09	***
morph	0.475	0.210	2.256	0.024	*
ZMorph	0.224	0.087	2.571	0.010	*
ZLexTALE	0.200	0.081	2.466	0.014	*
ZPrevLRT	0.097	0.032	2.994	0.003	**
PrevACC1	-0.429	0.117	-3.657	0.000	***
ZTrialNum	-0.120	0.037	-3.260	0.001	**
ZPrimeOrtho_N	0.035	0.072	0.488	0.625	
ZPrimePhono_N	-0.036	0.072	-0.503	0.615	
ZPrimeBG_Sum	0.201	0.124	1.628	0.104	
ZPrimeBG_Mean	-0.248	0.112	-2.211	0.027	*
ZPrimeBG_Freq_By_Pos	-0.007	0.087	-0.076	0.940	
ZTargetOrtho_N	0.089	0.189	0.473	0.636	
ZTargetPhono_N	0.053	0.187	0.284	0.777	
form:ZMorph	-0.113	0.103	-1.098	0.272	
opaque:ZMorph	-0.202	0.103	-1.961	0.050	*
morph:ZMorph	0.078	0.130	0.599	0.549	

Table 90. Morphological awareness model summary for accuracy for Turkish.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.031	0.176	17.189	<2e-16	***
form	-0.242	0.146	-1.662	0.097	.
opaque	-0.285	0.136	-2.102	0.036	*
morph	0.680	0.202	3.366	0.001	***
ZMorph	0.222	0.107	2.080	0.038	*
ZLexTALE	0.366	0.103	3.546	0.000	***
ZPrevLRT	0.020	0.035	0.575	0.565	
PrevACC1	-0.179	0.106	-1.694	0.090	.
ZTrialNum	-0.129	0.038	-3.395	0.001	***
ZPrimeOrtho_N	0.080	0.076	1.055	0.291	
ZPrimePhono_N	-0.111	0.079	-1.398	0.162	
ZPrimeBG_Sum	0.114	0.122	0.936	0.349	
ZPrimeBG_Mean	-0.138	0.113	-1.226	0.220	
ZPrimeBG_Freq_By_Pos	0.074	0.088	0.848	0.397	
ZTargetOrtho_N	0.333	0.218	1.528	0.127	
ZTargetPhono_N	-0.090	0.214	-0.419	0.675	
form:ZMorph	-0.353	0.110	-3.217	0.001	**
opaque:ZMorph	-0.248	0.112	-2.216	0.027	*
morph:ZMorph	0.089	0.138	0.645	0.519	

Table 91. Morphological awareness model summary for accuracy for Chinese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.250	0.134	16.763	<2e-16	***
form	-0.161	0.111	-1.453	0.146	
opaque	0.015	0.102	0.149	0.881	
morph	0.449	0.129	3.466	0.001	***
ZMorph	0.104	0.080	1.298	0.194	
ZLexTALE	0.247	0.071	3.487	0.000	***
ZPrevLRT	0.038	0.031	1.215	0.224	
PrevACC1	-0.347	0.077	-4.503	6.69e-06	***
ZTrialNum	-0.156	0.030	-5.152	2.57e-07	***
ZPrimeOrtho_N	0.074	0.060	1.234	0.217	
ZPrimePhono_N	-0.064	0.061	-1.048	0.295	
ZPrimeBG_Sum	-0.012	0.101	-0.119	0.906	
ZPrimeBG_Mean	-0.068	0.094	-0.729	0.466	
ZPrimeBG_Freq_By_Pos	0.039	0.071	0.552	0.581	
ZTargetOrtho_N	0.381	0.168	2.267	0.023	*
ZTargetPhono_N	-0.112	0.166	-0.678	0.498	
form:ZMorph	0.019	0.082	0.227	0.820	
opaque:ZMorph	-0.142	0.081	-1.754	0.079	.
morph:ZMorph	0.019	0.099	0.197	0.844	

Table 92. Morphological awareness model summary for accuracy for Vietnamese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.067	0.186	16.447	<2e-16	***
form	-0.389	0.181	-2.154	0.031	*
opaque	0.216	0.173	1.254	0.210	
morph	0.639	0.228	2.801	0.005	**
ZMorph	-0.096	0.136	-0.705	0.481	
ZLexTALE	0.469	0.127	3.701	0.000	***
ZPrevLRT	0.068	0.053	1.287	0.198	
PrevACC1	-0.351	0.158	-2.221	0.026	*
ZTrialNum	-0.120	0.054	-2.213	0.027	*
ZPrimeOrtho_N	-0.126	0.109	-1.159	0.246	
ZPrimePhono_N	0.005	0.124	0.043	0.965	
ZPrimeBG_Sum	0.147	0.171	0.863	0.388	
ZPrimeBG_Mean	-0.154	0.156	-0.988	0.323	
ZPrimeBG_Freq_By_Pos	-0.125	0.119	-1.054	0.292	
ZTargetOrtho_N	0.494	0.211	2.336	0.019	*
ZTargetPhono_N	-0.136	0.205	-0.660	0.509	
form:ZMorph	0.118	0.141	0.835	0.404	
opaque:ZMorph	0.093	0.142	0.659	0.510	
morph:ZMorph	0.227	0.184	1.233	0.217	

Table 93. CORank model summary with all covariates for the LRT for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.554	0.012	284.000	566.675	<2e-16	***
opaque	-0.002	0.011	1207.000	-0.217	0.828	
morph	-0.044	0.004	1932.000	-10.128	<2e-16	***
ZCORank	-0.006	0.006	569.000	-1.001	0.317	
ZLexTALE	-0.052	0.007	162.000	-7.111	3.47e-11	***
ZPrevLRT	0.042	0.004	166.000	11.548	<2e-16	***
PrevACC1	-0.011	0.005	163.000	-2.304	0.023	*
ZTrialNum	-0.015	0.003	160.000	-5.604	8.95e-08	***
ZPrimeLen	-0.002	0.009	3685.000	-0.255	0.799	
ZPrimeLogHal	-0.002	0.002	9689.000	-0.684	0.494	
ZTargetCobLog	-0.038	0.009	107.000	-4.459	2.04e-05	***
ZPrimeOrtho_N	0.000	0.006	9365.000	0.074	0.941	
ZPrimePhono_N	0.005	0.007	9934.000	0.766	0.443	
ZPrimeBG_Sum	0.016	0.017	3588.000	0.921	0.357	
ZPrimeBG_Mean	-0.017	0.015	3875.000	-1.167	0.243	
ZPrimeBG_Freq_By_Pos	0.001	0.004	7442.000	0.288	0.773	
ZTargetOrtho_N	-0.003	0.012	106.000	-0.229	0.819	
ZTargetPhono_N	-0.008	0.012	106.000	-0.650	0.517	
opaque:ZCORank	0.008	0.009	7778.000	0.870	0.385	
morph:ZCORank	0.009	0.004	13290.000	2.105	0.035	*

Table 94. CORank model summary with some covariates for the LRT for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.550	0.012	274.000	549.985	<2e-16	***
opaque	-0.004	0.011	1232.000	-0.358	0.720	
morph	-0.044	0.004	1730.000	-10.498	<2e-16	***
ZCORank	-0.007	0.006	687.000	-1.151	0.250	
ZLexTALE	-0.052	0.007	162.000	-7.097	3.74e-11	***
ZPrevLRT	0.042	0.004	166.000	11.549	<2e-16	***
PrevACC1	-0.011	0.005	163.000	-2.307	0.022	*
ZTrialNum	-0.015	0.003	160.000	-5.604	8.96e-08	***
ZPrimeOrtho_N	0.001	0.006	10780.000	0.256	0.798	
ZPrimePhono_N	0.005	0.007	10820.000	0.736	0.462	
ZPrimeBG_Sum	0.011	0.007	4826.000	1.550	0.121	
ZPrimeBG_Mean	-0.014	0.007	5842.000	-1.924	0.055	.
ZPrimeBG_Freq_By_Pos	0.002	0.004	8598.000	0.460	0.646	
ZTargetOrtho_N	-0.014	0.013	107.000	-1.087	0.280	
ZTargetPhono_N	-0.001	0.013	108.000	-0.087	0.931	
opaque:ZCORank	0.007	0.009	8911.000	0.823	0.410	
morph:ZCORank	0.008	0.004	13950.000	2.056	0.040	*

Table 95. CORank model summary without covariates for the LRT for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.553	0.012	248.000	567.268	<2e-16	***

opaque	-0.010	0.010	865.000	-0.995	0.320	
morph	-0.046	0.004	1318.000	-11.731	<2e-16	***
ZCORank	-0.005	0.006	722.000	-0.864	0.388	
ZLexTALE	-0.052	0.007	162.000	-7.065	4.54e-11	***
ZPrevLRT	0.042	0.004	165.000	11.579	<2e-16	***
PrevACC1	-0.011	0.005	162.000	-2.272	0.024	*
ZTrialNum	-0.015	0.003	159.000	-5.623	8.23e-08	***
opaque:ZCORank	0.007	0.009	8868.000	0.803	0.422	
morph:ZCORank	0.008	0.004	14000.000	1.996	0.046	*

Table 96. CORank model summary with all covariates for the LRT for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.469	0.015	111.000	422.999	<2e-16	***
opaque	0.031	0.018	257.000	1.738	0.083	.
morph	-0.040	0.008	96.000	-5.208	1.09e-06	***
ZCORank	-0.004	0.008	235.000	-0.583	0.561	
ZLexTALE	0.004	0.012	48.000	0.316	0.754	
ZPrevLRT	0.027	0.003	4485.000	8.061	8.88e-16	***
PrevACC1	-0.025	0.008	4459.000	-2.928	0.003	**
ZTrialNum	-0.018	0.003	4466.000	-6.419	1.51e-10	***
ZPrimeLen	-0.004	0.013	795.000	-0.313	0.754	
ZPrimeLogHal	-0.001	0.004	2150.000	-0.172	0.863	
ZTargetCobLog	-0.031	0.008	97.000	-3.649	0.000	***

ZPrimeOrtho_N	0.008	0.009	2248.000	0.800	0.424	
ZPrimePhono_N	0.018	0.011	2267.000	1.618	0.106	
ZPrimeBG_Sum	0.032	0.026	757.000	1.245	0.213	
ZPrimeBG_Mean	-0.018	0.023	811.000	-0.766	0.444	
ZPrimeBG_Freq_By_Pos	-0.014	0.007	1544.000	-2.023	0.043	*
ZTargetOrtho_N	-0.001	0.012	95.000	-0.064	0.949	
ZTargetPhono_N	-0.005	0.012	96.000	-0.404	0.687	
opaque:ZCORank	0.001	0.015	2323.000	0.033	0.973	
morph:ZCORank	0.014	0.007	3860.000	1.977	0.048	*

Table 97. CORank model summary with some covariates for the LRT for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.464	0.015	97.000	430.724	<2e-16	***
opaque	0.031	0.018	262.000	1.752	0.081	.
morph	-0.040	0.007	88.000	-5.346	6.97e-07	***
ZCORank	-0.007	0.008	262.000	-0.925	0.356	
ZLexTALE	-0.001	0.011	47.000	-0.057	0.955	
ZPrevLRT	0.046	0.007	57.000	6.743	8.79e-09	***
PrevACC1	-0.021	0.009	329.000	-2.409	0.017	*
ZTrialNum	-0.017	0.004	48.000	-4.272	9.15e-05	***
ZPrimeOrtho_N	0.011	0.009	2522.000	1.209	0.227	
ZPrimePhono_N	0.017	0.011	2459.000	1.470	0.142	
ZPrimeBG_Sum	0.026	0.011	980.000	2.397	0.017	*

ZPrimeBG_Mean	-0.013	0.012	1244.000	-1.094	0.274	
ZPrimeBG_Freq_By_Pos	-0.013	0.007	1749.000	-1.907	0.057	.
ZTargetOrtho_N	-0.011	0.012	98.000	-0.907	0.367	
ZTargetPhono_N	0.002	0.012	100.000	0.195	0.846	
opaque:ZCORank	0.000	0.015	2596.000	0.020	0.984	
morph:ZCORank	0.012	0.007	4122.000	1.833	0.067	.

Table 98. CORank model summary without covariates for the LRT for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.462	0.014	83.000	450.299	<2e-16	***
opaque	0.025	0.017	203.000	1.519	0.130	
morph	-0.042	0.007	71.000	-5.867	1.31e-07	***
ZCORank	-0.011	0.008	266.000	-1.383	0.168	
ZLexTALE	-0.001	0.011	47.000	-0.054	0.957	
ZPrevLRT	0.046	0.007	57.000	6.794	6.97e-09	***
PrevACC1	-0.020	0.009	324.000	-2.360	0.019	*
ZTrialNum	-0.017	0.004	48.000	-4.278	8.93e-05	***
opaque:ZCORank	0.004	0.015	2711.000	0.241	0.810	
morph:ZCORank	0.012	0.007	4209.000	1.836	0.067	.

Table 99. CORank model summary with all covariates for the LRT for Turkish.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.606	0.019	81.000	345.240	<2e-16	***

opaque	0.035	0.020	352.000	1.781	0.076	.
morph	-0.051	0.009	156.000	-5.646	7.56e-08	***
ZCORank	-0.010	0.009	248.000	-1.127	0.261	
ZLexTALE	-0.009	0.015	40.000	-0.610	0.545	
ZPrevLRT	0.009	0.003	3633.000	2.976	0.003	**
PrevACC1	-0.012	0.009	3649.000	-1.330	0.184	
ZTrialNum	-0.023	0.003	3645.000	-6.847	8.79e-12	***
ZPrimeLen	0.030	0.016	766.000	1.906	0.057	.
ZPrimeLogHal	-0.005	0.005	1884.000	-1.084	0.279	
ZTargetCobLog	-0.045	0.010	102.000	-4.510	1.73e-05	***
ZPrimeOrtho_N	-0.004	0.011	2005.000	-0.333	0.739	
ZPrimePhono_N	0.013	0.014	2114.000	0.921	0.357	
ZPrimeBG_Sum	-0.042	0.031	727.000	-1.345	0.179	
ZPrimeBG_Mean	0.029	0.027	772.000	1.066	0.287	
ZPrimeBG_Freq_By_Pos	0.005	0.008	1456.000	0.659	0.510	
ZTargetOrtho_N	-0.002	0.014	99.000	-0.145	0.885	
ZTargetPhono_N	-0.011	0.014	101.000	-0.745	0.458	
opaque:ZCORank	0.042	0.018	2142.000	2.405	0.016	*
morph:ZCORank	0.016	0.008	3339.000	1.896	0.058	.

Table 100. CORank model summary with some covariates for the LRT for Turkish.

<table>
<tr><th>Fixed effects:</th><th>Estimate</th><th>Std. Error</th><th>df</th><th>t value</th><th>Pr(>|t|)</th><th></th></tr>
<tr><td>(Intercept)</td><td>6.603</td><td>0.019</td><td>86.000</td><td>348.978</td><td><2e-16</td><td>***</td></tr>
</table>

opaque	0.030	0.020	347.000	1.482	0.139	
morph	-0.053	0.009	117.000	-5.915	3.34e-08	***
ZCORank	-0.010	0.009	272.000	-1.109	0.269	
ZLexTALE	-0.010	0.012	39.000	-0.848	0.401	
ZPrevLRT	0.029	0.005	31.000	5.570	4.37e-06	***
PrevACC1	-0.006	0.012	44.000	-0.479	0.634	
ZTrialNum	-0.022	0.006	40.000	-3.459	0.001	**
ZPrimeOrtho_N	0.002	0.011	2338.000	0.183	0.855	
ZPrimePhono_N	0.009	0.013	2419.000	0.705	0.481	
ZPrimeBG_Sum	0.008	0.013	1031.000	0.616	0.538	
ZPrimeBG_Mean	-0.015	0.014	1285.000	-1.088	0.277	
ZPrimeBG_Freq_By_Pos	0.007	0.008	1754.000	0.914	0.361	
ZTargetOrtho_N	-0.017	0.015	98.000	-1.158	0.250	
ZTargetPhono_N	-0.001	0.015	100.000	-0.044	0.965	
opaque:ZCORank	0.038	0.017	2456.000	2.196	0.028	*
morph:ZCORank	0.013	0.008	3524.000	1.627	0.104	

Table 101. CORank model summary without covariates for the LRT for Turkish.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.604	0.018	72.000	366.140	<2e-16	***
opaque	0.028	0.018	256.000	1.523	0.129	
morph	-0.054	0.008	92.000	-6.425	5.72e-09	***
ZCORank	-0.009	0.009	272.000	-1.027	0.305	

ZLexTALE	-0.010	0.012	39.000	-0.838	0.407	
ZPrevLRT	0.029	0.005	31.000	5.560	4.44e-06	***
PrevACC1	-0.006	0.012	44.000	-0.483	0.631	
ZTrialNum	-0.022	0.006	40.000	-3.452	0.001	**
opaque:ZCORank	0.039	0.017	2527.000	2.278	0.023	*
morph:ZCORank	0.012	0.008	3556.000	1.556	0.120	

Table 102. CORank model summary with all covariates for the LRT for Chinese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.600	0.016	103.000	405.836	<2e-16	***
opaque	-0.049	0.018	652.000	-2.748	0.006	**
morph	-0.050	0.008	278.000	-6.223	1.79e-09	***
ZCORank	-0.001	0.008	273.000	-0.150	0.881	
ZLexTALE	-0.025	0.012	47.000	-2.124	0.039	*
ZPrevLRT	0.040	0.007	49.000	5.790	4.86e-07	***
PrevACC1	-0.015	0.009	51.000	-1.679	0.099	.
ZTrialNum	-0.009	0.004	46.000	-2.219	0.031	*
ZPrimeLen	0.018	0.014	905.000	1.310	0.191	
ZPrimeLogHal	0.002	0.004	2350.000	0.576	0.564	
ZTargetCobLog	-0.035	0.009	105.000	-3.781	0.000	***
ZPrimeOrtho_N	-0.007	0.010	2350.000	-0.718	0.473	
ZPrimePhono_N	0.002	0.012	2527.000	0.132	0.895	
ZPrimeBG_Sum	-0.029	0.028	875.000	-1.058	0.290	

ZPrimeBG_Mean	0.015	0.024	928.000	0.605	0.546	
ZPrimeBG_Freq_By_Pos	0.003	0.007	1770.000	0.406	0.685	
ZTargetOrtho_N	-0.007	0.013	104.000	-0.500	0.618	
ZTargetPhono_N	-0.012	0.013	104.000	-0.920	0.360	
opaque:ZCORank	-0.018	0.015	2414.000	-1.138	0.255	
morph:ZCORank	0.008	0.007	3832.000	1.061	0.289	

Table 103. CORank model summary with some covariates for the LRT for Chinese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.598	0.016	105.000	402.757	<2e-16	***
opaque	-0.051	0.018	679.000	-2.835	0.005	**
morph	-0.052	0.008	249.000	-6.632	2.05e-10	***
ZCORank	-0.002	0.008	295.000	-0.242	0.809	
ZLexTALE	-0.025	0.012	47.000	-2.114	0.040	*
ZPrevLRT	0.040	0.007	49.000	5.804	4.65e-07	***
PrevACC1	-0.014	0.009	51.000	-1.640	0.107	
ZTrialNum	-0.009	0.004	47.000	-2.199	0.033	*
ZPrimeOrtho_N	-0.002	0.010	2584.000	-0.246	0.806	
ZPrimePhono_N	0.001	0.012	2703.000	0.121	0.903	
ZPrimeBG_Sum	0.005	0.012	1144.000	0.393	0.694	
ZPrimeBG_Mean	-0.013	0.012	1422.000	-1.089	0.276	
ZPrimeBG_Freq_By_Pos	0.003	0.007	1957.000	0.396	0.692	
ZTargetOrtho_N	-0.017	0.013	102.000	-1.279	0.204	

ZTargetPhono_N	-0.006	0.014	104.000	-0.409	0.684	
opaque:ZCORank	-0.020	0.015	2649.000	-1.295	0.196	
morph:ZCORank	0.005	0.007	4030.000	0.693	0.488	

Table 104. CORank model summary without covariates for the LRT for Chinese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.601	0.016	88.000	423.442	<2e-16	***
opaque	-0.059	0.016	548.000	-3.638	0.000	***
morph	-0.052	0.007	198.000	-7.152	1.62e-11	***
ZCORank	-0.001	0.008	302.000	-0.088	0.930	
ZLexTALE	-0.025	0.012	47.000	-2.129	0.039	*
ZPrevLRT	0.040	0.007	49.000	5.806	4.62e-07	***
PrevACC1	-0.014	0.009	51.000	-1.621	0.111	
ZTrialNum	-0.009	0.004	47.000	-2.211	0.032	*
opaque:ZCORank	-0.020	0.015	2750.000	-1.284	0.199	
morph:ZCORank	0.004	0.007	4082.000	0.628	0.530	

Table 105. CORank model summary with all covariates for the LRT for Vietnamese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.545	0.025	29.900	259.586	<2e-16	***
opaque	-0.006	0.024	116.900	-0.264	0.792	
morph	-0.052	0.010	153.700	-4.946	1.96e-06	***
ZCORank	0.000	0.010	226.200	-0.042	0.967	

ZLexTALE	-0.038	0.020	22.900	-1.852	0.077	.
ZPrevLRT	0.066	0.011	22.500	5.917	5.41e-06	***
PrevACC1	0.003	0.012	21.400	0.277	0.784	
ZTrialNum	-0.013	0.008	22.200	-1.629	0.117	
ZPrimeLen	-0.014	0.017	563.700	-0.791	0.429	
ZPrimeLogHal	-0.004	0.005	1276.000	-0.763	0.445	
ZTargetCobLog	-0.035	0.010	98.800	-3.470	0.001	***
ZPrimeOrtho_N	0.007	0.012	1370.000	0.532	0.595	
ZPrimePhono_N	0.003	0.016	1332.000	0.202	0.840	
ZPrimeBG_Sum	0.048	0.034	547.200	1.390	0.165	
ZPrimeBG_Mean	-0.040	0.030	577.600	-1.333	0.183	
ZPrimeBG_Freq_By_Pos	-0.005	0.009	981.700	-0.583	0.560	
ZTargetOrtho_N	0.006	0.014	95.900	0.411	0.682	
ZTargetPhono_N	-0.015	0.014	97.800	-1.068	0.288	
opaque:ZCORank	0.016	0.020	1361.000	0.835	0.404	
morph:ZCORank	0.004	0.010	1995.000	0.423	0.673	

Table 106. CORank model summary with some covariates for the LRT for Vietnamese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.541	0.025	29.600	258.078	<2e-16	***
opaque	-0.012	0.024	117.400	-0.498	0.619	
morph	-0.052	0.010	141.900	-5.078	1.18e-06	***
ZCORank	-0.002	0.010	240.100	-0.180	0.857	

ZLexTALE	-0.039	0.020	23.000	-1.910	0.069	.
ZPrevLRT	0.066	0.011	22.400	5.899	5.77e-06	***
PrevACC1	0.004	0.012	21.600	0.310	0.760	
ZTrialNum	-0.012	0.008	22.200	-1.586	0.127	
ZPrimeOrtho_N	0.010	0.012	1427.000	0.823	0.411	
ZPrimePhono_N	0.003	0.016	1371.000	0.171	0.865	
ZPrimeBG_Sum	0.022	0.015	667.600	1.511	0.131	
ZPrimeBG_Mean	-0.020	0.015	816.400	-1.287	0.199	
ZPrimeBG_Freq_By_Pos	-0.004	0.009	1020.000	-0.412	0.681	
ZTargetOrtho_N	-0.005	0.014	96.000	-0.347	0.730	
ZTargetPhono_N	-0.009	0.015	98.900	-0.584	0.560	
opaque:ZCORank	0.014	0.020	1443.000	0.733	0.464	
morph:ZCORank	0.004	0.010	2048.000	0.383	0.702	

Table 107. CORank model summary without covariates for the LRT for Vietnamese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.547	0.025	25.600	257.321	<2e-16	***
opaque	-0.024	0.023	84.200	-1.042	0.300	
morph	-0.055	0.010	99.200	-5.570	2.19e-07	***
ZCORank	-0.001	0.010	235.400	-0.148	0.882	
ZLexTALE	-0.036	0.021	21.900	-1.706	0.102	
ZPrevLRT	0.069	0.012	21.800	5.975	5.33e-06	***
PrevACC1	0.004	0.013	20.300	0.316	0.756	

ZTrialNum	-0.013	0.008	21.300	-1.605	0.123
opaque:ZCORank	0.013	0.020	1466.000	0.649	0.516
morph:ZCORank	0.005	0.010	1980.000	0.475	0.635

Table 108. CORank model summary with all covariates for accuracy for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.996	0.155	19.324	<2e-16	***
opaque	-0.064	0.164	-0.390	0.697	
morph	0.359	0.103	3.482	0.000	***
ZCORank	0.048	0.117	0.414	0.679	
ZLexTALE	0.539	0.058	9.250	<2e-16	***
ZPrevLRT	0.082	0.026	3.193	0.001	**
PrevACC1	-0.228	0.081	-2.817	0.005	**
ZTrialNum	-0.156	0.030	-5.225	1.74e-07	***
ZPrimeLen	0.150	0.168	0.893	0.372	
ZPrimeLogHal	-0.078	0.049	-1.585	0.113	
ZTargetCobLog	0.551	0.140	3.943	8.04e-05	***
ZPrimeOrtho_N	-0.018	0.096	-0.186	0.853	
ZPrimePhono_N	-0.004	0.145	-0.028	0.977	
ZPrimeBG_Sum	-0.342	0.339	-1.009	0.313	
ZPrimeBG_Mean	0.273	0.290	0.941	0.347	
ZPrimeBG_Freq_By_Pos	0.034	0.089	0.379	0.705	
ZTargetOrtho_N	0.062	0.195	0.320	0.749	

ZTargetPhono_N	0.005	0.195	0.025	0.980	
opaque:ZCORank	0.237	0.134	1.762	0.078	.
morph:ZCORank	-0.056	0.104	-0.539	0.590	

Table 109. CORank model summary with some covariates for accuracy for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.116	0.159	19.567	<2e-16	***
opaque	-0.117	0.154	-0.755	0.450	
morph	0.339	0.102	3.317	0.001	***
ZCORank	0.126	0.119	1.058	0.290	
ZLexTALE	0.538	0.058	9.229	<2e-16	***
ZPrevLRT	0.082	0.026	3.189	0.001	**
PrevACC1	-0.229	0.081	-2.835	0.005	**
ZTrialNum	-0.156	0.030	-5.211	1.88e-07	***
ZPrimeOrtho_N	-0.028	0.095	-0.297	0.767	
ZPrimePhono_N	0.031	0.147	0.209	0.835	
ZPrimeBG_Sum	-0.092	0.147	-0.626	0.532	
ZPrimeBG_Mean	0.028	0.151	0.182	0.855	
ZPrimeBG_Freq_By_Pos	0.040	0.088	0.448	0.654	
ZTargetOrtho_N	0.204	0.202	1.006	0.315	
ZTargetPhono_N	-0.086	0.205	-0.418	0.676	
opaque:ZCORank	0.179	0.131	1.367	0.172	

morph:ZCORank	-0.053	0.103	-0.518	0.605	

Table 110. CORank model summary without covariates for accuracy for the combined data of all language groups.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.081	0.152	20.309	<2e-16	***
opaque	-0.084	0.137	-0.613	0.540	
morph	0.348	0.099	3.516	0.000	***
ZCORank	0.132	0.118	1.118	0.263	
ZLexTALE	0.537	0.058	9.193	<2e-16	***
ZPrevLRT	0.082	0.026	3.175	0.002	**
PrevACC1	-0.234	0.081	-2.887	0.004	**
ZTrialNum	-0.158	0.030	-5.268	1.38e-07	***
opaque:ZCORank	0.158	0.120	1.313	0.189	
morph:ZCORank	-0.054	0.103	-0.526	0.599	

Table 111. CORank model summary with all covariates for accuracy for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	4.206	0.282	14.922	<2e-16	***
opaque	-1.432	0.317	-4.524	6.06e-06	***
morph	0.237	0.266	0.892	0.372	
ZCORank	0.041	0.180	0.226	0.821	
ZLexTALE	0.316	0.126	2.509	0.012	*
ZPrevLRT	0.179	0.055	3.255	0.001	**

PrevACC1	-0.557	0.215	-2.597	0.009	**
ZTrialNum	-0.043	0.065	-0.663	0.507	
ZPrimeLen	-0.306	0.325	-0.940	0.347	
ZPrimeLogHal	0.074	0.100	0.742	0.458	
ZTargetCobLog	0.434	0.186	2.333	0.020	*
ZPrimeOrtho_N	0.232	0.191	1.214	0.225	
ZPrimePhono_N	-0.386	0.298	-1.296	0.195	
ZPrimeBG_Sum	0.123	0.659	0.187	0.852	
ZPrimeBG_Mean	-0.133	0.562	-0.237	0.813	
ZPrimeBG_Freq_By_Pos	0.113	0.177	0.640	0.522	
ZTargetOrtho_N	-0.225	0.265	-0.847	0.397	
ZTargetPhono_N	0.200	0.264	0.758	0.449	
opaque:ZCORank	0.300	0.247	1.213	0.225	
morph:ZCORank	0.024	0.231	0.103	0.918	

Table 112. CORank model summary with some covariates for accuracy for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	4.204	0.284	14.812	<2e-16	***
opaque	-1.351	0.296	-4.568	4.93e-06	***
morph	0.267	0.264	1.011	0.312	
ZCORank	0.036	0.184	0.197	0.844	
ZLexTALE	0.317	0.126	2.513	0.012	*
ZPrevLRT	0.178	0.055	3.246	0.001	**

PrevACC1	-0.561	0.215	-2.608	0.009	**
ZTrialNum	-0.045	0.065	-0.682	0.496	
ZPrimeOrtho_N	0.153	0.188	0.811	0.417	
ZPrimePhono_N	-0.378	0.304	-1.246	0.213	
ZPrimeBG_Sum	-0.439	0.273	-1.607	0.108	
ZPrimeBG_Mean	0.374	0.291	1.285	0.199	
ZPrimeBG_Freq_By_Pos	0.099	0.173	0.571	0.568	
ZTargetOrtho_N	-0.073	0.266	-0.273	0.785	
ZTargetPhono_N	0.110	0.271	0.406	0.685	
opaque:ZCORank	0.368	0.244	1.508	0.132	
morph:ZCORank	0.066	0.230	0.286	0.775	

Table 113. CORank model summary without covariates for accuracy for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	4.135	0.265	15.616	<2e-16	***
opaque	-1.150	0.254	-4.524	6.07e-06	***
morph	0.297	0.257	1.156	0.248	
ZCORank	0.083	0.179	0.462	0.644	
ZLexTALE	0.313	0.126	2.489	0.013	*
ZPrevLRT	0.173	0.055	3.140	0.002	**
PrevACC1	-0.557	0.214	-2.601	0.009	**
ZTrialNum	-0.043	0.065	-0.664	0.507	
opaque:ZCORank	0.248	0.223	1.113	0.266	

morph:ZCORank	0.040	0.229	0.175	0.861

Table 114. CORank model summary with all covariates for accuracy for Turkish.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.299	0.271	12.155	<2e-16	***
opaque	-0.094	0.324	-0.289	0.772	
morph	0.505	0.225	2.247	0.025	*
ZCORank	0.320	0.198	1.612	0.107	
ZLexTALE	0.549	0.119	4.621	3.81e-06	***
ZPrevLRT	0.048	0.050	0.960	0.337	
PrevACC1	-0.037	0.179	-0.207	0.836	
ZTrialNum	-0.117	0.065	-1.801	0.072	.
ZPrimeLen	0.198	0.342	0.580	0.562	
ZPrimeLogHal	-0.161	0.103	-1.571	0.116	
ZTargetCobLog	0.952	0.206	4.614	3.95e-06	***
ZPrimeOrtho_N	-0.011	0.200	-0.054	0.957	
ZPrimePhono_N	0.129	0.305	0.424	0.672	
ZPrimeBG_Sum	-0.312	0.678	-0.461	0.645	
ZPrimeBG_Mean	0.179	0.583	0.307	0.759	
ZPrimeBG_Freq_By_Pos	0.149	0.180	0.829	0.407	
ZTargetOrtho_N	0.007	0.288	0.026	0.980	
ZTargetPhono_N	0.057	0.277	0.205	0.837	
opaque:ZCORank	0.054	0.281	0.193	0.847	

morph:ZCORank	-0.686	0.245	-2.804	0.005	**

Table 115. CORank model summary with some covariates for accuracy for Turkish.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.547	0.291	12.208	<2e-16	***
opaque	-0.172	0.303	-0.570	0.569	
morph	0.465	0.223	2.086	0.037	*
ZCORank	0.471	0.216	2.185	0.029	*
ZLexTALE	0.551	0.119	4.626	3.72e-06	***
ZPrevLRT	0.049	0.050	0.977	0.328	
PrevACC1	-0.035	0.178	-0.195	0.845	
ZTrialNum	-0.118	0.065	-1.811	0.070	.
ZPrimeOrtho_N	-0.113	0.201	-0.566	0.572	
ZPrimePhono_N	0.213	0.320	0.666	0.505	
ZPrimeBG_Sum	-0.074	0.298	-0.247	0.805	
ZPrimeBG_Mean	-0.076	0.302	-0.251	0.802	
ZPrimeBG_Freq_By_Pos	0.165	0.181	0.910	0.363	
ZTargetOrtho_N	0.232	0.311	0.746	0.456	
ZTargetPhono_N	-0.088	0.307	-0.287	0.774	
opaque:ZCORank	-0.018	0.277	-0.063	0.950	
morph:ZCORank	-0.668	0.251	-2.666	0.008	**

Table 116. CORank model summary without covariates for accuracy for Turkish.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.517	0.272	12.953	<2e-16	***
opaque	-0.183	0.270	-0.677	0.498	
morph	0.474	0.218	2.171	0.030	*
ZCORank	0.486	0.214	2.275	0.023	*
ZLexTALE	0.547	0.119	4.588	4.49e-06	***
ZPrevLRT	0.049	0.051	0.969	0.332	
PrevACC1	-0.032	0.178	-0.180	0.857	
ZTrialNum	-0.119	0.065	-1.832	0.067	.
opaque:ZCORank	-0.076	0.252	-0.303	0.762	
morph:ZCORank	-0.698	0.250	-2.792	0.005	**

Table 117. CORank model summary with all covariates for accuracy for Chinese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.333	0.183	12.754	<2e-16	***
opaque	0.390	0.250	1.561	0.119	
morph	0.476	0.145	3.277	0.001	**
ZCORank	0.046	0.138	0.337	0.736	
ZLexTALE	0.310	0.073	4.252	2.12e-05	***
ZPrevLRT	0.038	0.046	0.834	0.404	
PrevACC1	-0.260	0.118	-2.203	0.028	*
ZTrialNum	-0.236	0.048	-4.921	8.62e-07	***

ZPrimeLen	0.056	0.234	0.238	0.812	
ZPrimeLogHal	-0.037	0.073	-0.503	0.615	
ZTargetCobLog	0.600	0.148	4.064	4.82e-05	***
ZPrimeOrtho_N	-0.121	0.156	-0.778	0.437	
ZPrimePhono_N	0.091	0.216	0.419	0.675	
ZPrimeBG_Sum	-0.163	0.475	-0.343	0.732	
ZPrimeBG_Mean	0.046	0.414	0.112	0.911	
ZPrimeBG_Freq_By_Pos	0.127	0.130	0.976	0.329	
ZTargetOrtho_N	0.052	0.208	0.252	0.801	
ZTargetPhono_N	0.084	0.205	0.413	0.680	
opaque:ZCORank	0.204	0.218	0.935	0.350	
morph:ZCORank	0.037	0.148	0.247	0.805	

Table 118. CORank model summary with some covariates for accuracy for Chinese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.428	0.188	12.901	<2e-16	***
opaque	0.412	0.239	1.724	0.085	.
morph	0.471	0.143	3.303	0.001	***
ZCORank	0.105	0.145	0.729	0.466	
ZLexTALE	0.311	0.073	4.256	2.08e-05	***
ZPrevLRT	0.037	0.046	0.803	0.422	
PrevACC1	-0.264	0.118	-2.245	0.025	*
ZTrialNum	-0.234	0.048	-4.896	9.78e-07	***

ZPrimeOrtho_N	-0.181	0.156	-1.164	0.244	
ZPrimePhono_N	0.128	0.224	0.573	0.566	
ZPrimeBG_Sum	-0.076	0.212	-0.357	0.721	
ZPrimeBG_Mean	-0.043	0.223	-0.192	0.848	
ZPrimeBG_Freq_By_Pos	0.130	0.131	0.991	0.322	
ZTargetOrtho_N	0.223	0.218	1.026	0.305	
ZTargetPhono_N	-0.020	0.219	-0.091	0.928	
opaque:ZCORank	0.194	0.217	0.895	0.371	
morph:ZCORank	0.073	0.148	0.494	0.621	

Table 119. CORank model summary without covariates for accuracy for Chinese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.436	0.172	14.155	<2e-16	***
opaque	0.362	0.212	1.711	0.087	.
morph	0.469	0.137	3.427	0.001	***
ZCORank	0.122	0.142	0.858	0.391	
ZLexTALE	0.309	0.073	4.246	2.18e-05	***
ZPrevLRT	0.036	0.046	0.791	0.429	
PrevACC1	-0.263	0.118	-2.237	0.025	*
ZTrialNum	-0.233	0.048	-4.891	1.00e-06	***
opaque:ZCORank	0.160	0.204	0.786	0.432	
morph:ZCORank	0.070	0.147	0.479	0.632	

Table 120. CORank model summary with all covariates for accuracy for Vietnamese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.945	0.252	11.681	<2e-16	***
opaque	0.151	0.422	0.357	0.721	
morph	0.904	0.384	2.354	0.019	*
ZCORank	-0.001	0.179	-0.003	0.997	
ZLexTALE	0.521	0.119	4.380	1.19e-05	***
ZPrevLRT	0.107	0.091	1.177	0.239	
PrevACC1	-0.014	0.239	-0.060	0.952	
ZTrialNum	-0.186	0.087	-2.150	0.032	*
ZPrimeLen	-0.173	0.358	-0.483	0.629	
ZPrimeLogHal	0.039	0.113	0.346	0.729	
ZTargetCobLog	0.585	0.172	3.403	0.001	***
ZPrimeOrtho_N	0.026	0.253	0.104	0.917	
ZPrimePhono_N	-0.348	0.317	-1.098	0.272	
ZPrimeBG_Sum	0.091	0.722	0.126	0.900	
ZPrimeBG_Mean	0.073	0.637	0.115	0.909	
ZPrimeBG_Freq_By_Pos	-0.093	0.193	-0.481	0.630	
ZTargetOrtho_N	0.091	0.240	0.379	0.704	
ZTargetPhono_N	-0.025	0.234	-0.108	0.914	
opaque:ZCORank	0.182	0.343	0.530	0.596	
morph:ZCORank	-0.306	0.255	-1.200	0.230	

Table 121. CORank model summary with some covariates for accuracy for Vietnamese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.991	0.260	11.519	<2e-16	***
opaque	0.264	0.412	0.640	0.522	
morph	0.920	0.381	2.413	0.016	*
ZCORank	0.042	0.188	0.224	0.823	
ZLexTALE	0.525	0.120	4.384	1.17e-05	***
ZPrevLRT	0.101	0.089	1.129	0.259	
PrevACC1	-0.011	0.240	-0.045	0.964	
ZTrialNum	-0.194	0.087	-2.241	0.025	*
ZPrimeOrtho_N	-0.124	0.252	-0.491	0.623	
ZPrimePhono_N	-0.305	0.328	-0.930	0.353	
ZPrimeBG_Sum	-0.258	0.307	-0.841	0.401	
ZPrimeBG_Mean	0.395	0.341	1.160	0.246	
ZPrimeBG_Freq_By_Pos	-0.085	0.194	-0.438	0.661	
ZTargetOrtho_N	0.269	0.248	1.088	0.277	
ZTargetPhono_N	-0.143	0.248	-0.576	0.565	
opaque:ZCORank	0.259	0.346	0.751	0.453	
morph:ZCORank	-0.263	0.256	-1.028	0.304	

Table 122. CORank model summary without covariates for accuracy for Vietnamese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.962	0.237	12.507	<2e-16	***

opaque	0.352	0.389	0.904	0.366	
morph	0.872	0.363	2.405	0.016	*
ZCORank	0.097	0.181	0.535	0.593	
ZLexTALE	0.520	0.122	4.261	2.03e-05	***
ZPrevLRT	0.107	0.091	1.177	0.239	
PrevACC1	-0.041	0.243	-0.168	0.866	
ZTrialNum	-0.201	0.087	-2.312	0.021	*
opaque:ZCORank	0.163	0.340	0.478	0.633	
morph:ZCORank	-0.270	0.255	-1.059	0.290	

Table 123. AlterCondition LRT Model summary for English.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.438	0.017	85.400	389.875	<2e-16	***
NoAlter	-0.006	0.012	1748.000	-0.469	0.639	
unrelated	0.041	0.010	175.900	4.231	3.73e-05	***
ZLexTALE	-0.007	0.011	46.700	-0.663	0.511	
ZPrevLRT	0.040	0.006	50.300	7.132	3.60e-09	***
PrevACC1	-0.019	0.009	42.500	-2.184	0.035	*
ZTrialNum	-0.009	0.004	48.600	-2.395	0.021	*
ZTargetCobLog	-0.040	0.006	185.700	-6.393	1.28e-09	***
ZTargetBG_Freq_By_Pos	-0.004	0.004	1170.000	-1.038	0.300	

Table 124. AlterCondition LRT Model summary for Turkish.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.570	0.019	77.000	347.681	<2e-16	***
NoAlter	-0.005	0.015	2013.000	-0.351	0.726	
unrelated	0.060	0.012	145.000	5.087	1.11e-06	***
ZLexTALE	-0.017	0.015	40.000	-1.106	0.275	
ZPrevLRT	0.010	0.003	4853.000	3.769	0.000	***
PrevACC1	-0.012	0.008	4858.000	-1.472	0.141	
ZTrialNum	-0.019	0.003	4865.000	-6.361	2.18e-10	***
ZTargetCobLog	-0.061	0.007	184.000	-8.641	2.66e-15	***
ZTargetBG_Freq_By_Pos	0.000	0.005	960.000	0.022	0.983	

Table 125. AlterCondition LRT Model summary for Chinese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.558	0.018	90.000	363.033	<2e-16	***
NoAlter	0.003	0.014	245.000	0.217	0.829	
unrelated	0.056	0.010	2935.000	5.518	3.72e-08	***
ZLexTALE	-0.023	0.013	47.000	-1.696	0.097	.
ZPrevLRT	0.019	0.003	5571.000	7.019	2.50e-12	***
PrevACC1	-0.013	0.006	5551.000	-2.106	0.035	*
ZTrialNum	-0.010	0.003	5545.000	-3.995	6.54e-05	***
ZTargetCobLog	-0.051	0.007	195.000	-7.439	3.15e-12	***
ZTargetBG_Freq_By_Pos	-0.002	0.005	1222.000	-0.525	0.600	

Table 126. AlterCondition LRT Model summary for Vietnamese.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.526	0.026	31.000	246.815	<2e-16	***
NoAlter	-0.027	0.018	212.400	-1.541	0.125	
unrelated	0.043	0.013	285.900	3.235	0.001	**
ZLexTALE	-0.012	0.022	23.300	-0.564	0.578	
ZPrevLRT	0.050	0.009	23.000	5.608	1.05e-05	***
PrevACC1	-0.022	0.011	21.500	-1.953	0.064	.
ZTrialNum	-0.014	0.007	22.600	-1.977	0.060	.
ZTargetCobLog	-0.044	0.007	184.700	-5.968	1.20e-08	***
ZTargetBG_Freq_By_Pos	-0.001	0.005	756.400	-0.102	0.919	

Table 127. AlterCondition LRT model for the combined data for all language groups.

Fixed effects:	Estimate	Std. Error	df	*t* value	Pr(>|t|)	
(Intercept)	6.465	0.018	253.000	354.264	<2e-16	***
NoAlter	-0.009	0.011	3359.000	-0.851	0.395	
unrelated	0.036	0.008	1755.000	4.300	1.80e-05	***
Chinese	0.095	0.025	183.000	3.756	0.000	***
Turkish	0.095	0.024	176.000	4.041	7.93e-05	***
Vietnamese	0.063	0.027	174.000	2.371	0.019	*
ZLexTALE	-0.021	0.009	159.000	-2.318	0.022	*
ZPrevLRT	0.038	0.003	165.000	12.131	<2e-16	***
PrevACC1	-0.012	0.005	152.000	-2.412	0.017	*

ZTrialNum	-0.012	0.003	162.000	-4.466	1.49e-05	***
ZTargetCobLog	-0.051	0.006	196.000	-8.364	1.11e-14	***
ZTargetBG_Freq_By_Pos	0.000	0.003	5131.000	-0.162	0.872	
NoAlter:Chinese	0.005	0.014	3058.000	0.353	0.724	
unrelated:Chinese	0.010	0.011	1328.000	0.911	0.362	
NoAlter:Turkish	0.006	0.014	3005.000	0.393	0.695	
unrelated:Turkish	0.021	0.011	1296.000	1.883	0.060	.
NoAlter:Vietnamese	-0.005	0.017	2979.000	-0.286	0.775	
unrelated:Vietnamese	0.005	0.013	1282.000	0.410	0.682	

Table 128. The AlterCondition ACC model summary for English.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	4.305	0.369	11.671	<2e-16	***
NoAlter	-0.337	0.455	-0.740	0.459	
unrelated	-0.623	0.328	-1.897	0.058	.
ZLexTALE	0.260	0.097	2.699	0.007	**
ZPrevLRT	0.127	0.050	2.549	0.011	*
PrevACC1	-0.579	0.183	-3.157	0.002	**
ZTrialNum	-0.097	0.055	-1.776	0.076	.
ZTargetCobLog	0.694	0.139	4.981	6.31e-07	***
ZTargetBG_Freq_By_Pos	0.130	0.113	1.147	0.251	

Table 129. The AlterCondition ACC model summary for Turkish.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.651	0.352	10.387	<2e-16	***
NoAlter	0.139	0.430	0.323	0.747	
unrelated	-0.516	0.301	-1.712	0.087	.
ZLexTALE	0.497	0.110	4.523	6.11e-06	***
ZPrevLRT	0.047	0.046	1.033	0.302	
PrevACC1	-0.116	0.147	-0.788	0.431	
ZTrialNum	-0.157	0.054	-2.929	0.003	**
ZTargetCobLog	1.064	0.147	7.253	4.08e-13	***
ZTargetBG_Freq_By_Pos	0.158	0.117	1.353	0.176	

Table 130. The AlterCondition ACC model summary for Chinese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	2.728	0.227	12.002	<2e-16	***
NoAlter	0.073	0.300	0.242	0.809	
unrelated	-0.453	0.203	-2.236	0.025	*
ZLexTALE	0.287	0.081	3.543	0.000	***
ZPrevLRT	0.051	0.041	1.254	0.210	
PrevACC1	-0.287	0.098	-2.943	0.003	**
ZTrialNum	-0.182	0.039	-4.675	2.94e-06	***
ZTargetCobLog	0.769	0.105	7.347	2.02e-13	***
ZTargetBG_Freq_By_Pos	0.089	0.079	1.130	0.258	

Table 131. The AlterCondition ACC model summary for Vietnamese.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.608	0.456	7.909	2.60e-15	***
NoAlter	0.742	0.647	1.147	0.252	
unrelated	-0.655	0.435	-1.505	0.132	
ZLexTALE	0.454	0.108	4.210	2.55e-05	***
ZPrevLRT	0.138	0.074	1.868	0.062	.
PrevACC1	-0.115	0.195	-0.590	0.555	
ZTrialNum	-0.169	0.071	-2.382	0.017	*
ZTargetCobLog	0.793	0.137	5.778	7.57e-09	***
ZTargetBG_Freq_By_Pos	0.037	0.117	0.316	0.752	

Table 132. The AlterCondition ACC model summary for the combined data for all language groups.

Fixed effects:	Estimate	Std. Error	*z* value	Pr(>|z|)	
(Intercept)	3.503	0.274	12.808	<2e-16	***
NoAlter	-0.327	0.315	-1.037	0.300	
unrelated	-0.585	0.243	-2.407	0.016	*
Chinese	-0.638	0.300	-2.124	0.034	*
Turkish	-0.137	0.320	-0.428	0.668	
Vietnamese	-0.499	0.350	-1.429	0.153	
ZLexTALE	0.474	0.063	7.559	4.05e-14	***
ZPrevLRT	0.078	0.023	3.386	0.001	***
PrevACC1	-0.282	0.067	-4.183	2.87e-05	***

ZTrialNum	-0.157	0.025	-6.350	2.15e-10	***
ZTargetCobLog	0.737	0.101	7.300	2.88e-13	***
ZTargetBG_Freq_By_Pos	0.087	0.063	1.379	0.168	
NoAlter:Chinese	0.347	0.352	0.986	0.324	
unrelated:Chinese	0.354	0.271	1.306	0.192	
NoAlter:Turkish	0.611	0.404	1.514	0.130	
unrelated:Turkish	0.150	0.300	0.499	0.618	
NoAlter:Vietnamese	0.824	0.458	1.801	0.072	.
unrelated:Vietnamese	0.623	0.331	1.881	0.060	.

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