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LEARNING NOVEL MORPHOLOGY

The Role of Meaning and Orientation of Attention at Initial Exposure

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A large body of research has shown that suffixes—both inflectional and derivational—can be primed with adult native speakers, which informs our understanding of storage and access to morphology in mature systems. However, this line of research has not yet been conducted from an acquisition perspective: Little is known about whether or not representations of suffixes are formed after very little exposure to new morphology and, if so, about the nature of those representations or about the influence of attentional orientation and meaning at this initial stage. The three experiments reported here begin to address this gap by investigating the nature of suffixal representations following exposure to a small regular system of suffixed words. The experiment used crossmodal priming of recognition memory judgments to probe morphological representation. Although the lack of priming suggested

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that abstract morphological representations were not yet established, recognition judgments showed a clear sensitivity to sublexical morphemic units. The pattern of results was unaffected by the orientation of attention or the assignation of meaning to the words or suffixes during training. Offline tests of learning stem and suffix meanings also showed that both were learned to some extent even when attention was not oriented to their meanings and that the resulting knowledge was partially implicit. Thus, there was evidence of sensitivity to both the forms and meanings of the suffixes but not at the level required to support crossmodal priming. We argue that the reason for this may lie in the episodic nature of the knowledge gained after brief exposure.

Regardless of one's theoretical perspective, researchers can agree that it is a well-documented phenomenon that inflectional morphology is poorly learned in the first stages of second language (L2) acquisition, and that omissions can pervade even quite advanced grammars (Bardovi-Harlig, 2000; Clahsen & Felser, 2006; Hawkins, 2001; Klein, 1986). Much of the evidence for this comes from production data from L2 language learners, but there is also evidence from comprehension that suggests a lack of sensitivity to morphology in the input among intermediate and advanced learners (e.g., Jiang, 2004, 2007). However, little is known about the learning of morphological structure during initial exposure to a new language or about the effects of different types of exposure conditions. The current study uses priming and recognition tasks as well as offline judgment tasks to investigate the representations that are formed in the very initial stages of learning multimorphemic words. Additionally, we manipulate the exposure contexts in ways that broadly simulate some of the ways in which learners' attention can be focused on different aspects of new words, particularly during instructional events. This study, therefore, also informs debates about the role of attention and meaning during L2 acquisition.

BACKGROUND

Learning and Storage of Morphology in the L2

The extent to which morphology is attended to when L2 input is processed, how it is subsequently stored and accessed, and how these relate to acquisition are of central interest to SLA researchers, as indicated, for example, by Gor (2010). The current article relates to several of the strands of interest identified by Gor, including whether the morphological level exists in psycholinguistic terms or just in formal descriptions, and the nature of factors that influence morphological acquisition such as the type of input that learners receive. Although many studies have investigated first language (L1) and L2 differences in representation of regular and irregular morphology, particularly among advanced learners and bilinguals, rather few studies have investigated the sensitivity of learners to morphology in the input. Evidence to date for reduced attention to morphology in the input includes data from eye-tracking (Bernhardt, 1987; Sagarra, 2008), self-paced reading (Jiang, 2004, 2007), and lexical decisions (Marsden, Altmann, & St. Clair, in press). However, all of these studies were with learners with some prior experience with the target language, rather than at first exposure. Expanding this agenda, the current study set out to investigate (a) the extent to which L2 learners extract morphological information from brief, initial exposure to words in a completely unfamiliar language; (b) the nature of any resulting representation of the morphological information; and (c) how this process is affected by the way in which the multimorphemic words are presented.

Priming as a Test of Morphological Representation in the L1 and L2

To determine whether or not morphology has a structural representation, researchers have tended to adopt a priming paradigm, as there is strong evidence that words that share morphology influence the speed and accuracy of responses to one another. A substantial body of research has demonstrated that morphology can be primed among adult native speakers in a range of languages (for an overview, see Duñabeitia, Perea, & Carreiras, 2008). The motivation for the methods used in the present study came from a study by Marslen-Wilson, Tyler, Waksler, and Older (1994) that used a crossmodal priming task with native speakers of English. These authors found that the auditory presentation of a word facilitated lexical decisions (i.e., decisions as to whether or not the word presented is a real word) on a morphologically related visual target word presented immediately afterward. For example, *happiness* primed (i.e., elicited a quicker response time on the lexical decision for) HAPPY. Form-level-only priming was ruled out due to the lack of priming between purely form-related pairs—for example, tinsel-TIN[1]—and between pairs for which the morphological relationship is not semantically transparent (e.g., apartment-APART). Crucial for the current study, crossmodal priming effects have also been observed for shared derivational affixes (e.g., dark**ness**-TOUGH**NESS**; Marslen-Wilson, Ford, Older, & Zhou, 1996). These results reveal an abstract, modality-independent representation that is structured on a morphological basis.

Suffix priming, which is the focus of the present study, has also been obtained using the masked priming paradigm with all-visual stimuli. A prime is presented so briefly that the participant is not able to report it, and the prime is then immediately followed by a target word for lexical decision. Duñabeitia et al. (2008) found greater masked suffix priming between word pairs that shared a suffix (e.g., *-ness* in darkness-HAPPINESS) than for words that shared only nonmorphological endings (e.g., *-llow* in shallow-FOLLOW).[2] Furthermore, they demonstrated that the effect can even be obtained when the target is primed by the suffix in isolation (e.g., er-WALKER).

Several studies have found priming effects between inflectional morphemes. For example, Reid and Marslen-Wilson (2000), using a crossmodal immediate lexical decision task with adult native speakers of Polish, found in their first experiment that (a) prefixes denoting perfectives and (b) suffixes on nouns denoting diminutives and agentives produced priming effects. Their second experiment, which used auditory-auditory priming, demonstrated that a secondary imperfective inflectional suffix (and a derivational prefix) also produced clear priming effects. Smolík (2010) investigated priming of noun and verb inflections in Czech using masked and unmasked priming. For verbs, reactions were faster when inflections shared both their meaning and form with a prime as compared to suffixes that shared only their form. Smolík argued that this indicates that decomposition of inflectional morphology, not just of orthographical form, can happen within the first 50 ms of processing a short verb and within 150 ms for all verbs.

Rather few studies have looked at morphological priming in L2 learners. Second language morphological processing research is limited generally (as noted by Clahsen, Felser, Neubauer, Sato, & Silva, 2010), and our understanding of relationships that can be primed at a morphological level, specifically, is informed by very few studies indeed. Studies focusing on L1 and L2 storage of and access to regular and irregular morphology are not directly related to the current study, as they use stem priming (e.g., billed-BILL) to investigate morphological relatedness, whereas the current study used suffix priming. However, of relevance to the current study is that some of this research suggests that L2 learners may use a different system for processing morphology and that this may be constrained by proficiency level. Clahsen et al. (2010) argued that adult L2 learners are not as sensitive to morphological information as native speakers. Using masked priming, Silva and Clahsen (2008) found that, in contrast to natives, stem priming effects between, for example, boiled-BOIL were not observed for L2 learners with Chinese, Japanese, and German L1s. They also found a reduction (although not complete elimination) in stem priming effects with suffix-derived primes (e.g., boldness-BOLD) in the L2, although not in the L1. Similarly, in their third experiment, Neubauer and Clahsen (2009) showed that native German speakers exhibited facilitation between both regular and irregular types, whereas the nonnative speakers only showed facilitation for irregulars. These results suggest that nonnatives do not segment regular inflectional affixes from their stems during processing and that they rely more heavily on whole-word processing in their L2 than do native speakers (Clahsen et al., 2010; Ullman, 2005). However, Diependaele, Duñabeitia, Morris, and Keuleers (2011) found that high-proficiency Spanish-English and Dutch-English bilinguals performed the same as native English speakers on a masked morphological priming lexical decision task (see also Lemhöfer et al., 2008). Diependaele and colleagues found that stem priming effects were greatest when the suffixes were semantically transparent (e.g., viewer-VIEW), smaller when primes were opaque or pseudosuffixes (e.g., corner-CORN), and smallest in the form condition (e.g., freeze-FREE) (in line with the meta-analysis by Feldman, O'Connor, & Moscoso del Prado Martín, 2009).

A lack of difference between L1 and L2 morphological storage and access was also proposed by Feldman, Kostić, Basnight-Brown, Filipović Durdević, & Pastizzo (2010). For native and nonnative speakers, they found evidence for crossmodal facilitation between morphologically related regular and irregular pairs compared to either unrelated or orthographic controls. Of relevance to the current study is that crossmodal inhibition based on form overlap was not observed for nonnative speakers, which suggests that they were not affected by shared form between an auditory prime and a visual target (p. 132). Additionally, Feldman and colleagues examined the effect of L2 proficiency in an all-visual masked-priming experiment. The L2 learners had studied English for 9 years but were divided into high- and low-proficiency groups on the basis of reaction times (RTs) and correct responses. The high-proficiency learners patterned like the native speakers and showed facilitation from both regular and irregular primes to stem targets. The low-proficiency learners showed a similar numerical pattern, but the priming effects were only significant for one class of irregulars verbs (i.e., those with different as opposed to the same letter length, such as taught-TEACH as opposed to fell-FALL). This result is consistent with, although not strongly supportive of, the findings of Silva and Clahsen (2008) and Neubauer and Clahsen (2009).

In sum, the research to date provides strong evidence that morphology can be primed among adult natives and that crossmodal priming is thought to tap underlying abstract morphological representation (Marslen-Wilson et al., 1994; Experiment 1 in Reid & Marslen-Wilson, 2000; Experiment 2 in Feldman et al., 2010) as it reduces the likelihood that priming effects are simply due to the physical similarity between the prime and the target. The change in modality means that orthographic or acoustic overlap is unlikely to be the cause of observed effects. However, despite the considerable evidence that suffixes are represented in mature L1 systems in such a way that can produce priming effects, the evidence is not clear for L2 learners. Studies to date have been carried out with fairly advanced learners, and we know little about the early stages of morphological processing among beginner learners.

Word-Recognition Tasks as a Measure of Morpho-Orthographic Decomposition

One persistent difficulty in much morphological priming research is distinguishing the effect of deep, semantic-based morphological representations from that of shallower orthographic or phonological representations. For example, priming from the visual word *walker* to WALK may occur because they both access a common stem representation, or it may occur because, in the course of recognition, *walker* is decomposed into two orthographic units, *walk* and *-er*, and it is repetition of the orthographic unit *walk* that is responsible for the priming effect. It has also been found that nonwords with pseudoaffixes (e.g., PLOFER) are responded to more slowly than nonwords without such endings (e.g., PLOFET) (Caramazza, Laudanna, & Romani, 1988; Duñabeitia et al., 2008; Laudanna, Burani, & Cermele, 1994; Taft & Forster, 1976; and see Meunier & Longtin, 2007, for a review). This *pseudoaffixation effect* may occur because PLOFER seems meaningful, as it ends with the productive -ER morpheme, or it may occur because it is decomposed into two orthographic units in recognition, PLOF and -ER, which makes it seem orthographically more familiar than PLOFET, for which no such decomposition occurs.

The idea that there can be morphologically relevant parsing of input at the orthographic level was first suggested by Taft and Forster (1976) as the affix stripping hypothesis, which proposes a mechanism that was thought to help to isolate the affix and contribute to encoding the root morpheme. There has recently been a resurgence of interest in this idea because of studies that report masked priming between pairs such as corner-CORN, in which the prime has no morphological structure but happens to bear an ending, *-er*, that has a morphological status in other words (e.g., Rastle, Davis, & New, 2004; see Rastle & Davis, 2008, for a review). The idea is that, at some early stage of the recognition process, words are decomposed into potential "morpho-orthographic units" (Rastle & Davis, 2008, p. 958) that may or may not correspond to true morphological components of the word. A similar process of "morpho-phonological" decomposition has also been suggested for auditory word recognition (Post, Marslen-Wilson, Randall, & Tyler, 2008, p. 1). Note that because these representations are modality specific, they would not support crossmodal priming effects. Therefore, in the present study, we used crossmodal priming as a probe of abstract morphological representation and pseudoaffixation effects as a probe of potential morpho-orthographic decomposition. If pseudoaffixation effects are obtained in the absence of crossmodal priming, then we can say that pseudoaffixation effects are a reflection of morpho-orthographic decomposition. If pseudoaffixation effects are evident in the presence of crossmodal priming, then the source of pseudoaffixation effects remains ambiguous.

The notion of morpho-orthographic or phonological decomposition raises interesting issues in relation to acquisition. For example, what is the relationship between learning at this level and learning abstract morphological structure within the lexicon, in which morphemic units are defined in terms of their semantic and syntactic properties? Can morpho-orthographic or phonological units be formed without the support of meaning (e.g., on the basis of a pure distributional analysis of letters or phonemes)? Does the creation of abstract morphological representations depend on the provision of meaning, or are such representations formed as an inevitable consequence of the discovery of morpho-orthographic or phonological units? By applying our two tests of morphological structure to situations in which suffix meanings are either provided or withheld during training, we can attempt to begin to address these issues. Additionally, by manipulating whether or not attention is explicitly oriented toward the suffix meanings, we can ascertain whether or not the creation of morpho-orthographic units or abstract morphological representations depends on attentional orientation.

Orientation of Attention to the Input

The role of orientation to the input is central to improving our understanding of the necessity and effectiveness of focusing learners' attention on grammar. Some studies have demonstrated that an intentional and explicit focus on the form of language is necessary, as learning is not observed following mere exposure to forms (see DeKeyser, 1995; Marsden, 2006; Marsden & Chen, 2011; and evidence from experimental psychology such as Jiménez & Méndez, 1999; Logan & Etherton, 1994). Others have suggested that an explicit focus on a form is more beneficial than when exposure is implicit (Norris & Ortega, 2000), and that, when learners show awareness at the level of understanding, they perform better than when they do not (Leow, 1997, 2000). VanPatten (2007) and others have argued that, in the early stages, learners tend to prioritize attentional resources toward lexical items, rather than toward form (i.e., morphosyntactic features such as "functors, inflections"; VanPatten, 2002, p. 757), to obtain meaning. He suggests that some perceptual registration of the form of language can occur without being associated with meaning, but his proposal implies that such registration would not be evident on tests that measure learners' ability to generalize form-meaning connections. At its most conservative interpretation, the claim that learners initially have a tendency to process input for the meaning of lexical items predicts that, following limited exposure to a new set of words and exposure in which learners' attention is oriented to the form-meaning connections of the lexical items (and not to the features of form), there would be no evidence that learners would gain any generalizable knowledge of the meaning of the features of form. However, there is some evidence that learning of form-meaning connections can take place even when learners' attention is not oriented to the target form-meaning connection. Williams (2005) found that learners could generalize the function of a form at above chance levels even when their attention had not been previously oriented to that particular function of the form during training, at least when the target feature had a potential parallel in the participants' L1 (see also Leung & Williams, 2011, 2012). However, in those studies, the participants' attention was oriented to the form during training, albeit in connection with a meaning other than the one that was then tested. The current study builds on this work, to some extent, by using a training condition in which participants' attention was oriented not to the target form but rather to the lexical item (similar to DeKeyser, 1995). In addition to measuring participants' generalization abilities and their self-reported use of different knowledge types, the current study uses measures that are thought to be sensitive to implicit (i.e., without awareness) representations of language.

THE CURRENT STUDY

The current series of three experiments sought evidence for the very early representation of morphological form. As morphological priming has not, to date, been investigated with absolute beginner learners, we wanted to maximize the chances of representations being formed and, therefore, of finding morphological priming effects. To this end, a small artificial stem + suffix system was created. This allowed us to control a range of variables that are known to affect L2 learning—for example, regularity and reliability of form-meaning associations, phonological and morphosyntactic similarity to the L1, and amount and type of exposure to input. We therefore used words that are phonotactically permissible in the participants' L1 (i.e., English) and meaning contrasts that are, broadly, expressed using inflectional morphology in English; these included third-person singular versus plural (e.g., *eats* versus *eat*) and completed action (i.e., preterit) versus present (e.g., *walked* versus *walk*[*-s, -ing*]). The suffixes were phonologically salient, as this has been found to be one predictor of acquisition (e.g., Goldshneider & DeKeyser, 2001). All suffixes were syllabic (vowel-consonant), which is also a feature that is present in the participants' L1 (e.g., *watches*, *wanted*, *wanting*). It was predicted that the high salience of the suffixes would help to provide optimal circumstances for the learning of morphology. Obviously, this highly controlled input is in tension with the need to inform our understanding of natural language learning. However, we believe that such a design is one important first step.

In addition to language features that were favorable to the formation of representations, our study also sought to provide opportunities for suffixes to be detected and segmented from the input. This was done via the nature of the tasks given to learners during exposure (i.e., training). These tasks also simulated, to some extent, different learning contexts or instructional events. Each exposure phase provided the same miniature artificial language system, with the same types and tokens, but manipulated the cover task; this oriented learners' attention in different ways. In all three experiments, the task facilitated segmentation of the input at some level. The experiments also manipulated whether or not the task oriented attention toward the suffix and whether or not any meaning was given to the stem and affix. The first experiment asked participants to repeat the word and then count syllables. As the suffixes were syllabic, such a task might facilitate segmentation of the suffixes and, therefore, representation of the forms. As learners did not know the meaning of the language, this condition simulates a context in which learners have not assigned meaning or function to features of the language and are required or able to pay attention to the form of the features only. The second experiment required learners to learn the meaning of the stems via a picture-matching task that focused attention on the stem. Although attention was not oriented to the suffix, each suffix was also systematically linked to a meaning in the pictures. This exposure condition could facilitate segmentation of the stem from the suffixes and, thus, provide the opportunity to develop incidentally (or perhaps implicitly) both form and meaning representations of the suffix. This condition simulated contexts in which learners focus their attention on the meaning of lexical items (for reviews, see Marsden & Chen, 2011; VanPatten, 2007). The final experiment offered the most favorable conditions for observing morphological learning effects because it provided not only explicit information about the form and meaning of the suffixes (thus aiding segmentation) but also practice in the segmentation and assignment of meaning to the suffixes (but not the stems). This experiment simulated, to some extent, contexts in which learners are given explicit grammar instruction and practice in connecting grammatical forms to meanings (Marsden, 2006; VanPatten, 2004, 2007) and also allows us to evaluate incidental learning of the meaning of content words (i.e., stem meanings) under such conditions.

Following exposure, the participants performed a crossmodal priming test in which they were required to indicate whether or not the target words had occurred in the previous exposure phase. Our original assumption was that this recognition task could be regarded as an analog of the lexical decision (i.e., real or nonword) task used with adult native speakers and language learners (see the Discussion section for further comments on this assumption). Half the trials were familiar trials, and half were novel trials. For the familiar trials, participants had already been exposed to the targets during the training phase, so a "yes" response was required. Some of the familiar targets were morphologically related to the primes, whereas some were unrelated. If brief exposure can lead to crossmodal priming (as in adult natives), then reactions should be faster when the prime and the target shared the same suffix compared to morphologically unrelated pairs. A suffix-only prime condition was also used to investigate whether or not physical similarity, albeit in different modalities, would cause priming effects, and, if so, how this compared to potential morphological priming (i.e., related conditions) and the unrelated conditions. As argued by Duñabeitia et al. (2008, p. 1007), if a morpheme has an autonomous representation in the lexicon (Aronoff, 1994; Di Sciullo & Williams, 1987) then, by providing the participant with a suffix already segmented, participants may recognize the words preceded by their suffixes faster than those preceded by unrelated suffixes.

In the novel trials, "no" responses were expected, as participants had not previously been exposed to the targets (i.e., during the exposure phase), and all of the stems were novel. Some of these targets, however, had a familiar suffix, whereas others had a novel suffix. The analyses focused on finding any differences in reactions to items bearing novel versus familiar suffixes, rather than on the effect of morphological relatedness between the prime and target; as such, targets were morphologically unrelated to their primes in the familiar and novel suffix conditions. If morphologically structured representations had been formed, then rejections of these novel target words would be slower and less accurate when the suffix was familiar compared to when the suffix was novel, which is an analog of the pseudoaffixation effect. Additionally, some trials had suffix-only primes, as in the familiar trials, and, for these trials, the prime and target were morphologically related (e.g., -ot-GIMOT); these items are henceforth referred to as *suffix-only*. Note, therefore, that in the novel trials, two of the conditions had a familiar suffix in the target, and one condition had a novel suffix. Finally, in the second and third experiments, the priming test was followed by a picture-matching task that tested for generalizable knowledge of the meanings of the stems and affixes.

EXPERIMENT 1

The first experiment sought to establish whether initial exposure to a simple system of suffixes would lead to crossmodal priming effects or pseudoaffixation effects. During exposure, the novel words were given no meaning, and participants' attention during exposure was oriented toward the physical form of the words due to the fact that they were required to repeat each word and count its syllables.

Method

Participants. Thirty-six native speakers of English—students at a university in the United Kingdom—were paid for their participation in Experiment 1. All participants had spoken only English in their childhood homes, and none was studying linguistics or a foreign language. Their ages ranged from 18 to 25 years, and no auditory or visual problems were reported.

Materials (Exposure Phase). The small artificial word set created for the exposure phase was derived from 15 word stems (e.g., *gat-*), which are henceforth referred to as verbs, although we do not know if learners processed or categorized them as such. There were five mono-, five bi-, and five trisyllabic stems. Each stem appeared with one of three suffixes (i.e., *-ot*, *-ec*, *-ib*; see Appendix A for a list of words). Each suffixed word (e.g., *gatot*) was presented three times. This produced a list of 135 nonwords in which each suffix appeared with 15 different stems and 45 times in total.

Each word was presented orally and visually, with the visual form appearing at the onset of the oral form. The visual word stayed on the screen until the participant responded. The stimuli were recorded by a male native speaker of British English and were sampled at 44.1 kHz. Stress was always on the first syllable.

Exposure Phase Treatment. Participants were instructed to listen to the input and repeat each word they heard. They were then asked to indicate how many syllables each word had by pressing a button labeled 2, 3, or 4 on a response box. Participants were given visual feedback, either *correct* or *incorrect*, which remained on the screen for 2 s. The next word was then presented immediately. Prior to the main trials, participants completed two practice trials with novel words that were not used in the main study.

Tests. After the exposure phase, there was a 30 s interval followed by a crossmodal priming task with recognition judgments on the targets.

For each trial, an auditory prime was immediately followed by a visual target. Participants indicated whether or not they had encountered the visual targets during the exposure phase by pressing a button marked "Y" or a button marked "N." There were 54 trials in total. For half of these (i.e., the familiar trials), the correct answer was "yes" (see Appendix A), and, for the other half (i.e., the novel trials), the correct answer was "no" (see Appendices B and C). The 27 familiar trials consisted of the following three conditions: nine related trials (e.g., def**ot**-RUJ**OT**), nine unrelated trials (e.g., sem**ib**-GAT**OT**), and nine suffix-only trials with a suffix as the prime and a related suffix on the target (e.g., **ot**-YAB**OT)**. Eighteen words encountered during the exposure stage served as auditory primes, and the other 27 as visual targets. There were 27 auditory primes in total, including the suffix-only trials. All participants experienced all 54 preexposed words as either a prime or a target. The role of a particular word as either a prime or a target was counterbalanced between participants. As a result, each word appeared only once for a particular participant, whereas each word served, systematically, as a prime or a target for different participants.

In the 27 novel trials, the target words had not been presented during the exposure phase, and all the targets' stems were novel. The primes were the same as those used in the familiar trials. The novel trials consisted of the following three conditions: nine trials with NOVEL STEM + FAMILIAR SUFFIX targets (e.g., defot-KAMIB; see Appendix B), nine trials with NOVEL STEM + NOVEL SUFFIX targets (e.g., gatot-LOPOM; see Appendix C), and nine trials with NOVEL STEM + FAMILIAR SUFFIX targets but with a suffix-only prime (e.g., ot-SORUPOT; see Appendix B).

The visual target stayed on the screen until a response was made, up to a maximum of 5 s. There was no interval between the offset of the auditory prime and the onset of the visual target, thereby deterring the participants from developing strategies on the basis of expected relations between the prime and target (following Marslen-Wilson et al., 1994, p. 9). Additionally, because there is robust evidence that words are decomposed early in word processing (e.g., see Gold & Rastle, 2007; Marslen-Wilson et al., 1994), the minimal time lag between prime and target was another feature of the current study that increased the likelihood of observing priming effects.

Between each trial, participants saw a blank screen for 500 ms. A fixation cross was presented at the point the visual target was to appear to prevent drift during the auditory prime. Prior to the main trials, participants had nine practice trials. These used four suffixed words in which both the stem and the suffix were not used elsewhere in the experiment. The practice phase was structured as four trials, a screen reminder of the instructions, four more trials, another reminder of the instructions, and one more practice trial.

Results: Crossmodal Priming Test

Incorrect responses, which constituted 13% of the data, were eliminated for the RT analyses.[3] Outliers were eliminated on an individual basis: Latencies of ±2.5 standard deviations from the individual's mean over familiar and novel trials, respectively, were replaced with the next-highest (or next-lowest) value. This Winsorization procedure is conservative in that it curtails the effect of outliers while not eliminating their effect on the condition mean. In the end, 2.5% of the data were treated in this way. Reaction time and accuracy data were separated into two groups on the basis of trial type (i.e., familiar or novel) and are presented in Tables 1 and 2, respectively.

Familiar Trials. A one-way ANOVA revealed no significant effect of condition on either RTs, $F(2, 34) = 1.65$, $p = .207$, or accuracy, $F(2, 34) = 0.78$, $p = .47$. Note that accuracy rates suggested that the (whole) words had been reasonably well learned to the extent that recognition was good and that a bias toward "yes" responses cannot account for this, as the "no" responses in the novel trials were also accurate, see Table 2.

Novel Trials. Condition had a significant effect on RTs, $F(2, 34) = 6.06$, $p = .006$. Responses to targets with a NOVEL SUFFIX were significantly faster than responses to targets with a FAMILIAR SUFFIX (i.e., faster than both those with familiar stem + familiar suffix primes, $F[2, 34] = 5.04$, $p = .012$, and those with suffix-only primes $F[2, 34] = 11.23$, $p < .001$). No difference was found between the two conditions with targets with a FAMILIAR SUFFIX—that is, those with familiar stem + familiar suffix primes and those with suffix-only primes, $F(2, 34) = 2.05$, $p = .14$. Accuracy rates from these three conditions were not affected by condition in a statistically significant way, $F(2, 34) = 1.25$, $p = .30$, although accurate rejection was slightly higher in the NOVEL SUFFIX condition than the other conditions.

Table 1. Mean RTs and accuracy rates for familiar (yes) trials in the crossmodal priming test, Experiment 1

	Related (e.g., defot-RUJOT)		Unrelated (e.g., semib-GATOT)		Suffix only (related; e.g., ot-YABOT)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	724	193	706	203	686	139
Accuracy (max = 9)	7.3	1.5	7.6	1.3	7.5	1.8

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

Table 2. Mean RTs and accuracy rates for novel (no) trials in the crossmodal priming test, Experiment 1

	Suffix only: NOVEL STEM + FAMILIAR SUFFIX (related; e.g., ot-TAMIPOT)		Familiar stem + familiar suffix: NOVEL STEM + FAMILIAR SUFFIX (unrelated; e.g., defot-KAMIB)		Familiar stem + familiar suffix: NOVEL STEM + NOVEL SUFFIX (unrelated; e.g., gatot-LOPOM)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	704	197	679	230	648	171
Accuracy (max = 9)	8.2	1.3	8.0	1.2	8.4	1.4

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

Summary and Discussion

During the training component of this experiment, participants repeated each suffixed word and counted its syllables. As a result, they experienced 45 tokens of each of the three suffixes, but they were not given any meaning associations, nor were they asked to try to understand the words. Following this, we found that participants were slower to reject words that had not been experienced before if the words had a FAMILIAR SUFFIX compared to words with a NOVEL SUFFIX. This suggests that participants had become sensitive to the physical structure of the words during the brief exposure, in that they preferred a familiar word ending. Participants were slightly more likely to reject words with a NOVEL SUFFIX compared to words with a FAMILIAR SUFFIX, although this was not statistically significant. However, we did not find any evidence of morphological priming; that is, RTs and accuracy scores were the same regardless of whether the prime was related (e.g., rujot-GATOT) or unrelated (e.g., rujib-GATOT) to the target or was a suffix-only prime (e.g., ot-GATOT). The lack of crossmodal priming suggests that representations at the level of morphology were not yet established after this kind and amount of exposure.

However, the evidence from the RTs in the novel trials does suggest that the participants had developed some representation of the ending, which indicates an emerging sensitivity to expectations about the distributional properties of the novel words. Note that the two types of novel trials that had targets with a FAMILIAR SUFFIX—that is, those with related primes that were suffix-only and those with unrelated primes that were familiar stem + familiar suffix—produced the same RTs as each other, which suggests that the relatedness of the prime to the TARGET had no effect. Note also that both of these trial types produced slower RTs than the trials in which the primes also had a familiar, unrelated suffix but the targets had a NOVEL SUFFIX. These findings further suggest that any sensitivity was to surface forms (perhaps syllabic, orthographic, or possibly phonological) in the visual target rather than to abstract (i.e., crossmodal) morphological representations. The issue of whether this sensitivity to familiar endings can be regarded as evidence for morpho-orthographic decomposition will be considered in the General Discussion section in light of the pattern of results of the experiments overall.

EXPERIMENT 2

Experiment 2 investigated whether the processing of the semantics carried by the stems—but not the suffixes—could facilitate segmentation of the stem from the suffix, which could, in turn, possibly aid in the development of representations of the suffixes to a greater extent than the form-only orientation of Experiment 1. In Experiment 2, therefore, the exposure provided meanings for the words via practice that focused attention on the meaning of the stems through pictures. This experiment was thought to provide a more favorable exposure condition than Experiment 1 for morphological priming effects to be observed.

We also included a picture-word matching task in the test phase that was designed to test knowledge of the meanings of the stems and suffixes. Although performance on the stems was expected to be very good, what was of most interest was whether or not above-chance performance would be obtained for the suffixes. This would indicate incidental learning of the suffixal meanings in a task that directed attention to stem meanings. To gauge the degree of explicitness of this knowledge, participants were asked to indicate if each decision was based on guessing, intuition, memory, or rule (Dienes & Scott, 2005; Rebuschat & Williams, 2006; see Rebuschat, in press, for use of these measures in SLA research). Dienes (2008) argued that a subjective judgment of the source of the knowledge used to make a decision, which we refer to here as knowledge source judgments, provides a reliable measure of its degree of explicitness; responses in the guess and intuition categories reflect implicit knowledge,[4] whereas responses in the memory and rule categories reflect explicit knowledge. Dienes and Scott (2005) validated these knowledge measures by showing how participants responded to task manipulations designed to influence the extent to which they relied on implicit or explicit knowledge in a judgment task.

Method

Participants. Another 36 native speakers of English (from the same kind of student pool as Experiment 1) participated in Experiment 2. They had not participated in any other experiments in this series.

Exposure Phase Treatment. The language in the exposure phase was identical to Experiment 1; that is, the same tokens and types were presented, orally and visually, at the same time. However, instead of counting the syllables, participants completed a 135-item picture-matching task. Each pair of pictures represented two different activities (or actions). For example, participants heard and saw *sifedot*, and the pictures shown in Figure 1 were presented simultaneously with the onset of the auditory word and the appearance of the visual word.

Participants indicated to which picture the word referred; following this, they were given feedback regarding the correctness of their choice, and the correct picture appeared on the screen. The word was not repeated again, visually or orally. At the start, participants' responses had to be random, as they were given no prior instruction. However, the feedback allowed them to infer meanings of the stem.

Within each pair, particular functions were held constant. Both pictures represented one of three functions: (a) singular, present (or continuous); (b) plural, present (or continuous); or (c) singular, past (or completed action). The suffixes *-ot*, *-ib*, and *-ec* were assigned one of these functions, and these form-meaning pairings were counterbalanced across different lists (i.e., for one third of the participants, *-ot* represented plural present, *-ec* represented singular present, and *-ib* represented singular past), to reduce any potential effect of one particular

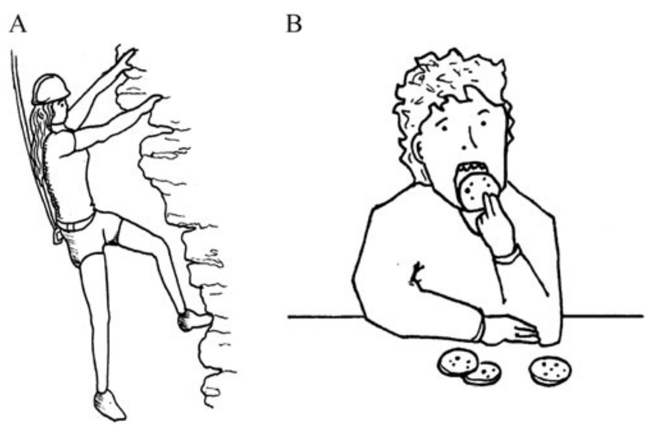

Figure 1. Example of a picture-matching trial during the exposure phase in Experiment 2 for the word *sifedot*.

form-meaning association being easier than others. These functions were subsequently tested in the generalization test. Each picture appeared in equal amounts, and each suffix appeared in equal amounts.

Following the exposure, the same crossmodal priming test was used as in Experiment 1. This was followed by a generalization test with knowledge source judgment questions. There was no break between the priming test and the generalization test, although there were several screens of instructions.

Generalization Test with Knowledge Source Judgment Questions. This 24-item picture-matching test measured participants' receptive knowledge of the meanings (i.e., functions) of the stems and suffixes (see Appendix D for a list of the words used). Nine items tested knowledge of the suffixes. For example, participants simultaneously heard and saw a new stem with a familiar suffix (e.g., *smafot*) and saw three pictures labeled A, B, or C (Figure 2). Each picture showed one of the functions from the exposure phase: singular, past (or completed action); plural, present (or continuous); or singular, present (or continuous). None of the pictures had been seen before. Participants had to press button A, B, or C on a response box.

Fifteen items tested knowledge of stems. Participants simultaneously heard and saw a familiar stem with a new suffix (e.g., *gatas*) and saw three pictures A, B, and C (Figure 3). All pictures had been seen before, in equal amounts, but never in combination with that suffixed word. The suffix items and the stem items were presented randomly within the same single test.

After each item, participants responded to a knowledge source judgment question that asked, "When you answered the question, did you guess, use intuition (just felt right), use a rule, or use memory? Press g, i, r or m on the keyboard."

Results

Crossmodal Priming Test. Outliers, which constituted 2.2% of the data, were treated using the same procedure as in Experiment 1. Also like

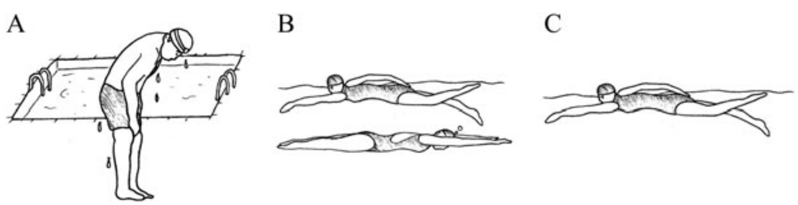

Figure 2. Example of a suffix item in the generalization test (used in Experiments 2 and 3).

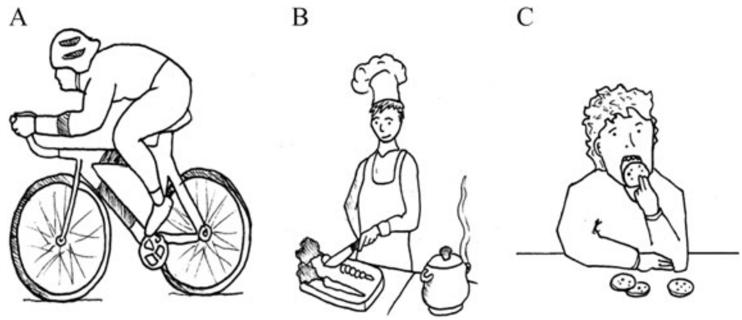

Figure 3. Example of a stem item in the generalization test (used in Experiments 2 and 3).

Experiment 1, incorrect responses, which represented 23% of the data, were excluded.[5]

Familiar trials. Mean RTs and accuracy scores are presented in Table 3. Similar to Experiment 1, the within-subject factor condition did not have any effect on RTs, $F(2, 34) = 1.92$, $p = .162$. However, condition significantly affected accuracy, $F(2, 34) = 4.69$, $p = .016$. Pairwise comparisons showed that accuracies in the related and the unrelated conditions did not differ from each other, $F(2, 34) = 0.80$, $p = .458$, but participants responded less accurately in these two conditions compared to the suffix-only condition, $F(2, 34) = 6.06$, $p = .006$; $F(2, 34) = 6.30$, $p = .005$, respectively. Note that, as in Experiment 1, accuracy rates overall suggested that the (whole) words had been learned to the extent that recognition was good.

Novel trials. Mean RTs and accuracy scores are presented in Table 4. As in Experiment 1, RTs were significantly modulated by condition, $F(2, 34) = 4.32$, $p = .021$. Responses from the two conditions with a

Table 3. Mean RTs and accuracy scores for familiar (yes) trials in the crossmodal priming test, Experiment 2

	Related (e.g., defot-RUJOT)		Unrelated (e.g., semib-GATOT)		Suffix only (e.g., ot-YABOT)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	788	196	790	237	825	240
Accuracy (max = 9)	6.3	1.8	6.3	1.8	7.1	1.8

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

Table 4. Mean RTs and accuracy scores for novel (no) trials in the crossmodal priming test, Experiment 2

Measure	Suffix only: NOVEL STEM + FAMILIAR SUFFIX (related; e.g., ot-TAMIPOT)		Familiar stem + familiar suffix: NOVEL STEM + FAMILIAR SUFFIX (unrelated; e.g., defot-KAMIB)		Familiar stem + familiar suffix: NOVEL STEM + NOVEL SUFFIX (unrelated; e.g., gatot-LOPOM)	
	M	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	787	310	793	323	709	231
Accuracy (max = 9)	7.9	1.26	7.9	1.57	8.3	1.39

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

FAMILIAR SUFFIX in the targets (i.e., those with familiar stem + familiar suffix primes and those with suffix-only primes) were significantly slower than responses to targets with a NOVEL SUFFIX, $F(2, 34) = 8.41$, $p = .001$ $F(2, 34) = 10.29$, $p < .001$, respectively. There was no difference in RTs between the two conditions with a FAMILIAR SUFFIX in the target, $F(2, 34) = 0.38$, $p = .687$. These results parallel those from Experiment 1. Condition did not have a statistically significant effect on accuracy, $F(2, 34) = 1.53$, $p = .231$, although accuracy (i.e., correct rejection of the word) was higher for targets with a NOVEL SUFFIX.

Generalization Test and Knowledge Source Judgments. Participants had a high accuracy rate (i.e., 83%) on generalizing their knowledge of stem meanings, which was statistically significantly different from a chance score of 33% according to a one-sample *t* test, $t = 21.52$, $p < .001$. Because participants' attention was directed to the stems, this finding is unsurprising. Table 5 shows the percentage of responses in each source category and the relevant accuracy rates. According to Dienes (2008), the guess and intuition categories can be combined to form a measure of implicit knowledge, and the memory and rule categories combine to provide a measure of explicit knowledge. Significant differences in accuracy from the chance level of 33% were calculated using a binomial test. Regardless of the reported knowledge source (i.e., memory, rule, or intuition), accuracy rates were high. Even guessing produced accuracy rates that were significantly above chance, which shows that even in those relatively few cases in which participants were not sure of their answer, the answers given tended to be accurate.

Table 5. Knowledge source data for the suffix and stem items in the generalization test in Experiment 2

Knowledge source judgment	Suffix: Percentage of total responses (N = 324)	Suffix: Percentage of correct responses with that knowledge source	Stem: Percentage of total responses (N = 540)	Stem: Percentage of correct responses with that knowledge source
Guess	60	40*	11	47**
Intuition	22	32	17	75***
Memory	2	38	56	92***
Rule	16	39	17	82***
Guess or intuition	82	38*	27	64***
Memory or rule	18	38	73	89***

* $p < .05$. ** $p < .01$. *** $p < .001$.

The overall accuracy on suffix test items was 38%, which was significantly above the chance score of 33% according to a two-tailed t test, $t = 2.17$, $p = .037$, and suggests that some suffix learning also took place. As shown in Table 5, only a very small proportion of the responses were reported to be informed by a rule or by memory. The majority (i.e., 82%) were driven by guessing and intuition, which suggests a lack of awareness of the target rule. Crucially, accuracy was significantly above chance even when participants claimed to be guessing and when guess and intuition categories were combined. Accuracy was no higher when participants claimed to be using memory or a rule (i.e., explicit knowledge), although, in this case, accuracy was not significantly different from chance due to the smaller sample size.

Discussion

As in Experiment 1, we did not find evidence of representation of the suffixes at a morphological level that was independent of modality. However, also in line with Experiment 1, we found that participants had begun to develop some representation of the suffix forms as they displayed sensitivity to sublexical structure, which appears to be in line with previous research that shows pseudoaffixation effects in L1 speakers.

We also found some evidence that new morphology and its functions can be generalized at an above-chance rate even when learners' attention is not oriented to that form and meaning, and even when they report that their answers were based on guesswork rather than a rule or memory. This finding is broadly in line with evidence from Williams (2005) and Leung and Williams (2011, 2012) for learning form-meaning connections without learners being aware of the specific form-meaning rules being tested. The current findings go further in that our participants' attention was not oriented to the form by the training task, whereas in Williams's and Leung and Williams's studies, participants' attention was drawn to the relevant form by their training.

EXPERIMENT 3

Experiment 3 was designed to enhance still further the saliency of the target features, and, as such, to improve the likelihood of finding evidence of modality-independent morphological representation. This experiment provided the segmented forms in isolation and some explicit information about their functions prior to the training. Additionally, the training oriented participants' attention toward the function of the target form by juxtaposing it against a different form-meaning association, as in referential activities in processing instruction (Marsden & Chen, 2011; VanPatten, 2007). If morphemes have an autonomous representation in the lexicon, then the nature of this training may increase the rate at which such representations are formed and thus lead to crossmodal priming effects after very little exposure. An interesting additional question is whether or not participants will incidentally learn the meanings of the stems under these conditions.

Method

Participants. Another 36 native speakers of English (from the same kind of student pool as Experiments 1 and 2) participated in Experiment 3. They had not participated in any other experiments in this series.

Exposure Phase Treatment. The language in the training phase was identical to that in Experiments 1 and 2; however, the task given to the participants was different. First, brief instruction was given that provided explicit information about the suffixes' forms and meanings. For example, participants read:

> The words you are about to hear have one of three endings. Each ending has a meaning. *-ot* = singular, present; *-ec* = plural, present; *-ib* = singular, past. You must remember these and match the correct pictures to the word.

The specific form-meaning pairs were counterbalanced across lists, as in Experiment 2. The participants then completed a 135-item picture-matching task. For each item, the word was presented visually and orally, and two pictures appeared on the screen simultaneously. Both pictures depicted the same action, yet the two pictures juxtaposed two different functions (i.e., singular, present [or continuous]; plural, present [or continuous]; and singular, past [or completed action]). All combinations occurred in equal amounts: singular present with plural present, singular present with singular past, and plural present with singular past. For example, participants heard and saw *sifedec* and had to choose picture A or B in Figure 4. Or participants heard and saw *sifedib* and had to choose picture A or B in Figure 5. Participants were given feedback regarding the correct versus incorrect nature of their response. This kind of activity is based on a well-researched instructional technique (i.e., referential activities in processing instruction) that has been shown to be an effective procedure for teaching verb morphology (Marsden & Chen, 2011; VanPatten, 1996).

Tests. The same crossmodal priming and generalization tests were administered as in Experiment 2.

Results

Crossmodal Priming Test. Incorrect responses (i.e., 19% of the data) were excluded. Outliers (i.e., 2.3% of the data) were treated using the

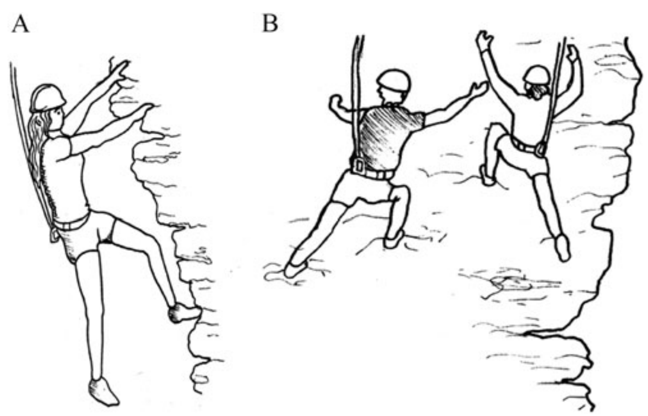

Figure 4. Example of a picture-matching task item during the exposure phase in Experiment 3 depicting a choice between singular present (A) and plural present (B).

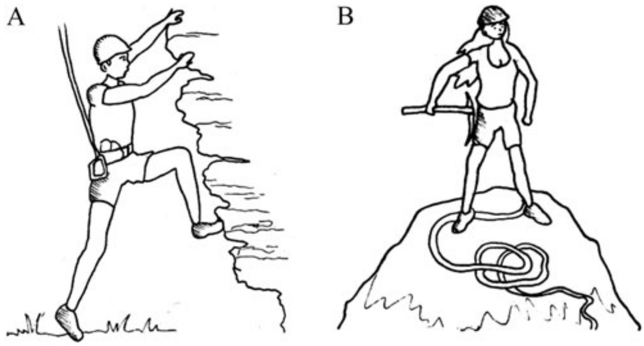

Figure 5. Example of a picture-matching task item during the exposure phase in Experiment 3 depicting a choice between singular present (or continuous) (A) and singular past (or completed action) (B).

same procedure as in Experiments 1 and 2. The group means of RTs and accuracy for familiar trials are shown in Table 6 and for novel trials in Table 7.

Familiar trials. A one-way, within-subject ANOVA revealed no main effect of condition on either RTs, $F(2, 34) = 0.92$, $p = .408$, or accuracy, $F(2, 34) = 0.90$, $p = .416$, which indicates that prime type (i.e., related, unrelated, or suffix-only) did not affect participants' responses to the target items.

Novel trials. A one-way ANOVA on the novel trials showed a significant main effect of condition on RTs, $F(2, 34) = 7.16$, $p = .003$, and on accuracy, $F(2, 34) = 11.10$, $p < .001$. Pairwise comparisons indicated that RTs in the NOVEL SUFFIX condition were reliably shorter compared to both of the FAMILIAR SUFFIX conditions: those with familiar stem + familiar

Table 6. Mean RTs and accuracy scores in the familiar trials in the crossmodal priming test, Experiment 3

	Related (e.g., defot-RUJOT)		Unrelated (e.g., semib-GATOT)		Suffix only (e.g., ot-YABOT)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	1024	407	1043	397	1036	331
Accuracy (max = 9)	6.0	2.1	5.8	2.0	6.5	1.9

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

Table 7. Mean RTs and accuracy scores for novel trials in the crossmodal priming test, Experiment 3

	Suffix only: NOVEL STEM + FAMILIAR SUFFIX (related; e.g., ot-TAMIPOT)		Familiar stem + familiar suffix: NOVEL STEM + FAMILIAR SUFFIX (unrelated; e.g., defot-KAMIB)		Familiar stem + familiar suffix: NOVEL STEM + NOVEL SUFFIX (unrelated; e.g., gatot-LOPOM)	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
RT (ms)	1082	467	1038	503	939	399
Accuracy (max = 9)	7.3	1.81	7.3	1.6	8.5	1.0

Note. RT = reaction time; max = maximum; *M* = mean; *SD* = standard deviation.

suffix primes, $F(2, 34) = 8.85$, $p = .001$, and those with suffix-only primes, $F(2, 34) = 13.52$, $p < .001$. There was no difference in RTs between the two FAMILIAR SUFFIX conditions, $F(2, 34) = 1.04$, $p = .364$. Furthermore, participants rejected the target words with a NOVEL SUFFIX more accurately than the target words in both of the FAMILIAR SUFFIX conditions: those with familiar stem + familiar suffix primes, $F(2, 34) = 23.46$, $p < .001$, and those with suffix-only primes, $F(2, 34) = 13.43$, $p < .001$. Accuracy rates in the two FAMILIAR SUFFIX conditions did not differ from each other, $F(2, 34) = 0.92$, $p = .408$.

Generalization Test and Knowledge Source Judgments. The generalization test data suggested that directing participants' attention to the suffixes (i.e., *-ot*, *-ib*, and *-ec*) led to substantial learning of the suffixes. In fact, participants exhibited an accuracy rate of 94%, which is clearly above chance according to a one-sample *t* test, $t = 31.95$, $p < .001$. Rule use was the most frequently reported source of knowledge and, along with memory, was a reliably accurate source (Table 8). Additionally, participants responded to learned stems with novel suffixes with 57% accuracy, which indicates stem learning at well-above-chance levels, $t = 6.63$, $p < .001$. Participants reported using guesswork and intuition for most responses to stem items (i.e., 65%), yet their accuracy was significantly above chance even when guessing, which suggests use of implicit knowledge. However, these were not as reliable sources of knowledge as when participants reported use of rule or memory. Accuracy tended to be higher for these items, which suggests that

Table 8. Knowledge source data for the suffix and stem items in the generalization test in Experiment 3

	Suffix		Stem	
Knowledge source judgment	Percentage of total responses (*N* = 324)	Percentage of correct responses with that knowledge source	Percentage of total responses (*N* = 540)	Percentage of correct responses with that knowledge source
Guess	7	71***	44	42**
Intuition	3	60	21	55***
Memory	11	97***	24	82***
Rule	78	97***	11	64***
Guess or intuition	10	67***	65	46***
Memory or rule	90	97***	35	76***

* $p < .05$. ** $p < .01$. *** $p < .001$.

they had awareness of stem meanings even though their attention had not been oriented toward the stems' meanings by the training task.

Discussion

Despite explicit pretraining on the suffix forms and their meanings, we still did not obtain any crossmodal priming between morphologically related pairs (e.g., rujot-GATOT) in the familiar trials compared to unrelated or suffix-only pairs, even though, as in the previous experiments, accuracy rates suggested that the (whole) words had been learned to the extent that recognition was good. Once again, the results from the novel trials suggested sensitivity to the suffix forms because novel stems with familiar suffixes were rejected more slowly and less often than completely novel forms.

Although broadly similar to the results of Experiments 1 and 2, there were two subtle differences. First, overall RTs to the familiar and novel targets were markedly slower than in Experiments 1 and 2 (i.e., an overall mean of 1,027 ms versus 691 ms in Experiment 1 and 782 ms in Experiment 2).[6] Second, in the novel trials, the better rejection of NOVEL SUFFIX items was evident in accuracy as well as RT, whereas, in Experiments 1 and 2, there were only statistically significant effects in RT.[7] The slower RTs might have been caused by participants using their explicit knowledge of suffix forms and meanings to segment the targets into stems and suffixes, which slowed processing. The accuracy effect in the novel trials may reflect a greater confidence that targets with no known suffix are likely to be novel. Thus, these effects can be seen as a reflection of greater explicit knowledge of stem forms and meanings after suffix training compared to syllable or stem training.

As would be expected, the generalization test and knowledge source judgment questions showed good learning of the suffixes, mainly via reported rule use. Participants also learned the stems, performing well above chance, even though the training task did not explicitly require them to learn the stem meanings. Therefore, learning of the stem meanings was incidental. The fact that accuracy was above chance even when the participants claimed to be guessing or using intuition suggests that their knowledge of stem meanings was at least partly implicit. The memory and rule sources were used less often but led to higher accuracy, which indicates that explicit knowledge had also been developed.

GENERAL DISCUSSION

In summary, regardless of training condition, we did not find evidence of modality-independent morphological priming after the kinds of initial exposure provided in the current study, as there was no facilitation—measured by RTs or accuracy rates—between a related suffix in a prime and a target in the crossmodal priming test. In other words, our findings from the familiar trials suggest that, in this very initial stage of learning of our highly constrained and regular system (i.e., the invented set of words), abstract (i.e., modality-independent) morphological decomposition did not happen, even when participants had highly accurate explicit knowledge of the stem forms and meanings (i.e., Experiment 3). These findings are broadly compatible with previous research that has found weak sensitivity to inflectional morphology among L2 learners (e.g., Bernhardt, 1987; Jiang, 2004, 2007; Marsden et al., in press; Sagarra, 2008). However, we did find evidence of representation at an orthographic level during visual recognition, as participants responded more slowly and less accurately to nonwords with a familiar suffix. We also found that our participants learned to recognize the whole words successfully, demonstrated by their high recognition accuracy scores across all priming conditions.

Although we could not have native controls, our lack of crossmodal priming contrasts with research that has shown suffix and inflectional priming with mature native speakers (e.g., Diependaele et al., 2011; Duñabeitia et al., 2008; Marslen-Wilson et al., 1996; Reid & Marslen-Wilson, 2000; Smolík, 2010). However, we note that our findings are also compatible with those of Feldman et al. (2010), with both their L1 and L2 participants, in that there was a lack of convincing evidence of decomposition of regular morphological form at an abstract level. This was noted by Feldman and colleagues particularly for their lower proficiency learners, which is of some relevance to the current study. However, as native speakers of our small, highly regular, novel word set do not exist, we cannot ascertain the extent to which our findings are compatible with arguments that adult L2 learners rely more heavily on lexical storage and are, thus, not as sensitive to abstract morphological structure as native speakers (e.g., Clahsen et al., 2010). We do argue, however, that the very early stage of learning of our participants may explain why our findings are in contrast to those that have found suffix priming in L2 users (e.g., Diependaele et al., 2011). Indeed, Diependaele et al. (2011, p. 353) suggest that proficiency level may be the reason for discrepancy between their findings and Silva and Clahsen's (2008) results, and they recommend that future research should consider the possibility that lower proficiency may lead to significant processing differences as compared with L1 speakers (p. 356). Diependaele and colleagues also argue that these differences may be "an intermediate state in the transition towards the target" (p. 356). The results from our novel trials in the current study, which suggest some level of representation during visual word recognition, could be one indication of such a transition.

As described earlier, many studies have found that, in a lexical decision task, nonwords bearing pseudoaffixes are rejected more slowly and with more errors than nonwords without affixes. This pseudoaffixation effect is regarded as evidence for a process of affix stripping (Taft & Forster, 1976) or morpho-orthographic decomposition (Rastle & Davis, 2008) that operates during word-form recognition and prior to access of the morphological lexicon. We now consider whether or not the effects we obtain here in the novel trials are evidence of the same kind of process.

Recently, and in a line of work independent from that reported here, Merkx, Rastle, and Davis (2011) reported a study that also looked at morphological learning in an artificial language-learning paradigm using the pseudoaffixation effect as a diagnostic of learning morphological structure. However, unlike the present study, they examined a situation in which novel derivational affixes were added to the native lexicon. For example, in their semantic-learning condition, participants learned that *sailnept* means "the hourly cost of learning how to navigate a yacht" and *sleepnept* means "the hourly cost of sleeping in an airport bed." In the form-learning condition, the words were presented without definitions. There were 16 novel affixes to learn, each presented 96 times in training. Following this, there was a lexical decision task on English words in which the "yes" items were known English words (none of which had occurred as stems in the training phase) and the "no" items were nonwords. Of critical interest was the difference between nonwords that bore an affix that had been learned in the training phase (e.g., *morknept*) and those that did not (e.g., *fishnule*); this was, then, a test of the pseudoaffixation effect. The results showed no pseudoaffixation effects in either the form-learning or semantic-learning conditions when tested immediately after training or after a 2-day delay. However, the effect did emerge in the semantic-learning condition after a delay of 2 months between training and test (with no further training). The authors interpret the pseudoaffixation effect as diagnostic of lexicalization of the affixes and conclude that this requires both semantic support and considerable time (but not necessarily exposure).

Seen in this context, our results seem rather surprising because we observed pseudoaffixation effects immediately after training and even, as shown in Experiment 1, with no semantic support. The main difference between the studies is that Merkx et al. (2011) were looking at integration of novel affixes into the existing English lexicon, whereas we looked at learning of an entirely artificial lexicon. It is not surprising that integration into the existing lexicon requires some time (although, apparently, not large amounts of exposure). Word-learning studies have shown that, after a few exposures to a novel word form such as *cathedruke*, recognition memory can be very good, but it is not until the following day that the new form acts as a competitor to other form-related words such as *cathedral* in recognition tasks (Dumay & Gaskell, 2007). It appears that integration of novel forms into the existing lexicon is dependent on processes of consolidation that occur during certain phases of sleep (see Lindsay & Gaskell, 2010, for a review). These processes involve interactions between hippocampal and neocortical representations and slowly integrate new, rapidly learned information with prior knowledge (McClelland, McNaughton, & O'Reilly, 1995). Although it is rather surprising that Merkx et al. (2011) did not find any effects until two months after exposure, their results are broadly consistent with the idea that integration of new forms into an existing lexicon takes time.

In the present experiments, the participants performed a recognition memory task rather than the lexical decision used by Merkx et al. (2011). Responses would have been made simply by consulting memory traces established during the training phase. During the short time scale investigated here, it seems likely that these memories were episodic in nature, in the sense that they retain information about time, place, and context that distinguish them as part of a particular personally experienced event (i.e., a language experiment). We assume that our pseudoaffixation effects are simply a reflection of the structure of these episodic representations. They do not depend on the integration of episodic information into the preexisting lexicon, and, so, effects can be obtained even with immediate testing. It is important to note, however, that crossmodal priming effects may require integration of orthographic, phonological, and semantic information into a coherent representation, and this may require a period of consolidation (or, for some reason, may never happen in L2 acquisition).

To refer to the representations formed after brief exposure as episodic does not, by any means, diminish their relevance to language learning. We assume that linguistic knowledge can emerge from these representations. By *episodic*, we simply mean that episodic details are represented relatively strongly and can lead to an experience of remembering (Conway, 2009). The essential linguistic content and structure of the representations, however, still form the basis for linguistic development.

Let us now turn to the nature of the learning mechanism that underlies the discovery of sublexical units. Research on the segmentation of continuous speech into potential word units has stressed the role of statistical learning of the distribution of syllables (Saffran, Newport, & Aslin, 1996). For example, people may track the transition probabilities between syllables (Aslin, Saffran, & Newport, 1998), or they may apply general principles of chunking (Perruchet & Vinter, 1998). In the present case, isolation of the affixes would be particularly easy because they occur at the right edge of the words (Endress, Nespor, & Mehler, 2009). Crucially, these learning processes are automatic and unconscious, although they do require attention to form (Toro, Sinnett, & Soto-Faraco, 2005). Given that, in all of our training conditions, participants had to pay attention to form, we would expect these kinds of learning processes to deliver segmentation into potential stems and affixes at the level of orthography and phonology.

Although the different training conditions had little impact on the pseudoaffixation effect, performance on the offline stem and affix generalization tests was clearly affected by the different training tasks in Experiments 2 and 3. As expected, the accuracy for the trained meanings was very high. What is more interesting, however, is that performance on the untrained meanings was also significantly above chance. In Experiment 2, learners' attention was oriented not to the target suffix in training but rather toward the host stem, and, yet, they could generalize the meaning of the suffix at a rate that was above chance. Although the effect was slight, it suggests that, under certain conditions, learners can learn the meaning of a grammatical form at the same time as the meaning of lexical items, even when the comprehension task promotes attention to the lexical item and when the meaning carried by the suffix is communicatively redundant (i.e., the suffix could not be used to distinguish between the two pictures, as its function was constant in both). This refines our understanding of the notion that, in the early stages of learning, learners tend to process lexical items rather than (i.e., in tension with) form (e.g., VanPatten, 1990). Our findings underline that this is a processing tendency rather than a mutually exclusive processing constraint that consistently favors lexical items over grammatical form. Moreover, under these learning conditions, the knowledge of the suffix meanings in our experiment appeared to be largely implicit, as responses made on the basis of guessing and intuition were significantly above chance and were no worse than when participants claimed to be using explicit knowledge.

Conversely, when learners' attention was oriented toward the meanings of the suffixes in Experiment 3, the participants incidentally acquired the meanings of the stems, as shown by the offline generalization test. Responses were predominantly based on guess and intuition, were significantly above chance, and were, again, suggestive of reliance on implicit knowledge. However, veridical explicit knowledge was also present, as shown by the higher accuracy when memory and rule were used. Thus, directing attention to either the stem or the suffix does not preclude learning the meaning associated with the other, although the knowledge tends to be implicit. When we claim that participants acquired implicit knowledge of stem or suffix meanings, we are merely claiming that this knowledge is represented too weakly to surface into consciousness as crystallized knowledge, and not that, in this context, there is any difference in the form of conscious and unconscious knowledge (following a graded notion of consciousness; Cleeremans, 2006). Recall that judgments made on the basis of guessing and intuition were still far from accurate, which indicates that unconscious knowledge exerts a relatively weak influence over judgments in this task.

In sum, our results suggest the beginnings of sublexical representations. The extent to which these correspond to morphological units remains unclear, as we found no evidence of abstract morphological representation at this early stage of learning, at least as assessed by the crossmodal priming paradigm. We suggest, rather, that, regardless of training condition, some associative patterning based on simple, distributional cues occurred. On the basis of our study, we cannot say whether or not this constitutes the initial stages of a nativelike grammar. The evidence in the novel trials could be explained by the participants in all three training conditions having learned that words in this language end in one of three syllables. At the same time, there was evidence from the stem-training condition (i.e., Experiment 2) that participants were able to incidentally learn, at least to some extent, the associations between these sublexical units and meanings, even though their attention was not explicitly drawn by the task to the relevant information. Thus, there is evidence of the early stages of the formation of suffixlike units with associated meanings, but not to the extent of being able to support crossmodal priming. Whether this simply reflects a lack of exposure, a lack of consolidation, or a fundamental limitation on L2 learning remains a matter for further research.

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NOTES

1. Primes are in lowercase letters, and TARGETS (also known as PROBES) are in uppercase letters.

2. The actual stimuli were Spanish nouns.

3. The use of nonwords throughout the study, experienced in a relatively short training phase with a short interval and no sleep between learning and testing, is unlikely to have facilitated full integration into long-term memory (Dumay & Gaskell, 2007). These factors could have contributed to the relatively high error rates compared to experiments using real words.

4. The difference between a guess and an intuition response is a matter of confidence in the decision.

5. The higher error rate in Experiment 2 compared to Experiment 1 may be because the training task in Experiment 1 (i.e., syllable counting) directed attention to the form of the whole word, thus facilitating whole-word recognition, whereas the picture-matching task in Experiment 2 directed attention to only part of the word (see also results for Experiment 3).

6. An ANOVA showed that there was a main effect of experiment on RTs, $F(2, 105) = 13.99$, $p < .001$. Post hoc Scheffe tests showed that the mean RT in Experiment 3 was significantly slower than in Experiments 1 and 2, $p < .001$ in each case.

7. An ANOVA on accuracy showed a borderline significant interaction between experiment and training conditions, $F(3.88, 203.84) = 2.414$, $p = .05$, using the Huynh-Feldt correction. The planned contrasts indicated a significant interaction with experiment for both of the conditions with FAMILIAR SUFFIXES (i.e., those with familiar stem + familiar suffix primes and those with suffix-only primes) when compared to the NOVEL SUFFIX condition, $F(2, 105) = 3.669$, $p = .029$; $F(2, 105) = 3.588$, $p = .031$, respectively. There was no interaction with experiment between the two FAMILIAR SUFFIX conditions (i.e., those with familiar stem + familiar suffix primes and those with suffix-only primes, $F[2, 105] = 0.305$, $p = .738$).

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APPENDIX A

Suffixed stems in the exposure phase and crossmodal priming test (familiar items):

Bojickec
Bojickib
Bojickot
Davicamec
Davicamib
Davicamot
Defec
Defib
Defot
Doyelec
Doyelib
Doyelot
Fasiperec
Fasiperib
Fasiperot
Ficenec
Ficenib
Ficenot
Fumatilec
Fumatilib
Fumatilot
Gatec
Gatib
Gatot
Jeklifugec
Jeklifugib
Jeklifugot
Pelgidec
Pelgidib
Pelgidot
Rujec
Rujib
Rujot
Semec
Semib
Semot
Sifedec
Sifedib
Sifedot
Tulliclopec
Tulliclopib
Tulliclopot
Yabec
Yabib
Yabot

APPENDIX B

Novel stems (with familiar suffixes) in novel trials in the crossmodal priming test:

Jipwemec
Vuxib
Wafsumporec
Sorupot
Bonhiprusib
Yulec
Rupsimib
Beritupot
Gimot
Fegib
Jelimsulot
Wovlifib
Remstepulec
Kaftrupot
Lopec
Dokrusfarib
Lajavec
Fodot

APPENDIX C

Novel stems (with novel suffixes) in novel trials in the crossmodal priming test:

Gocyadig
Wimaslubil
Fikef
Retom
Buvut
Tupglotok
Hifedolep
Sopdriculaj
Tamipus

APPENDIX D

The generalization test:

Suffix items	Stem items
Smafot	Pelgiduj
Drimerot	Davicamut
Trefayalot	Rujog
Werib	Yabef
Rufetib	Faseperov
Julopasib	Bojickol
Bafec	Ficenip
Dufchalec	Doyelam
Frutilorec	Fumatilas
	Semuk
	Tulliclopik
	Gatas
	Jeklifugem
	Defit
	Sifedev