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Effects of Subjective Type Frequency and Phonetic Structure on L2 Morphological Processing: A Constructional Perspective

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Abstract

Little research has been conducted to investigate the effects of subjective type frequency and phonetic structure on morphological processing. From the perspective of construction, this study carried out two experiments to examine whether these two factors have impacts on the processing of derivatives by Chinese EFL learners. In Experiment 1, the masked priming paradigm produced facilitation effect for the prefixed words rather than the suffixed ones. However, participants with higher subjective type frequency of the target words did not differ significantly from their counterparts in response times (RTs). In Experiment 2, words whose phonetic structure is consistent with the morphological structure took significantly longer RTs than the inconsistent group and the monomorphemic words in the unprimed lexical decision task. These findings demonstrated that subjective type frequency may be a necessary but not a sufficient condition for the generalization of morphological constructions, while phonetic structure can affect the perceptual salience of affix, thus playing an important part in morphological decomposition.

Keywords: frequency, phonetic structure, morphological processing, construction, vocabulary

1. Introduction

The issue of what factors may affect morphological processing has attracted considerable attention, yet existing findings are not consistent to draw a conclusion. Some studies have shown the effects of factors such as formal regularity (Masrai & Milton, 2015; Shi & Chen, 2014), semantic transparency (Marslen-Wilson et al., 1994; Wang & Zhang, 2013; Xu & Taft, 2015; Zhang, 2015, 2016), affix productivity (Bertram et al., 1999; Dal Maso & Giraudo, 2014; Lu, 2003; Vannest et al., 2011; Clark, 2014), surface frequency (Dal Maso & Giraudo, 2014; Davies et al., 2016; MacLeod & Kampe, 1996; Masrai & Milton, 2015; Meunier & Segui, 1999), root frequency (Beauvillain, 1996; Yao et al., 2012), stem frequency (Giraudo et al., 2015), and base frequency (Taft, 2004; Xu & Taft, 2015). Productivity refers to the possibility that a word-formation pattern is used to create words. Surface frequency is the frequency of a polymorphemic word. Specifically, it is the token frequency, i.e., the total occurrences of the word in a certain corpus. Base frequency is the total frequency of the inflections of the whole word and its base. Some other studies have demonstrated that morphological processing is not related to semantic information (Jun, 2014; Li et al., 2017; Rastle & Merkx, 2011). Compared with decomposable words which show sensitivity to base frequency rather than surface frequency, the whole-word items are not affected by base frequency (Vannest et al., 2011).

Despite various findings on factors involved in morphological processing, little research has been done on the basis of Construction Morphology (CxM, Booij, 2010), which is a better explanation of L2 processing mechanisms (Giraudo & Dal Maso, 2018). CxM, a usage-based theory, states that the formal and semantic similarities shared by a group of complex words can be explained by morphological constructions (Booij, 2012). For example, the construction of -er noun series is generalized from the relatedness among the members worker, teacher, driver, and so on, and can be illustrated by a schema like $[[X]_V$ er$]_N$. -Er noun series is composed of nouns with the suffix -er. In the schema $[[X_]_V$ er$]_N$, "X" is the base, "V" and "N" are the syntactic category of the base and of the whole word respectively. In the process of morphological generalization, decomposing complex words into morphemes is a significant step, without which the components of a construction would not be recognized and the acquisition of morphological knowledge would be impossible. This study assumes that factors which influence the generalization of morphological constructions may also have effect on the processing

of complex words, and these factors are supposed to be related to the formulation of constructional schemas. Therefore, the present study selects two variables based on CxM (Booij, 2010), including subjective type frequency and phonetic structure, and examines their roles in the processing of derivatives by Chinese EFL learners to offer useful implications for the instruction of L2 morphology. According to Balota et al. (2001), objective frequency refers to the occurrences of words in a given language. In contrast, subjective frequency is the encounter estimates by language users. Following Balota et al. (2001), this study adopts the "subjective type frequency".

Based on existing findings and CxM (Booij, 2010), this study sheds light on type frequency from the language input exposed to learners, namely, the subjective type frequency, and the phonetic structure of complex words. The research questions are addressed as follows.

(1) Does subjective type frequency affect the processing of en verbs?

(2) Does phonetic structure affect the processing of suffixed words?

2. Relevant Studies on Morphological Processing

2.1 Morphological Generalization

Morphological generalization, or morphological analysis, involves three primary steps, viz. separation or decomposition of the constituents of a particular complex word, understanding the meaning of each component, and deriving the meaning of the whole word through semantic integration of the parts (Rastle & Merkx, 2011; White et al., 1989; Wysocki & Jenkins, 1987). For instance, the morphological generalization of the complex word enlarge involves breaking it into two parts (i.e., the prefix en- and the root/base large), then figuring out the meaning of en- (i.e., to make) and the meaning of large (i.e., big in size or quantity) before recombining them to get the meaning of enlarge (i.e., to make something bigger).

Based on the construction approach, morphological generalization involves the analysis of the internal structure of words as well as the paradigmatic relationship between series members (Voga et al., 2014). From the syntagmatic perspective, morphemes are the units of morphological generalization. It means that the investigation of L2 learners' morphological generalization should take into account their competence of decomposing complex words into constituent morphemes. From the paradigmatic perspective, morphological generalization is not restricted to individual words in that the semantic information of a complex word is not completely compositional but related to a set of words with similar morphological structures. Therefore, it is necessary to conduct the investigation in the context of series.

The importance of morphological generalization lies in the following three aspects. Firstly, it benefits learners not only in comprehension and production, but also in the organization of the words in the lexicon. A well-organized lexicon provides an opportunity for learners to process words in a systematic and an efficient way rather than retrieving them from arbitrary lists of lexical units. Secondly, it will reflect learners' vocabulary size to some extent since morphological generalization is based on the acquisition of concrete words. Only when learners encounter sufficient complex words which share similar formation patterns can they abstract the schemas these words conform to. Thirdly, learners' competence of generalizing the constructions can reflect their understanding of the word formation rules and indicate their potential for morphological production. It will have implications for morphological acquisition and L2 teaching as well.

2.2 Factors Involved in Morphological Processing

The masked priming paradigm has been extensively employed to investigate morphological processing. It is a technique to examine facilitation effects on word recognition produced by a prime which is presented after a series of marks and followed by a target word. The facilitation is examined through comparison of the latency of the lexical-decision response to the targets in different conditions, for example, the morphologically related prime-target condition relative to the unrelated prime-target condition. If it takes significantly less time to recognize the target in the former condition, it is likely that the learner has activated the morphological relatedness between the prime and the target and decomposed the target automatically since any conscious reflection on the prime is unavailable due to the short duration of its presence.

Previous research on morphological processing has proved that decomposition is not a compulsory processing mechanism applicable to all lexical forms including real complex words, pseudo-morphological words, even nonwords (Giraudo & Dal Maso, 2018). Instead, it depends on the underlying morphological complexity (Pliatsikas et al., 2014) or the interplay of linguistic factors (Bertram et al., 1999).

Evidence concerning the issue of what factors are involved in the processing of complex words has accumulated

over the past twenty years. This section mainly reviews studies on the effects of semantic transparency, frequency, consistency, and affix position.

2.2.1 Semantic Transparency

Semantic transparency refers to the extent to which the meaning of a derivative is related to that of its root or base (Giraudo & Grainger, 2003; Meunier & Longtin, 2007). For example, the word different has a semantic relationship with its root differ, hence semantically transparent. Related words such as differ, difference, different, and differently compose what we call a "family". In contrast, semantically opaque words are "morphological accidents" since the co-occurrence of the component morphemes has nothing to do with meanings (Voga & Giraudo, 2017). For example, there is a semantic distance (Davies et al., 2016) between the opaque pair indifferent and different since a semantic shift takes place after the attachment of the original Latin root differed to the prefix in-. If a complex word is semantically transparent, it would be easy to understand according to the meaning of its base (White et al., 1989). On the contrary, words like indifferent are decomposable on the orthographic level, but their meanings cannot be guessed easily from the base. It should be noted that semantic transparency is not an all-or-nothing relationship between a complex word and its component morphemes. Rather, it is a graded construct where partially transparent words lie between the transparent and the opaque ones. For example, archer does not mean a person who arches, but the bow used by an archer looks like an arch (Xu & Taft, 2015).

Many studies have considered morphological decomposition and the facilitation of word recognition in relation to semantic transparency (Marslen-Wilson et al., 1994; Wang & Zhang, 2013; Xu & Taft, 2015). It is pointed out that semantically transparent forms are decomposed while semantically opaque ones are represented like unanalyzed monomorphemic words (Marslen-Wilson et al., 1994). In prior studies, semantically transparent or morphologically related prime-target pairs were compared with the orthographically overlapped and unrelated conditions to verify whether there is facilitation of the identification of the targets—the so-called priming effects. There is a consensus among researchers that the semantic information shared by the word pair can activate the target in the lexicon, making the processing automatic and efficient. This is based on the fact that in the process of morphological generalization, decomposition occurs followed by the semantic integration of the components, and finally the interpretation of the whole word. Therefore, once the complex word is parsed into parts, the remaining steps would be easy to accomplish provided that the base is semantically overlapped with the whole word. Conversely, semantic opacity causes difficulty in analyzing affixed words since word meaning cannot be obtained by the sum of its parts (White et al., 1989). As a consequence, it is of little help to interpret a semantically obscure word even though the meaning of the base is available.

However, there is also empirical evidence that morphological effects are not necessarily related to semantic information but due to a mechanism of mandatory decomposition which can be automatically applied to seemingly complex words (Voga & Giraudo, 2017). Findings indicate that priming effects are not confined to morphologically related prime-target pairs, but exist between non-morphological forms, even non-words with pseudo-morphological structures (Rastle et al., 2004). It means that decomposition takes place in the initial stage of the identification of complex words based on orthographic analysis (Rastle & Davis, 2008). This may be a reasonable explanation for the existence of priming effects independent of semantic transparency.

2.2.2 Frequency

As far as morphological processing is concerned, the frequency of a complex word (i.e., surface frequency) and the total frequency of forms morphologically related to a word (i.e., base frequency) are considered to affect the access to word meaning.

By the manipulation of surface frequency, the following two experiments provided evidence that the acquisition of morphological knowledge was affected by the statistical formal overlap between primes and targets. In Giraudo & Grainger's (2000) study, native speakers of French performed the lexical decision task (LDT) on the same target words which were paired with high frequent suffixed words, low frequent suffixed words and monomorphemic words. Priming effect was only observed in the first condition. Giraudo & Grainger (2000) concluded that frequency played a role in the processing of complex words, supporting the morpheme-based processing hypothesis. To examine whether frequency had the same priming effects on formally overlapped prime-target pairs, they conducted another experiment. The results revealed negative effects of high frequent primes on the recognition of the targets. It was stated that word frequency influenced the processing of formal information and morphological information in different manners.

In addition to surface frequency, base frequency effect has also been reported by studies concerning morphological processing. It was found that high base frequency benefited the recognition of complex words,

but it only took effect in words which were semantically transparent, and the magnitude of the benefit varied in the degree of semantic transparency (Xu & Taft, 2015).

As part of a complex word, affix also contributes to word meaning. The above studies shed light on the frequency of words but ignored the frequency of affixes. While the significance of affix frequency has been mentioned in some studies (Freyd & Baron, 1982; Laudanna & Burani, 1995; Muñoz & Velasco, 2018; Nagy et al., 1993; Shi & Chen, 2014; White et al., 1989), its effect on the processing of complex words is still uncertain. A few studies on affix productivity have implications for the role of the type frequency (Bertram et al., 1999; Dal Maso & Giraudo, 2014; Lu, 2003; Vannest et al., 2011; Clark, 2014), since the two factors highly correlate with each other. However, the available findings are still controversial. It may be because the objective productivity of an affix is relatively fixed in the language, but the actual or subjective types of words occurring in the input can vary with learners.

2.2.3 Consistency

Another factor related to type frequency is consistency. It is operationalized as the proportion of real derivatives (e.g., worker) to non-derivatives (e.g., matter) sharing a string of letters with the affix of the former.

To date, only a few studies have investigated morphological processing in terms of consistency (Chateau et al., 2002; Dal Maso & Giraudo, 2019; Giraudo & Dal Maso, 2016, 2018). For example, in Giraudo & Dal Maso's (2016) masked priming paradigm, a more consistent series ending in -tore was compared with a less consistent one with -etto. Four fifths of the words ending in -tore and two fifths ending in -etto are morphologically complex. Results showed that neither of the two series generated priming effects, but a stronger base priming effect was obtained for more consistent primes relative to the less consistent ones. Moreover, longer RTs for the -etto series relative to the unrelated condition indicated the inhibition of word recognition. It was concluded that consistency was a fundamental factor because the generalization of morphological constructions would be interfered by non-derivatives (Giraudo & Dal Maso, 2016).

However, consistent series do not necessarily have higher type frequency, since the proportion of real derivatives to non-derivatives can be large but the number of real derivatives (i.e., the type frequency) can be smaller than that of the less consistent series. Considering that type frequency reflects the size of morphological series and has potential statistical effects, it should not be ignored in the discussion of the perceptual salience of affixes in morphological processing.

2.2.4 Affix Position

Previous studies using masked priming paradigms have reported asymmetric priming patterns induced by prefixed words and suffixed ones. For instance, Duñabeitia et al. (2008) investigated the processing of Spanish derivatives, and found that suffixed words were primed by three kinds of primes, namely, real suffixed words (e.g., brevedad/IGUALDAD), the suffix of the target (e.g., dad/IGUALDAD), and suffix with a symbol string (e.g., %%%%%dad/IGUALDAD). The study conducted by Crepaldi et al. (2015) provided further evidence to prove the role of suffix in morphological processing. It was demonstrated that priming effect emerged when the target word was presented after a nonword with a pseudo suffix (e.g., sheeter/TEACHER) and disappeared when the pseudo suffix was not in the usual position of a normal one (e.g., ersheet/TEACHER). These two studies attributed decomposition to morphological structures, i.e., suffixes could be identified in derivatives, even in pseudo words having a morphological structure. However, the study conducted by Giraudo & Grainger (2003) revealed that not all morphologically structured words were processed through morphemes. In fact, facilitation effects on word recognition were obtained in the prefixed condition (e.g., enjeu/ENVOL) but not in the suffixed condition (e.g., fumet/MURET). These findings were in support of the left-to-right processing hypothesis in that the suffix shared by the priming pair was activated at a later stage due to its position relevant to the base.

It should be noted that affixes cannot stand independently of bases for they are bound morphemes, i.e., affix meaning cannot be obtained without access to the meaning of the base even if the affix can be stripped off the whole word (Berg, 2015). From this perspective, neither the prefix nor the suffix will be at an advantage in priming, because the processing preference for prefix will delay the recognition of the base, while the activation of the suffix is at a later stage after the access to the base. It was pointed out that the distinct processing manners between prefixed and suffixed words did not arise from purely positional factors, but may depend on the consistency between the morphological structure and the phonetic structure (Yu, 2021). Similar to Giraudo & Grainger's (2003) findings, Yu's (2021) study produced priming effect for prefixed words rather than suffixed ones. This may be attributed to the special materials selected in the experiments, since all the prefixed words have consistent morpho-phonetic structures relative to the suffixed ones, for example, en•courage - en•courage vs. broad•en - broa•den (the dot indicates the morphological boundary and the phonetic boundary). Therefore,

further research is needed so as to confirm the effectiveness of phonetic structure in morphological processing, with the variable of affix position being controlled.

In general, relevant studies on the effects of semantic transparency, frequency, consistency and affix position have respectively considered the semantic relationship between the morphemic components and the whole word, the statistical effect of individual words, the formal relationship between series members, and the linear feature of the affix. However, the understanding of affix meaning is impossible outside a construction where series members are orthographically and semantically connected, and the generalization of a construction should be based on the exposure of an adequate number of different words which belong to the same morphological series (Booij, 2012). In addition, the position of an affix not only restricts the syntactic category of the base attached to it, but also affects the phonetic structure of the whole word. Since phonological awareness has impacts on the reading of complex words (Li & Chen, 2016), the phonetic structure should also be taken into consideration in the investigation of morphology.

3. Research Methodology

3.1 Experiment 1

In Experiment 1, the role of subjective type frequency was investigated through a masked priming paradigm combined with familiarity ratings conducted to investigate the subjective type frequency. It was analysed by the 2 × 3 between-subjects factorial ANOVA. The independent variables included the subjective type frequency (2 levels: high and low) and the priming condition (3 levels: affixed, orthographic, and unrelated), while the dependent variable was the RTs for the target words.

3.1.1 Participants

Since language proficiency plays an important part in the acquisition of morphological knowledge (Leontjev et al., 2016; Li et al., 2017), this study selected advanced Chinese EFL learners as the participants. There were 130 female postgraduates majoring in English from a language university in South China, with the average age at 23. All of them had passed the Test for English Majors-Band 8 (TEM 8) when the present study was carried out. To confirm the validity of the test items, 10 of the participants not involved in the masked priming paradigm were assigned to a pre-test which required to provide the Chinese equivalents of the target words. The rest of the participants were randomly divided into 3 groups (40 for each priming condition). The results of the vocabulary size test (Nation & Beglar, 2007) did not show significant difference among the groups ($F(2, 117) = 2.079$, $p > .05$). These 3 groups of participants would carry out the familiarity ratings after the masked priming paradigm. Then, each group of participants would be further divided into two sub-groups according to the results of the familiarity ratings. For the sake of statistical analysis, each of the 120 participants had a constant test number used in the whole process of the experiment.

3.1.2 Materials

To control variables such as affix length, affix productivity, and semantic transparency, this study selected 32 words for the masked priming paradigm from Yu's (2021) list of en verbs. En verbs are verbs composed of the prefix en- and/or the suffix -en. The prefix and the suffix are of the same length and productivity. And most of the en verbs are semantically transparent (Yu, 2021). The results of the pre-test showed that the test items were valid since all of the Chinese equivalents provided by the 10 participants were correct.

Sixteen of the lexical items (half prefixed and half suffixed) were used as the target words of the masked priming paradigm. Each of them was paired with 3 conditions of primes, namely, the affixed condition (e.g., enlarge/ENRICH, strengthen/FRIGHTEN), the orthographic condition (endure/ENRICH, eighteen/FRIGHTEN), and the unrelated condition (e.g., prohibit/ENRICH, accurate/FRIGHTEN). The primes (either for the prefixed target words or the suffixed ones) in each condition were matched in frequency and word length (number of letters). The fillers consisted of 48 real words (8 prefixed, 8 suffixed, and 32 monomorphemic) and 64 nonwords (8 pseudo en- words, 8 pseudo -en words, 8 prefixed, 8 suffixed, and 32 monomorphemic).

The familiarity ratings for the comprehensive list of 117 real en verbs (Yu, 2021) and 18 pseudo en verbs were administered online using the Wenjuanxing questionnaires design website based on a 5-point Likert scale (1 = not familiar, 5 = extremely familiar). Considering that the participants may rate the words met in the priming paradigm as "2" (a little familiar), this study sets a criterion for the assessment of subjective type frequency. That is, a word rated as "3" (moderately familiar) or above is assumed to have been encountered by the participant before this study and will be marked as 1 subjective type frequency.

3.1.3 Procedure

To present the primes and the target words, the Standalone PsychoPy 3.0.7 software (Peirce, 2007) was employed. The masked priming paradigm was carried out in a quiet room. Each participant sat in front of a computer. The LDT began with an instruction on the screen to decide as quickly and accurate as possible whether the presented letter sequences were real words or not. One thousand milliseconds (ms) after the participants pressed the Space key, a series of marks (#####) appeared and lasted for 500 ms, followed by 57 ms' presentation of the prime, then substituted by the target word which stayed until the participants pressed the key "J" (for "Yes") or "F" (for "No"). The next trial started after an interval of 1000 ms. Every target word was presented at random. To get the participants familiar with the procedure, 10 trails with words not involved in the experiment were provided to practise.

After the masked priming paradigm, the participants gave the familiarity ratings on line through the computer.

3.2 Experiment 2

Experiment 2 was an unprimed LDT aiming to provide evidence of the effectiveness of phonetic structure on morphological processing, with affix position under control. It was a One-way within-subjects ANOVA, with structure (3 levels: consistent morpho-phonetic structures, inconsistent morpho-phonetic structures, and monomorphemic structure) as the independent variable and the RTs as the dependent variable.

3.2.1 Participants

Forty female postgraduates (average age: 23) participated in Experiment 2. They were English majors from the same university as those involved in Experiment 1. All of them had passed TEM 8 before they were recruited to this study. Ten of the participants were invited to take a pre-test to make sure that all the critical affixes selected in Experiment 2 were familiar to them, while the rest of the participants performed the unprimed LDT.

3.2.2 Materials

Considering that almost all English prefixed words have consistent morpho- phonetic structures, Experiment 2 selected suffixed words as the critical items.

Thirty-six suffixed words were equally divided into 3 groups: (1) 12 with consistent morpho-phonetic structures (e.g., settlement), (2) 12 with inconsistent morpho-phonetic structures (e.g., instruction), and (3) 12 monomorphemic words (e.g., challenge). There were 8 nouns and 4 adjectives in each group. The three groups of words were semantically transparent and matched in surface frequency, stem frequency, word length, affix length, and number of syllables. All the derivatives consisted of two morphemes, namely, the base and the suffix. None of the bases experienced spelling shift due the attachment to the corresponding suffix, except for the one in pleasure. Twenty-three suffixes were involved, one of which appeared in Groups 1 and 2 (i.e., the suffix -ee).

The pre-test required the 10 participants to rate their familiarity with the 23 suffixes using a 5-point Likert scale (1 = not familiar, 5 = extremely familiar). Results showed that all words were rated "familiar", "moderately familiar", or "extremely familiar", and the Independent Samples T-test showed that there was no significant difference ($df = 18$, $t = -.567$, $p > .05$) between the suffixes of the derivatives in the first group ($M = 4.68$, $SD = 0.24$) and those in the second one ($M = 4.73$, $SD = 0.15$). Therefore, the two groups of suffixes were considered as homogeneous.

Besides the critical items, there were 156 fillers, including 24 real prefixed words, 24 pseudo prefixed ones, 24 suffixed nonwords, 36 real monomorphemic words, and 48 monomorphemic nonwords. All the affixes contained in the fillers were different from those in the critical items.

3.2.3 Procedure

The procedure of Experiment 2 replicated the priming paradigm of Experiment 1 in this study, except that there were no masked primes.

4. Results and Discussion

4.1 Results

4.1.1 Results from Experiment 1

As stated in Section 3.1.1 of this article, the familiarity ratings were conducted after the masked priming paradigm. However, the results of the ratings were analysed first so as to divide the participants of each priming condition into two sub-groups, namely, the high-subjective-type-frequency group (HG) and the low-subjective-type-group (LG).

None of the 120 participants rated over 20% pseudo en verbs as “moderately familiar”, “very familiar”, or “extremely familiar”, therefore no data were discarded. In each priming condition, 20 of the participants who scored higher were considered as the HG, and the rest of the participants were categorized to the LG (see Table 1).

Table 1. The mean (M) and standard deviations (SD) of the subjective type frequency

	M (SD)		
	Affixed	Orthographic	Unrelated
HG	69 (12)	69 (11)	66 (8)
LG	46 (6)	48 (7)	45 (8)

The data were analysed by SPSS 22. The Two-way ANOVA showed main effect of group ($F (1, 114) = 179.140$, $p < .05$). There was no main effect of condition ($F (2, 114) = 1.066$, $p > .05$) or interaction between the two variables ($F (2, 114) = .252$, $p > .05$). Therefore, the HG had significantly higher subjective type frequency than the LG.

With regard to the RTs in the LDT, the data of correct responses to the critical test items were analysed, while the data of wrong answers (0.8%) and RTs above or below two standard deviations (1.3%) were removed.

The analysis through the Two-way ANOVA did not reveal any main effects of group ($F (1, 114) = .218$, $p > .05$) or condition ($F (2, 114) = 1.801$, $p > .05$). There was no interaction between the two variables either ($F (2, 114) = .089$, $p > .05$) (see Table 2). The analysis of the error rates did not find any main effect (group: $F (1, 114) = .073$, $p > .05$; condition: $F (2, 114) = .218$, $p > .05$) or interaction effect ($F (2, 114) = .073$, $p > .05$).

Table 2. The mean (M) and standard deviations (SD) of the RTs (in ms) in the masked priming paradigm

	M (SD)		
	Affixed	Orthographic	Unrelated
HG	1340 (23)	1345 (28)	1348 (17)
LG	1341 (22)	1345 (25)	1352 (20)

To investigate whether the subjective type frequency had effect on the RTs for the prefixed words and the suffixed ones between the HG and the LG, further analyses were made (see Table 3). The subjective type frequency for the prefixed and the suffixed words differed significantly between the HG and the LG in each priming condition (Prefixed: $F (1, 114) = 67.706$, $p < .05$; Suffixed: $F (1, 114) = 68.899$, $p < .05$). However, the significant difference of subjective type frequency did not contribute to the asymmetry of RTs between the HG and the LG in the three conditions (Prefixed: $F (1, 114) = .329$, $p > .05$; Suffixed: $F (1, 114) = .095$, $p > .05$).

Table 3. The mean and standard deviations (in brackets) of the subjective type frequency and the RTs for the prefixed and the suffixed target words between the HG and the LG

		Subjective type frequency		RTs (in ms)	
		Prefixed	Suffixed	Prefixed	Suffixed
Affixed	HG	31 (10)	38 (7)	1338 (22)	1342 (26)
	LG	21 (5)	25 (5)	1337 (24)	1345 (21)
Orthographic	HG	33 (10)	36 (7)	1343 (29)	1346 (28)
	LG	21 (5)	27 (7)	1345 (24)	1345 (26)
Unrelated	HG	30 (8)	36 (8)	1347 (17)	1349 (17)
	LG	19 (4)	26 (7)	1353 (24)	1351 (20)

Intriguingly, the Independent Samples T-test demonstrated that the difference between the prefixed and the suffixed words in subjective type frequency reached statistical significance ($df = 238$, $t = -4.705$, $p < .05$). It means that significantly more suffixed words had been exposed to the participants in their language input before this study. If subjective type frequency was beneficial to the processing of complex words, the identification of the suffixed words should have been facilitated. However, the comparison of the RTs between the affixed

condition and the unrelated condition showed priming effect for the prefixed words ($F (2, 117) = 3.151$, $p < .05$) rather than the suffixed ones ($F (2, 117) = .758$, $p > .05$).

What led to the priming effect for the prefixed words relative to the suffixed ones? It may be due to the affix position as reported in previous studies (e.g., Giraudo & Grainger, 2003). However, if we compare the prefixed en verbs with the suffixed ones, we will find that the boundary between the morphemes (i.e., the morphological structure) and the boundary between the syllables (i.e., the phonetic structure) are identical for the former, but it is the opposite for the latter. To examine the effect of phonetic structure on the processing of complex words, Experiment 2 was conducted.

4.1.2 Results from Experiment 2

The data of the fillers and the erroneous responses (0.9%) were removed, while the RTs for the critical items were used for analysis. The analysis of the data by SPSS 22 did not show any outliers.

The analysis by the repeated-measures ANOVA indicated that the association between structure and RTs was statistically significant ($F (2, 58) = 10.134$, $p < .05$, $\eta^2 = .259$). Specifically, the RTs for words with consistent morpho-phonetic structures were longer than the RTs for words in the other two groups which did not differ significantly from each other (see Table 4). The difference between the groups in error rates was not significant ($F (2, 58) = .097$, $p > .05$, $\eta^2 = .003$).

Table 4. RTs for the three groups of words

	Consistent	Inconsistent	Monomorphemic
N	30	30	30
RTs	1280 (60)	1239 (47)	1231 (48)

Note: N = numbers of participants, (In)Consistent = (in)consistent morpho-phonetic structures, Monomorphemic = monomorphemic structure.

4.2 Discussion

Two main findings were obtained in this study. In Experiment 1, the subjective type frequency did not affect the processing of en verbs. In Experiment 2, the consistency between morphological structure and phonetic structure influenced the morphological decomposition of the suffixed words.

On the basis of CxM (Booij, 2010), this section gives account for the processing of English derivatives from two perspectives, viz. the paradigmatic and the syntagmatic perspective.

4.2.1 The Paradigmatic Perspective: the Implicit Effect of Subjective Type Frequency

The finding on the ineffectiveness of subjective type frequency in Experiment 1 does not support the hypothesis of this study, but it has profound implications for L2 morphological processing.

The unavailability of activating the morphological information between series members demonstrated that higher subjective type frequency did not contribute to the recognition of the paradigmatic relatedness between the series members. In Experiment 1, the subjective type frequency did not afford any advantage to the HG in processing en verbs despite the fact that the HG had met significantly more types of words with the prefix en- and the suffix -en. If subjective type frequency is an essential factor in the generalization of morphological constructions just as pointed out by Booij (2010), the HG should have responded to the targets faster than the LG. However, the HG did not outperform their counterparts in the LDT, indicating the failure in activating the affix shared by the prime and the target. In other words, the exposure of the members of a morphological series did not necessarily result in the familiarity with the shared affix. Although advanced learners may have encountered a large quantity of sample words of a construction, it is not easy to notice the morphological relatedness if these words are separately presented. This complies with CxM, because affix knowledge is not gained outside a construction but generated from the systematic relationship between a series of words overlapping in form and meaning (Booij, 2012). The abstraction of constructions is based on exemplars, but it is probabilistic (Cai & Chen, 2019). If learners are not aware of the series, they will be unlikely to establish a connection between the members. And the whole word forms may not be decomposed into sub-components if the shared affix is not noticed. In Experiment 1, the relatively higher subjective type frequency of the suffixed verbs did increase the likelihood of morphological generalization, yet the process ended up in failure since the morphological structure had not been successfully perceived by the learners. It proves that the realization of morphological generalization is determined by the extent to which the learners have noticed and comprehended the underlying construction suited for the verbs they have encountered.

The ineffectiveness of the subjective type frequency on the recognition of the prefixed and the suffixed verbs demonstrated that the morphological information exposed to the learners was not successfully decoded and internalized in the mental lexicon. It contradicts Booij's (2012) statement about the importance of input type frequency to L1 morphological processing, indicating differences between L1 and L2 in morphological processing mechanisms. As pointed out by Nevat et al. (2018), type frequency has effect on early stages of L1 acquisition and the effect is implicit. By implicit it is meant that learners are able to use the knowledge but do not need to explain it by rules. The implicit effect of type frequency indicates that L1 learners will notice the commonality and abstract the morphological constructions after encountering a sufficient number of sample words. This process is unconscious and natural, since they can infer the meaning of new words produced from a particular construction without studying the rules for word formation, even create novel words according to those they previously encountered. When the processing of morphological information becomes automatic, L1 learners will tend to decompose words with morphological structures into morphemes, whether they are semantically transparent or not. For example, in Rastle et al.'s (2004) study, apparent morphological forms with a pseudo-affix (e.g., corner/CORN) were segmented into constituents based on their morpho-orthographic properties irrespective of semantic information. What is worth noticing is that there is lack of consistency of morpho-phonetic structure for suffixed words like corner. This provides clear evidence of L1 learners' strong sensitivity to morphological constructions. In the context of L2 learning, however, language input is not exposed to the learners in a natural environment. The transformation of input into intake is not a spontaneous process but requires conscious and explicit analyses of the language. Though some L2 learners can develop language intuition, it is rather difficult to reach a native-like level. Since L2 learners do not have as strong an intuition of language as native speakers do, they are prone to employ grammatical rules to analyse morphological patterns. Consequently, it may cost much effort to generalize the constructions of morphological series. Based on the above analyses, we can reach the conclusion that the inactivation of the connection between series members may indicate the ineffective way of exposure rather than the insignificance of the quantity of input.

4.2.2 The Syntagmatic Perspective: the Explicit Effect of Phonetic Structure

Findings in Experiment 2 of this study indicated that morphological processing may not be affected by semantic transparency but related to some formal features, since not all the target words, which were transparent in meaning, were processed either in a composed manner or in a whole-word way. The significantly different RTs between the consistent and the inconsistent groups indicated that the phonetic structure of the former one facilitated the noticing of morphological structure.

Different from the implicit effect of subjective type frequency, the impact of the phonetic structure on affix learning is explicit (Nevat et al., 2018), meaning that the phonological cue provided by the phonetic structure is clear and easy to understand. This is because the understanding of phonetic structures does not deal with the semantic information of morphemes or the systematic form-meaning mapping between words. When the stem-affix boundary coincides with the syllabic boundary, learners would be facilitated to notice the combinatorial patterns for complex words, because the morphological structure is obvious once the phonological structure is discovered. In Experiment 2, the significantly slower responses to words with consistent morpho-phonetic structures indicated the emergence of decomposition. In the process of morphological generalization, decomposition is the initial and the most significant step. The occurrence of decomposition means the understanding of the morphological structure. But it is possible that the participants of the present study may not decode complex words as automatically as L1 speakers do. They may divide words with consistent morpho-phonetic structures into syllables first, and the division coincided with that between the morphemes. Since the representations of the syllables and the morphemes were accessed simultaneously, activating the phonetic units of suffixed words with consistent morpho-phonetic structures would facilitate the identification of the morphemic elements. There is possibility that the morphological boundary of the words in the consistent group became obvious due to the activation of the phonetic structure. When the participants noticed that the decomposed syllables, which functioned as affixes, also existed in other complex words, they began to draw an analogy between the words and generalized the pattern consciously. For example, the syllabic structure of the suffixed words like government in Experiment 2 provided an opportunity for the participants to make an analogy between the tested words and previously learned instantiations. And the analogy enabled them to recognize the elements as stem and suffix. After locating the constituents in their mental lexicon, the participants testified whether the stem and the suffix fitted in with the constructional schema for other similar words. The whole process required more effort to retrieve the target word and decide on its validity, hence the significantly more RTs than those spent on the identification of words with inconsistent morpho-phonetic structures and on the monomorphemic words.

In contrast, words with inconsistent morpho-phonetic structures were processed as monomorphemic items. Since the suffix of the words in the inconsistent group must be combined with the last consonant to form a syllable, the salience of the suffix was decreased. The perception of words in the inconsistent group as unanalysable units may be attributed to the lack of transparency of the morphological structure, which is indicated by the boundary between the morphemes. Even though words with inconsistent morpho-phonetic structures may also be decomposed into syllables in the beginning, these divided components may not be internalized and stored in the long-term memory since they bear no meaning and cannot produce a form-meaning mapping system.

Contrary to the findings in Experiment 2 of this study, Giraudo &Grainger's (2003) study revealed that the agreement between the affix-stem boundary and the syllabic boundary did not affect the RTs for French suffixed words. The result was considered to be attributed to positional factors rather than the phonetic structure. It is worth noticing that not all the French suffixed words in their study contained a free morpheme as the root. For instance, the prime rouage ("wheel") consists of a nominal suffix -age and a bound root rou which cannot stand independently of other morphemes. The nature of roots (i.e., being free or bound morphemes) has been proved to be effective on the processing of complex words (Rubin, 1979), i.e., complex words with a bound stem are accessed via the whole word form rather than the decomposed parts (Giraudo & Voga, 2016). Therefore, the absence of morphological decomposition in Giraudo and Grainger's (2003) study may not be reduced to the position alone but also linked to the bound roots.

5. Conclusion

Evidence obtained in this study lead to the following conclusions. First, subjective type frequency may be a necessary but not a sufficient condition for the establishment of morphological constructions. The meaning of an affix should be generalized based on the interrelation between the bases which can be attached to it. Separate exposure of different types of bases, however, may not predict the outcome of recognizing the systematic form-meaning mapping of a construction. Second, the phonetic structure of complex words influences the perceptual salience of the morphemic components, which in turn affects the noting of the morphological structure. For Chinese EFL learners who are likely to represent words as syllables in their L1, the consistency between morpho-phonetic structures may enhance the noticing of L2 morphemes. Third, the syntagmatic relationship between morphemes and the paradigmatic relationship between complex words work together to generate a morphological construction. While the former offers the possibility of decomposition, the latter benefits the reorganization of the decomposed morphemes to formulate the constructional schema.

6. Limitations of This Study and Suggestions for Future Studies

In spite of the significance of the findings of this study to the field of L2 morphological processing, there are limitations as follows. First, the target words selected in the experiment were limited to verbs derived from the affix en. Second, the number of words was relatively small.

Future studies on L2 morphological processing can be conducted on learners with different levels of language proficiency so as to investigate the patterns of morphological acquisition in different developmental stages. Furthermore, future research can be directed to the interplay of affix position, subjective type frequency and phonetic structure. Considering almost all English prefixed words have consistent morpho-phonetic structures, other languages should be selected instead of English in the investigation of affix position.

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