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# It's hard to be *talented*

## What possessional adjectives tell us about lexical representation

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In a visual lexical decision task, recognition is shown in two experiments to be harder for possessional adjectives that look like they are inflected verbs (e.g., *talented*) than for genuine inflected verbs (e.g., *consulted*), especially when the nonword distractors have real-word stems (e.g., *infanted*). Such a result implies that inflected words do not have a form-based whole word representation, but are recognized when functional information associated with their stem and affix is recombined after decomposition. A third experiment goes on to demonstrate that the addition of the verb suffix *-ing* to the noun stem of such pseudo-verb-stem words (i.e., *talenting*) leads to more erroneous classifications as a real word than when the stem is another type of noun (e.g., *infanting*). Moreover, a negative correlation is observed between the accuracy of recognition of the pseudo-verb-stem words and the classification as a nonword of the *-ing* version of their stems. On the basis of these experiments, a model is proposed in which a pseudo-verb-stem word is recognized through a lexical representation of its stem that corresponds to a bound ornative verb and which is different to the representation used to recognize its free-standing noun version.

**Keywords:** affixed word recognition, bound morphemes, inflectional morphology, lexical processing, morphological decomposition

Everything one needs to know about an inflected word can be entirely determined on the basis of the semantic and syntactic function of its stem in combination with the semantic and syntactic function of its affix. For example, the functional information associated with the inflected word *jumped* (i.e., its semantic and syntactic features) is identical to the functional information associated with the verb stem *jump* combined with the notion of completion associated with the suffix *-ed* which is typically used to convey a past tense or past participle. As such, there is no need to store a representation for the whole word

*jumped* in lexical memory for the same reason that regularly inflected words are not included as entries in a dictionary. If this is the case, it means that recognition of *jumped* requires form-based decomposition into *jump* and *-ed* so that the lexical representation for *jump* can be accessed (e.g., Marslen-Wilson & Tyler, 2007; Taft, 2004). The functional information associated with that lexical representation (both semantic and syntactic) would then have to be recombined with the functional information associated with the representation for the suffix *-ed* so that it can be established that the presented word is the past tense or past participial version of the verb *jump*.

Taft (2004) provides empirical evidence for the above account of inflected word recognition by demonstrating that low frequency inflected words with a high frequency stem (e.g., *moons*) are easier to recognize in a visual lexical decision task than a frequency-matched inflected word with a low frequency stem (e.g., *cliffs*), indicating access via the stem. Importantly, though, this stem frequency effect is only observed when the recombination stage is not critical for discriminating the words from the nonword distractors (i.e., when the nonwords have stems with no lexical representation, such as *mofs*). When, in contrast, the nonword distractors have a real word stem (e.g., *muds*), the only way to establish the lexical status of a word item is to thoroughly analyze the combinability of the functional information associated with the stem and affix. The more unusual this combination is relative to the normal use of the stem (e.g., *moons* vs *moon* compared to *cliffs* vs *cliff*), the harder it is to decide that the word exists. Thus, on finding a reverse stem frequency effect when the nonword distractors have real word stems (e.g., *moons* being harder to recognize than *cliffs*), Taft (2004) concludes in favor of a recombination stage for the visual recognition of inflected words.

On the other hand, Crepaldi, Rastle, Coltheart, and Nickels (2010) argue that the reverse stem frequency effect can be explained without the existence of a recombination stage. They suggest that an inflected word actually possesses a representation at the form (i.e., orthographic) level, and it competes for recognition with the representation for its stem after form-based decomposition has taken place. That is, *moon* competes with *moons* and *cliff* competes with *cliffs*, with stronger competition in the former case because of the far higher frequency of the stem relative to the inflected word. However, since such competition builds up over time, it is only when response times are slowed down as a result of the task being difficult (i.e., when the distractors are very word-like, such as *muds*) that the more adverse effect of competition from the high frequency stem relative to the low frequency stem is observed.

Now, if it is the case that the appropriate way to conceptualize the recognition of inflected words is in terms of stem access followed by recombination, as

suggested by Taft (2004), a word should be hard to recognize if it has a suffix that is potentially misleading with regard to its function. For example, the suffix *-ed* overwhelmingly combines with a verb stem to refer to that verb in a completed state, either as its past tense or as its past participle. Occasionally, however, *-ed* can be added to a noun to derive an adjective, such as *talented* (referred to as “possessional” adjectives; see Jespersen, 1954) and this will lead to processing difficulties if there is a function-based recombination stage following decomposition. In particular, the primary function associated with the inflection *-ed* requires the stem to be a verb, which means that the word *talented* cannot be recognized via such a recombination process because *talent* does not exist as a verb. Therefore, such words can only be recognized once their superficial appearance as a verb plus inflection is overridden.

The following research begins by examining whether possessional adjectives such as *talented* that are derived from nouns through the addition of *-ed* (referred to here as “pseudo-verb-stem” words) are harder to recognize than verbs of the same frequency that are genuinely inflected with *-ed* (e.g., *consulted*). Such a result should be observed if inflected words have no form-based whole-word representation and are only recognized at a recombination stage following access to the stem. According to the alternative account of Crepaldi et al. (2010), however, there should be no difference in difficulty between recognizing a pseudo-verb-stem word and a genuine verb-stem word because they both possess a form-based whole-word representation and no function-based recombination is involved. While a pseudo-verb-stem word would suffer competition from activation of its stem representation, this would be equally true for a normally inflected word as long as stem frequency is controlled.

## Experiment 1

The first experiment compares lexical decision responses to pseudo-verb-stem words (e.g., *talented*, *conceited*, *domed*) with those to genuine verb-stem words (e.g., *consulted*, *scheduled*, *limped*) in order to determine whether it is harder to recognize the former than the latter. Such a result would be expected if the pseudo-verb-stem word were decomposed and an attempt made to combine the functional information most strongly associated with the stem and the inflection. That is, the inflection *-ed* typically combines with a verb stem and, therefore, a pseudo-verb-stem item (e.g., *talented*) should prove relatively hard to classify as a real word because its stem is a noun. Moreover, if any difficulty with pseudo-verb-stem words arises from a problem in recombining the stem and affix at the functional level, this should be particularly pronounced when the recombination

stage is required by the experimental conditions, namely, when the ability of the stem to combine with the affix is critical in distinguishing the words from the nonwords. So, when the distractor nonwords have a real-word stem (e.g., *infanted*, *wealthed*), the difficulty in recognizing *talented* relative to *consulted* should be greater than when the mere existence of a real-word stem can be used to distinguish the words from the nonwords (i.e., when the distractors have nonsense stems, such as *sprouled* and *deaved*).

The present experiment therefore compares pseudo-verb-stem words to genuine verb-stem words under two different conditions that vary on the type of nonword distractors used. If there is obligatory decomposition followed by function-based recombination, longer RTs and/or a higher error rate should be observed for the pseudo-verb-stem words than for the genuine verb-stem words, and more so when the nonword distractors have real-word stems than when they have nonsense stems.

## Method

### Materials

The pseudo-verb-stem condition comprised 28 possessional adjectives that were combinations of a noun stem and the suffix *-ed* (e.g., *talented*, *famed*, *hooded*). The genuine verb-stem condition was composed of 28 inflected words that were the combination of a verb stem and the suffix *-ed* (e.g., *consulted*, *scheduled*, *glared*). The stem of many of these words was a noun as well as a verb (e.g., *schedule*), but importantly, there was no doubt that the verb version existed. The two conditions were matched on length ( $\bar{x}=7.25$  letters). They were also closely matched on word frequency (mean per million  $\log=0.24$  and  $0.28$  for the pseudo and genuine verb-stem conditions respectively according to the CELEX norms of Baayen, Piepenbrock, & van Rijn, 1993) and on base frequency (i.e., the cumulative frequency of the stem and its transparent morphological relatives), with  $\log$  values of  $1.14$  and  $1.10$  respectively,  $p$ 's  $> .1$ . A list of the items is presented in the Appendix.

All participants received the same 56 word targets along with a set of 56 nonword distractors all with suffix *-ed*. For one group of participants ( $n=40$ ), the nonwords had stems that were not English words (e.g., *sprouled*, *deaved*, *thoided*), while the nonwords for a second group ( $n=44$ ) had stems that were real words that did not combine with *-ed*, most being nouns and some being adjectives (e.g., *infanted*, *milded*, *carboned*).

## Procedure

Participants were tested individually using the DMDX program (Forster & Forster, 2003). Items were presented in size 20 Arial font and remained on-screen until a response was given, up to a maximum of 4000 ms. All items were presented in a random order with an inter-trial interval of 1000 ms. Participants were instructed to decide as quickly but as accurately as possible whether the letter string was a real English word or not, with responses recorded on a keyboard via keys labeled 'yes' and 'no' respectively. Before the experiment, a total of 12 practice trials were provided, containing targets that were similar to those used in the main experiment.

## Participants

Eighty-four undergraduate students from the University of New South Wales (UNSW) participated in Experiment 1 in exchange for course credit. All were English monolinguals, and were randomly assigned to one of the two nonword conditions (i.e., nonwords with nonsense stems or with real-word stems).

## Results

Average RTs for correct responses and error rates from the two conditions are presented in Table 1. One participant was eliminated from the analysis due to a high number of display errors (arising from response latencies that exceeded the inter-trial interval).

**Table 1.** Adjusted condition means for RT (in ms) based on the final LME model and % error rates (ER) for Experiment 1. Standard errors reported in parentheses

	With nonsense stem distractors (e.g., <i>thoided</i> )		With real-word stem distractors (e.g., <i>infanted</i> )	
	RT	ER	RT	ER
Pseudo-verb-stem (e.g., <i>talented</i> )	697.8 (17.5)	19.4 (3.8)	787.7 (17.3)	29.8 (4.8)
Genuine verb-stem (e.g., <i>consulted</i> )	667.0 (17.3)	9.9 (2.3)	723.9 (17.0)	11.6 (2.4)
<b>Difference</b>	<b>30.8 ms</b>	<b>9.5%</b>	<b>66.71 ms</b>	<b>18.2%</b>

The results were analyzed using linear mixed effects modelling in R, with the package *lme4* (Baayen, Davidson, & Bates, 2008). The fixed effects of interest were the type of target (i.e., pseudo-verb-stem or genuine verb-stem word), type

of distractor (i.e., real-word stem or nonsense-stem nonwords), and the interaction between these two factors. The response times on the previous trial, word length, log word frequency, and log base frequency of the targets were entered into the fixed-effect structure as covariates, and were centered according to their respective means. The covariates were all retained in the final model, apart from word length, as they improved its goodness-of-fit as assessed via a step-wise selection procedure.<sup>1</sup> The random effects included the random intercepts for subjects and items. The effects of subject-related variance on the fixed factors of interest were assessed via by-subject random slopes, but these were omitted from the final model as they did not improve its fit. In the reaction time analyses, inverse RTs were used as the DV (i.e.,  $-1000/\text{RT}$ ) to minimize effects of positive skew in the distribution. Values for  $p$  were obtained by using the R package *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2014). The analyses of error rates (ER) followed the same procedure as the RT analyses (apart from the exclusion of RT on the previous trial as a covariate). ER was entered as a binary variable using the *glmer* function in the *lme4* package, and values for  $p$  were generated using the Wald  $z$  statistics for the fixed factors.

The results showed that when nonwords had nonsense stems (e.g., *sproulded*), the pseudo-verb-stem condition produced longer response times,  $t=2.34$ ,  $p<.05$ , and a greater number of errors,  $z=3.20$ ,  $p<.01$ , than the genuine verb-stem condition. The same pattern emerged when the nonwords had real-word stems (e.g., *infanted*) on both RT,  $t=3.74$ ,  $p<.01$ , and ER,  $z=5.01$ ,  $p<.01$ . In addition to words being harder to recognize when the nonwords had real-words stems than when they had nonsense stems,  $t=5.01$ ,  $p<.01$  for RT, and  $z=4.99$ ,  $p<.01$  for ER, the former type of distractor generated a larger effect of word type than did the latter. This interaction was significant for both RT,<sup>2</sup>  $t=2.01$ ,  $p<.05$ , and ER,  $z=3.42$ ,  $p<.05$ .

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1. Both word frequency and base frequency improved the goodness-of-fit even though they were correlated with each other ( $r=0.62$ ).
  2. Given that slower RTs may lead to larger effects (see, Faust, Balota, Spieler, & Ferraro, 1999), it is possible that the word type effect was greater when the distractors had real-word stems than nonword stems simply because the former were associated with slower RTs. Against this, however, a post-hoc analysis found that the interaction remained significant even when RTs were standardized,  $t=2.19$ ,  $p<.05$ .

## Discussion

It is apparent that derivationally affixed words that appear to be inflected (e.g., *talented*) are harder to recognize than genuinely inflected words (e.g., *consulted*). It is argued that this arises from the fact that decomposition into stem and inflection is obligatory and that an attempt is then made to recombine the functional information associated with each morpheme (see Taft, 2004). The difficulty for pseudo-verb-stem words arises because the functional information does not successfully combine. The fact that *talent*, for example, is established at the functional level to be a noun means that it cannot combine with the function most commonly associated with *-ed*, namely, that the action defined by a verb stem is completed. This account is reinforced by the finding that the difficulty with such pseudo-verb-stem words is significantly greater when more weight must be placed on information at the stage at which functional combination occurs, namely, when the nonword distractors have real-word stems (e.g., *infanted* rather than *sproulded*).

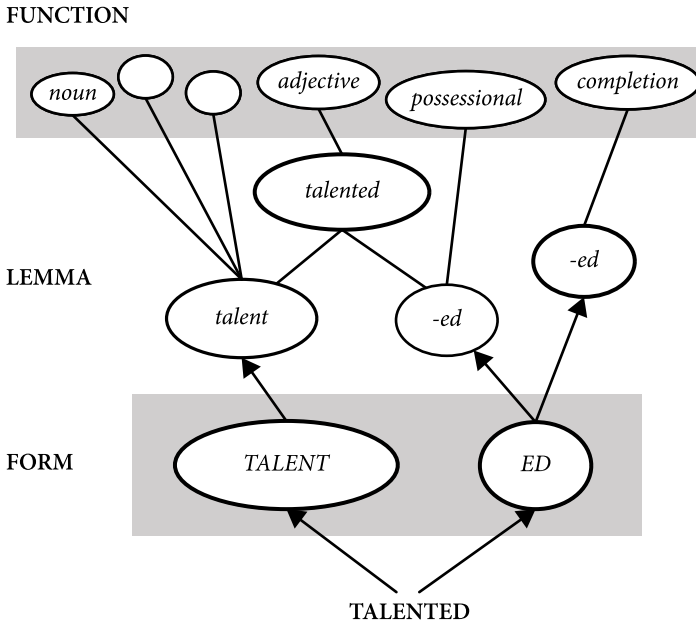
Such a pattern of results is incompatible with the model of inflected word recognition proposed by Crepaldi et al. (2010) where form-based decomposition occurs, but where the inflected word is nonetheless recognized via a whole-word form-based representation rather than through a recombination process. In such an account, there might be competition from the stem of the pseudo-verb-stem word, but that should be equally true for the stem of the genuinely inflected word and, therefore, they should not differ. Both whole-word and stem frequency were matched between the two conditions so any competition should be the same. Moreover, there is no reason for the nature of the nonword distractors to have a differential impact on the competition arising from the stem of each type of word.

If it is the case that difficulties in recognizing a possessional adjective arise from the incompatibility between the information associated with its stem and the most strongly activated function of its suffix, the question can then be raised as to how such a word can be ultimately recognized. That is, how can the lexical status of the word *talented* be differentiated from that of the nonword *infanted*, when both involve an abortive attempt at combining a noun with the verb function of *-ed*?

The most obvious account of this is that there is a whole-word representation for *talented*, but not for *infanted*, and the form-based representation of *-ed* activates more than one function (see Adams, 2014). It is the adjectival function that combines with the noun stem to activate the whole-word representation. This is readily envisaged if we adopt the idea that there are units of representation that mediate between form and function, namely, the “lemma” units that are central to the model of polymorphemic word recognition proposed by Taft (2004, 2015). These are modality-free units that correspond to both free and bound morphemes, as well as to whole polymorphemic words when the meaning of



the whole word is not entirely predictable from the function of its component morphemes. So, while there will be no need for a whole-word lemma when the polymorphemic word is inflected, a derivationally complex word will typically require a lemma in order to provide a link to aspects of its functioning that cannot be entirely captured by a rule-governed combination of the functions associated with the lemmas of its component morphemes (e.g., Taft, 2004, 2006; Taft & Ardisinski, 2006; Taft & Nguyen-Hoan, 2010). According to this idea, the fact that a word like *talented* is a possessional adjective derived from a noun, means that it is represented by a whole-word lemma that is activated via the lemma for *talent* and the lemma for the possessional version of *-ed*. The way in which such a theoretical framework might be envisaged is depicted in Figure 1. The fact that *talented* is a word while *infanted* is not, can be established on the basis of the existence of a whole-word lemma for the former and not for the latter.



**Figure 1.** A framework for processing the pseudo-verb-stem word *talented*, based on Taft (2004)<sup>3</sup>

3. The “form” level refers to the orthographic representation, where stems are stored separately from affixes. The “function” level captures semantic and syntactic information, while the intermediary “lemma” level provides the link between form and function. The existence of a derivationally complex word such as *talented* is represented by a whole-word lemma. The empty circles at the functional level are a neutral way of representing the semantic features associated with the word. The width of ellipse outlines indicates strength of activation.

Note that the whole-word representation depicted here is different to the whole-word representation that is incompatible with the results of Experiment 1. The latter refers to a form-based representation (e.g., Crepaldi et al., 2010, see also Schreuder & Baayen, 1995) which, if it were to exist, should be equally available for pseudo-verb-stem and genuine verb-stem words, and whose access should be unaffected by the focus on functional combinability arising from the inclusion of distractors that have real-word stems. Instead, the whole-word representation in Figure 1 is found at a higher level that is directly associated with functional information. As such, the relative difficulty observed with pseudo-verb-stem words in Experiment 1 can be explained in terms of the competition that occurs between the two different functions of *-ed* as embodied in their two different lemma representations. Since the completion function (captured in the past tense and past participle) is far more common than the possessional function, the lemma corresponding to the former will be more strongly activated than the lemma corresponding to the latter (as depicted in Figure 1 by the width of the lines). So, when it is the latter that is appropriate for access to the whole-word representation (as in the case of *talented*), access will suffer from inter-lemma competition more than when the more common completion function is appropriate (as in the case of *consulted*).

The fact that the existence of distractors with real word stems inflates the difficulty observed with pseudo-verb-stem words relative to genuine verb-stem words can also be explained within this framework. In order to differentiate the words from nonwords with real-word stems, it is necessary to establish whether a whole-word lemma exists or not. This is a judgement that will be affected by how easy it is to access the whole-word lemma, which in turn will be affected by the competition arising from the attempt to establish whether the more strongly activated version of *-ed* can combine with the lemma for the stem. When the nonwords have nonsense stems, participants may not always try to establish the existence of a whole-word lemma because the mere existence of a lemma for the stem should suffice to differentiate the words from the nonwords. The fact that the effect of word type still emerges with distractors that have nonword stems simply indicates that most participants are not prepared to fully rely on such a stem-based strategy.

Before the theoretical interpretation of the results is developed further, however, concerns that can be raised in relation to the materials used in Experiment 1 need addressing. First, some of the items included in the pseudo-verb-stem condition have stems that are actually attested as verbs, even if very rare. For example, *quilt* and *hood* can be found as verbs in an on-line search. While the inclusion of potentially known verbs amongst items that are not meant to be verbs is less than ideal, it is hard to see how this could explain the difficulty in recognizing the pseudo-verb-stem items. The argument would have to be that

the difficulty arises from the verb version of *-ed* strongly competing with the less common possessional version of *-ed* that is most appropriate for words like *quilted* or *hooded*. However, this argument is the explanation already being given for the difficulty in recognizing pseudo-verb-stem words, so it does not constitute an alternative account. In fact, the inclusion of genuine verb-stem words amongst the pseudo-verb-stem items will only serve to dilute any difference between the pseudo-verb-stem and genuine verb-stem conditions and, therefore, does not help explain the difference that was observed between those conditions.

The second issue that can be raised in relation to the materials is the artificiality of the fact that every item in the experiment ended in *-ed*. It might be argued that such a design led to an experiment-specific strategy being adopted whereby the task was one of deciding whether the stem could be combined with *-ed* or not, hence being artificially affected by the functional information associated with *-ed*. In fact, the use of nonword distractors composed of a real word affixed with *-ed* (e.g., *infanted*) was explicitly designed to observe what happens when deciding whether a stem can combine with *-ed* or not. It may be an artificial task, but it provides insight into the use of functional information in recognizing suffixed words. Moreover, it helps establish whether a whole-word representation is available for direct access from the letter-string because, if it is, adopting the combinability strategy would actually be detrimental to performance. That is, if it were possible to discriminate the words from the nonwords purely on the basis of whether or not a lexical representation exists for the whole word, there would be no reason to spend time trying to establish the combinability of the stem with *-ed*. Therefore, the involvement of a stage where consideration is given to the combinability of the stem and suffix indicates that there is no form-based whole-word representation to fall back on.

Despite this counterargument against potential problems in using the same suffix throughout the experiment, a second experiment was nevertheless carried out in an attempt to replicate the difficulty in recognizing pseudo-verb-stem words, but this time with a range of different suffixes being included throughout the materials.

## Experiment 2

Pseudo-verb-stem words were again compared to genuinely inflected words in Experiment 2 with a new, though overlapping set of items. A number of different suffixes, both inflected and derived, were included amongst the word and nonword items, though only *-ed* was used in the pseudo-verb-stem condition. Only one type of nonword distractor was adopted in Experiment 2, namely,

nonwords with real-word stems (e.g., *cabbaged*), because the use of such distractors optimizes the involvement of the functional information required for the recombination of the stem and inflection, as seen in the results of Experiment 1.

## Method

### Materials

The suffix *-ed* was added to 25 nouns to generate a new set of pseudo-verb-stem words of the same type that were tested in Experiment 1 (e.g., *talented*, *toothed*, *principled*). Indeed, 12 of these items were also used in Experiment 1. A new set of 25 genuinely inflected words were also generated, the majority of which were inflected in *-ed* and the others in *-s* or *-ing* (e.g., *murdered*, *roomed*, *achieves*), including two examples of plural nouns (which is why this condition is no longer referred to as “genuine verb-stem” words). The two conditions were matched ( $p$ 's > .1) on number of letters ( $\bar{x}$  = 8.52 and 8.68 for the pseudo-verb-stem and genuinely inflected conditions respectively), word frequency (mean per million  $\log$  = 0.22 and 0.16 respectively), and base frequency (mean per million  $\log$  = 1.33 for both conditions). All items are presented in the Appendix.

In addition to these 50 words largely suffixed in *-ed*, there were 25 filler words inflected with *-ing* (e.g., *elbowing*, *chasing*, *laughing*), 25 inflected with *-s* (e.g., *struggles*, *bridges*, *symbols*), and 25 with derivational suffixes (e.g., *pocketful*, *raider*, *faintly*). The distractor nonwords all had real word stems and consisted of 40 items ending in *-ed* (e.g., *cabbaged*, *miled*, *wealthed*), 25 ending in *-ing* (e.g., *infanting*, *maiding*, *studenting*), 25 ending in *-s* (e.g., *trouts*, *oxygens*, *healths*), and 25 ending in a derivational suffix (e.g., *faultish*, *arguely*, *roader*).

### Procedure

The procedure was identical to that of Experiment 1.

### Participants

The participants were 40 UNSW undergraduate students who had not participated in Experiment 1. They received course credit for their participation.

## Results

The data were analyzed in the same manner as in Experiment 1. Five participants were excluded because of a high number of display errors (>10 such errors), and one item (*moneyed*) was eliminated from the RT analyses because of an error rate of over 80%. Mean response times and error rates are presented in Table 2.

**Table 2.** Adjusted condition means for RT (in ms) based on the final LME model and % error rates (ER) for Experiment 2. Standard errors reported in parentheses

	RT	ER
Pseudo-verb-stem (e.g., <i>talented</i> )	649.4 (12.9)	32.7 (4.8)
Genuinely inflected (e.g., <i>murdered</i> )	630.7 (12.4)	18.1 (3.8)
<b>Difference</b>	<b>18.7 ms</b>	<b>14.6%</b>

The fixed effect of interest was the type of target (i.e., pseudo-verb-stem or genuinely inflected). The covariates that were entered into the fixed effect structure were length, log word frequency, and log base frequency, centered according to their respective means, as well as response time on the previous trial in the RT analysis. All of the covariates were retained in the final model. The random effects included the random intercepts for subjects and items, while by-subject random slopes were omitted from the final model for both RTs and ERs.

The difficulty in recognizing pseudo-verb-stem words (e.g., *talented*) relative to genuinely inflected words (e.g., *murdered*) was highly significant on error rates,  $z=3.19$ ,  $p<.01$ . However, the difference on the RT measure failed to reach significance,  $t=1.43$ ,  $p>.1$ .

## Discussion

The effect observed on the accuracy measure in Experiment 2 replicates the difficulty in recognizing pseudo-verb-stem words that was seen in Experiment 1. However, there are two obvious differences between the results of the two experiments. First, the difficulty in recognizing pseudo-verb-stem words that was observed in Experiment 1 on the RT measure was not significant in Experiment 2, and, second, mean RTs were considerably shorter in Experiment 2 ( $\bar{x}=660$  ms) than in Experiment 1 when the distractors were of the same type, namely, real-word stems ( $\bar{x}=774$  ms). A possible explanation for these differences needs to be given.

One might have expected to have observed the difficulty in recognizing pseudo-verb-stem words on both the speed and accuracy measure in Experiment

2, as was the case in Experiment 1. For example, when *talented* is presented, the completion version of *-ed* will be more strongly activated than the adjectival version, and this will prove incompatible with the lemma for *talent* because it corresponds to a noun rather than a verb. If processing were to cease at this point, an erroneous nonword response would be made. On the other hand, if processing continues until the less frequent version of *-ed* is found to be appropriate, the correct response can be made, but more slowly than for a verb inflected with *-ed*, such as *consulted*, where the lemma for the stem corresponds to a verb, hence being compatible with the more strongly activated completion version of *-ed*.

Importantly, however, this relative difficulty for pseudo-verb-stem words holds when compared to genuinely inflected words like *consulted* whose stem can only be a verb. Responses will be harder for genuinely inflected words when their stem can also be a noun, especially one that is more common than the verb (e.g., *roomed*, whose stem *room* is far more common as a noun than as a verb). It was necessary to draw upon such items in order to match the genuinely inflected words with the pseudo-verb-stem words on both word frequency and base frequency. On the assumption that the verb and noun versions of a word have separate lemmas, it is the verb lemma for *room* that needs to be activated if *roomed* is to be recognized, but there will be strong competition from its higher frequency noun lemma. Therefore, delays and errors can also occur for genuinely inflected words if the stem can be a noun that is more common than its use as a verb. As it happens, Experiment 2 included more cases of this type of *-ed* word than did Experiment 1 (e.g., *roomed*, *jockeyed*, *paraded*, *crewed*, *buttoning*), with 45% of the former having a greater than 80/20 noun/verb ratio (according to Brysbaert, New, & Keuleers, 2012), compared to only 21% of the latter. This discrepancy is reflected in the higher error rate for the genuinely inflected words in Experiment 2 than in Experiment 1, and the smaller difference in RTs between the two conditions. It appears that the difference in accuracy between the two conditions was still consistent enough in Experiment 2 to observe a significant effect, but the higher error rate meant that RTs were based on fewer correct responses, potentially making them a less reliable measure than in Experiment 1. Such an explanation is given credence from a post-hoc LME analysis of the 23 participants in Experiment 2 who made 25% or fewer overall errors, because the difference in mean RTs between the two conditions (22.65 ms) then becomes significant,  $t = 2.22$ ,  $p < .05$ .

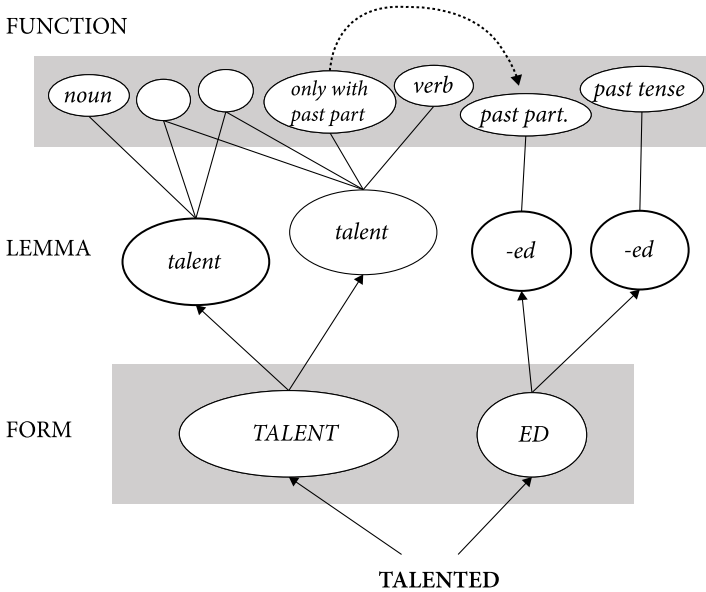
With regard to the faster RTs in Experiment 2 than in Experiment 1 (under the condition where the distractor nonwords had real-word stems), the difference in the variety of suffixes used in the experiments might be a possible cause. In Experiment 1, the fact that every item ended in *-ed* might have led to an automatic focus on the part of the letter-string that varied from item to item, namely, the stem.

However, such a focus on the stem would prevent the participant from being able to discriminate the words from the nonwords given that both had real-word stems and, therefore, it would have been necessary for participants to override this bias in order to determine whether the stem could actually combine with *-ed*. It may have been this added attentional process that slowed down response times relative to Experiment 2 where there was no consistent suffix.

Since it is apparent that Experiment 2 confirms the findings of Experiment 1 with regard to the difficulty in identifying pseudo-verb-stem words relative to genuinely inflected words, we can turn now to a theoretical explanation for how such words are recognized. In the framework depicted in Figure 1, recognition of a pseudo-verb-stem word is impeded by the fact that the verb version of *-ed* competes with the less strongly activated adjectival version of *-ed* and remains a viable option until it is established that the stem is a noun rather than a verb. Consistent with such a position, Adams (2014:p.7) suggests that the contrast between an inflected verb, as in “John was *alarmed*”, and a possessional adjective, as in “the building was *alarmed*”, can be captured by having two versions of *-ed*, one attaching to verbs and one attaching to nouns. However, she also presents an interesting alternative possibility and this is that only a verb version of *-ed* exists and that the putative noun stem of a possessional adjective is actually a verb. That is, the stem of *alarmed* in “the building was *alarmed*” is actually a denominal verb meaning ‘to supply with an alarm’ (i.e., it has an ornative sense), and that the *-ed* takes on the function of a past participle. Such an idea is consistent with the parallels that are pointed out by Hirtle (1970) between the adjectival and past-participial function of *-ed* (see also Hudson, 1975), where a past participle can typically be used as an adjective, as in “the *consulted* doctor” or “a *jumped* page”.

Now, if such an idea were extended to possessional adjectives like *talented*, it would be necessary to postulate the existence of an ornative verb that means ‘to supply/imbue with talent’, which is only ever used in combination with the past participle *-ed*. Such a verb stem would be a bound morpheme because it cannot stand alone as a word without the past participle. Moreover, possessional adjectives would now be seen as being inflected words rather than derivationally suffixed, and this has potential implications for the way in which they are represented in lexical memory. In particular, it has been argued (e.g., Taft, 2004; Taft & Ardasinski, 2006) that an inflected word does not require a whole-word representation because it can be entirely understood by combining the functional information associated with its stem and the functional information associated with its suffix, whereas the meaning of a derived word typically goes beyond the combined meaning of its parts and, hence, requires a whole-word representation to capture the idiosyncratic information. If this is the case, then, there should be no whole-word representation for a possessional adjective at the lemma level,

unlike Figure 1. The way in which the representation of such words might be conceptualized is illustrated in Figure 2, again based on the framework adopted by Taft (2004, 2015).



**Figure 2.** The lemma framework where a lemma unit exists for a version of the stem *talent* that corresponds to a verb and is only ever used in combination with the past participle *-ed*

As seen in the figure, two lemmas exist for the stem of a pseudo-verb-stem word, one corresponding to the primary use of the word as a free-standing noun and the other being used only with the past-participial version of *-ed*. The latter representation is equivalent to that for a bound stem. That is, just as *soapsud* must always be pluralized, the bound version of *talent* must always be combined with the past participle (see Taft & Forster, 1975, and Taft, 1994, for evidence that bound morphemes have a lexical representation). The idea that separate lemmas exist for different functional uses of a word is consistent with the original notion of lemmas put forward in relation to word production (e.g., Levelt, Roelofs, & Meyer, 1999) where a lemma captures the syntactic characteristics of a word.

The bound version of *talent* is associated with semantic features that overlap with those associated with the free version of *talent* (depicted neutrally as empty circles) along with syntactic information that includes grammatical class (i.e., verb) and the fact that it can only be used with a past participle. There are also two lemmas activated via the form unit for *-ed*, each corresponding to a different function that



can modify a verb: past tense and past participle. So, the letter-string *talented* is recognized after form-based decomposition activates two lemmas for the stem *talent* and two lemmas for the inflection *-ed*, with only one combination being acceptable, namely, the past-participial function combined with the verb version of the stem. The fact that there are competing combinations leads to the difficulty in recognizing pseudo-verb-stem words as observed in Experiments 1 and 2.

We see, then, that there are two suggested ways to explain the results of Experiments 1 and 2 where pseudo-verb-stem words are relatively hard to recognize but can nonetheless be recognized as real words most of the time. Either there is a lexical representation for the noun stem specifying that it forms an adjective when combined with the suffix *-ed* (as depicted in Figure 1), or there is a bound version of the stem that corresponds to a verb and can only be combined with the past-participial version of *-ed* (as depicted in Figure 2). Experiment 3 is designed to differentiate these two accounts.

### Experiment 3

If it is actually the case that there is a verb representation for *talent* that must be combined with a past participle in order to generate a real word (i.e., *talented*), then it follows that a nonword that requires consideration of the functional information associated with that verb representation should be harder to classify as a nonword in a lexical decision task than one that does not. For example, in trying to establish whether *talenting* is a word or not, the existence of a verb lemma for *talent* would see an attempt at recombination with the suffix *-ing* which typically attaches to a verb. This being the case, a nonword classification could only be made on the basis of information that specifies that this verb lemma must combine with a past participle (see Figure 2) and never with *-ing* (either as a present participle or as a gerund). Such a process should therefore render responses more difficult than those to a nonword like *liquidating* where only a noun lemma exists for the stem. That is, the existence of a verb version of *talent* might trick the reader into thinking that *talenting* is a word because *-ing* overwhelmingly attaches to a verb stem, whereas such a situation would not arise with *liquidating* because its stem has no verb version.<sup>4</sup> In contrast, if only a noun lemma were to

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4. Very occasionally *-ing* can attach to a noun stem (e.g., *yachting*, *scaffolding*). However, this is a consideration that holds equally for stems like *talent* and *liquid* and is therefore irrelevant when trying to detect the potential existence of a verb lemma for the former. In fact, it could be argued that the stems of *-ing*-suffixed nouns also have a bound version that acts as a verb, which is a possibility also raised by Adams (2014).

exist for *talent*, responses to *talenting* should be no different to any other noun that has *-ing* attached, such as *liquidating*.

Experiment 3 also tests a further prediction that arises from the idea that a pseudo-verb-stem word (e.g., *talented*) is recognized via a verb lemma representing its stem. Specifically, the easier it is to access that lemma, the easier it should be to recognize the pseudo-verb-stem word that is activated through it, but the harder it should be to make a nonword classification when the stem is inappropriately combined with the verbal suffix *-ing* (e.g., *talenting*). So, Experiment 3 uses the same stems that were used in Experiment 2 for the pseudo-verb-stem items to establish whether there is a negative correlation between the responses made in the two experiments.

Note that if a pseudo-verb-stem word were recognized by accessing a whole-word representation through the lemma for its noun stem (as in Figure 1) there would be no reason to expect such a negative correlation. In fact, a positive correlation might even be expected. If a pseudo-verb-stem is recognized through the lemma for its noun stem, the easier it is to access that lemma, the easier it should be to recognize the pseudo-verb-stem word, but also the easier it might be to establish that the functional information associated with that lemma is incompatible with the verbal suffix *-ing*.

## Method

### Materials

Twenty-five nonwords were generated from the noun stems used in the pseudo-verb-stem condition of Experiment 2 combined with the suffix *-ing* (e.g., *talenting*, *toothing*, *principling*). These will be referred to as the “pseudo-ing” condition. The control condition in this experiment, referred to as the “noun-ing” condition, was composed of another 25 nonwords that were also made up of a noun stem and the suffix *-ing*, but these stems could not be combined with the suffix *-ed* (e.g., *infanting*, *maidling*, and *liquidating*, where *infanted*, *maidled*, and *liquidated* are not words).

Because some of the stems of the pseudo-ing items can be found as verbs in an on-line search, it was important to ensure that the noun-ing items had stems that were equally likely to have been encountered as verbs. To establish this, a rating task was carried out on the stems of the pseudo-verb-stem items used in Experiment 2 mixed together with a pool of words that could be potentially used in the noun-ing condition of Experiment 3. These items were all presented with the suffix *-ing* for judgement as to whether they had ever been encountered before. Given that a word to which the suffix *-ing* is added is almost always a verb, these

ratings provide a measure of how often the stems of the pseudo-ing and noun-ing items have been encountered as verbs. The raters were 20 UNSW undergraduate students (none of whom participated in the experiment itself) who were given the following instructions: “For each of the following items, please respond whether you think you have ever come across it being used as a word (Yes or No). In responding, think about a sentence context where you might have previously encountered it as a word”. On the basis of these ratings it was possible to find a set of noun-ing items that were matched with the pseudo-ing items on their estimated frequency of occurrence in the language. The mean number of times the letter-string was adjudged as never having been encountered before was 82.80% for the pseudo-ing condition and 83.40% for the noun-ing condition, a non-significant difference,  $p > .1$ . All items received at least 70% “No” responses.

The two conditions were also closely matched ( $p$ 's  $> .1$ ) on number of letters ( $\bar{x}$ = 8.52 and 8.68 respectively), the cumulative base frequency of their stems (mean per million  $\log$ =1.33 and 1.45 respectively) and, as a measure of word-likeness, the number of words that differed by a single substituted letter (i.e., the “N” measure: 1.00 and 0.56 respectively). All items can be found in the Appendix.

In addition to the 50 nonword items ending in *-ing*, a further 40 nonwords ending in *-ed* were included as fillers (e.g., *cabbaged*, *miled*, *wealthed*) so that not every item ended in the same way. Also included were 80 inflected real words that allowed the lexical decision task to be performed, half of which were suffixed with *-ing* (e.g., *tempting*, *joking*, *elbowing*) and half suffixed in *-ed* (e.g., *mastered*, *hiked*, *colluded*).

## Procedure

The experimental set-up was identical to that of the other experiments.

## Participants

A new group of 42 students from the same population as Experiments 1 and 2 were recruited for Experiment 3, receiving course credit for their participation.

## Results

The data comparing the pseudo-ing or noun-ing conditions were analyzed in the same manner as in the other experiments. One participant was removed from the RT analysis because of error rates greater than 80%. Table 3 presents the mean RTs and error rates.

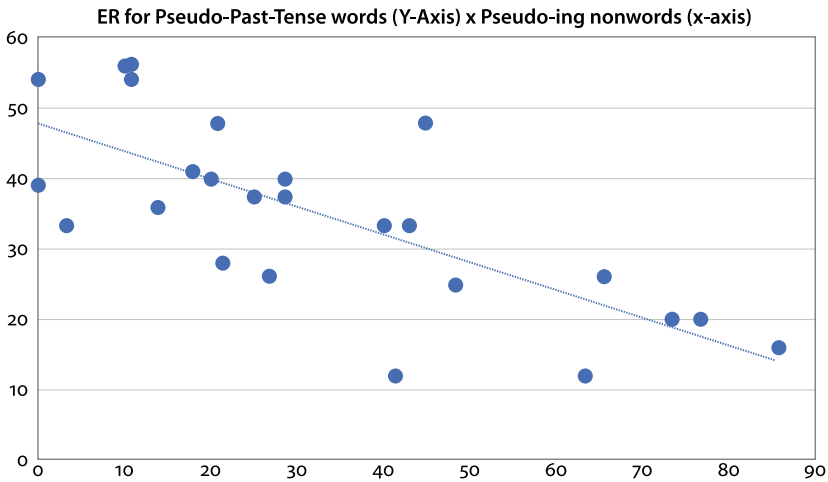
**Table 3.** Adjusted condition means for RT (in ms) based on the final LME model and % error rates (ER) for Experiment 3. Standard errors reported in parentheses

	RT	ER
Pseudo-ing (e.g., <i>talenting</i> )	874.0 (33.2)	34.6 (2.7)
Noun-ing (e.g., <i>infanting</i> )	866.9 (33.3)	29.3 (2.2)
<b>Difference</b>	<b>7.1 ms</b>	<b>5.3%</b>

The fixed effect in this analysis was the type of target (i.e., pseudo-ing or noun-ing). Word length, N, log base frequency, and the proportion of judges who rated the item as being a word were entered into the fixed-effect structure as covariates, and were centered according to their respective means. The response time on the previous trial was also entered into the RT analysis, and retained in the final model along with the first two covariates. The final model for the ER analysis included base frequency and word ratings as covariates. The random effects included the random intercepts for subjects and items, while by-subject random slopes were omitted from the final model for both RTs and ERs.

The accuracy data showed that the items in the pseudo-ing condition (e.g., *talenting*) were harder to classify as nonwords than those in the noun-ing condition (e.g., *infanting*),  $z = 2.10$ ,  $p < .05$ . However, there was no difference on the RT measure,  $t = 0.59$ ,  $p > .1$ .

A correlational analysis was also carried out between the responses to the pseudo-ing items in this experiment and the responses to the pseudo-verb-stem items of Experiment 2 that were generated from the same stems. The correlation between the error rates of the two sets of items was highly significant in a negative direction,  $r(25) = -0.74$ ,  $p < .001$  (see Figure 3 for the scatterplot). The correlation between RTs (without *moneyed* and *moneying*) showed a trend in the same direction,  $r(24) = -0.26$ ,  $p > .1$ , but the error rate was extremely high for a number of the pseudo-ing items which potentially reduced the reliability of their mean RTs. Indeed, when those items for which more than 60% errors were made were excluded, the correlation on the RT measure showed a much stronger trend,  $r(20) = -0.38$ ,  $p < .1$ .



**Figure 3.** Scatterplot showing error rates for the pseudo-verb-stem items of Experiment 2 mapped against the error rates for the pseudo-ing items of Experiment 3 that share the same stem

## Discussion

When the stem of a possessional adjective (e.g., *talented*) is used in combination with the verb inflection *-ing* to create a nonword (e.g., *talenting*), it is harder to make a lexical decision response than when other noun stems are combined with *-ing* (e.g., *liquidizing*), at least in terms of accuracy. Such an outcome suggests that the stem of the possessional adjective is actually represented as a bound ornative verb (see Adams, 2014), as conceptualized in Figure 2. If there were only a noun version of the stem *talent* (as depicted in Figure 1), there would be no reason for a nonword created from that stem by the addition of an inappropriate verb inflection to be treated any differently to a nonword created by adding that verb inflection to any other noun. The apparent existence of a representation for a verb version of *talent* can only be explained if such a representation served some purpose, and the argument being made here is that this purpose is to allow recognition of *talented*.

However, the fact that difficulty with pseudo-ing nonwords relative to noun-ing nonwords was found on error rates and not on correct RTs needs to be addressed. A possible reason for the lack of an RT effect is the potential unreliability of RTs when many errors are made. Because of the apparent difficulty in deciding that a word does not combine with a particular inflectional suffix, the average error rate was as high as 32% in this experiment (comparable to the 35.6% error rate reported by Taft, 2004 for similarly constructed nonwords). However, an interpretation in terms of unreliable RTs can be dismissed on the grounds

that a post-hoc analysis of the 20 participants who had a 25% or lower error rate was still non-significant on RTs, with the direction of the difference between the conditions actually reversing by 7 ms. It appears, then, that when the stem of a pseudo-ing nonword is treated as a verb, a word classification is erroneously made, but there is no delay when this potential mistake is avoided on the basis of specific information that the stem can only combine with a past participle. Why should there be no delay under such circumstances relative to the control noun-ing condition?

A plausible reason that can be given is that the control condition actually requires a similar amount of processing. Just because the stem of the control item (e.g., the *liquid* of *liquid*ing) activates a noun lemma that cannot combine with *-ing*, this does not mean that processing can cease at that point. It is possible that a less frequent verb lemma for the stem does exist (as with, say, *elbowing*, *chairing*, or indeed, *talented*) and it takes time to establish that there is no such representation. Since this is a matter of extra processing and not a matter of misinterpreting the appropriateness of a lemma, there is no reason for an error to be made. The response to a pseudo-ing item will also be delayed by the activation of the noun lemma, but in contrast to the noun-ing item, will successfully activate a verb lemma. Because *-ing* is a verbal inflection, an erroneous “word” response might be made at that point, overlooking the restrictions specified for the use of that lemma. Therefore, the need to determine whether a verb lemma exists in the noun-ing condition eliminates any difference with the pseudo-ing condition in terms of latency, but maintains a difference in terms of accuracy.

The negative correlation between responses to the pseudo-verb-stem words of Experiment 2 and the pseudo-ing nonwords of Experiment 3 can be readily explained within the proposed model in which the possessive adjective is treated as the past participle of an ornative verb and, hence, recognized through the bound lemma for that verb. Specifically, the easier it is to activate that lemma, the easier it will be to recognize the pseudo-verb-stem word through it, but the harder it will be to establish that an inappropriate verbal suffix (i.e., *-ing*) should be rejected. Moreover, the ease of activating the bound verb lemma will be largely determined by the frequency of the possessive adjective, since this would be the only word that makes use of that lemma, and this means that the frequency of the possessive adjective should be positively correlated with the ease of classifying its pseudo-ing version. That is, the higher the frequency of the bound version of the stem, the harder it should be to reject an incorrectly suffixed version of that stem. Such a correlation was indeed observed in Experiment 3 for error rates,  $r(25) = 0.59, p < .01$ , though not significantly so for RTs,  $r(25) = 0.24, p > .1$ .

Note that if both the possessive adjective and the *-ing* nonword created from its stem were processed through the lemma that exists for the free-standing noun

stem (as in Figure 1), there would be no reason for a negative correlation to be found between the items of Experiment 2 and 3. In fact, a positive correlation might have been expected since the easier the access to the noun lemma, the easier it should be not only to combine it with *-ed* to allow the possessive adjective to be recognized, but also to reject its combination with the inappropriate suffix *-ing*. In addition, the ease of rejecting the stem when inappropriately suffixed with *-ing* should be positively correlated with the frequency of all uses of that stem (i.e., its base frequency) rather than the frequency of the possessive adjective alone, since the ease of activating the noun lemma will be determined by the frequency of all words that are accessed through it. Contrary to this prediction, however, the correlation between responses to the pseudo-*ing* nonwords of Experiment 3 and the base frequency of their stems was non-significant on both error rates and RTs, with the former actually being negative if anything,  $r(25) = -0.24$ ,  $p > .1$  and  $r(25) = 0.11$ ,  $p > .1$ , respectively. Therefore, the data are again more in line with an account that includes a lemma for accessing a possessional adjective that is separate from the lemma used for accessing its free-standing noun stem, than an account where a single lemma is used to access both.

## General discussion

Experiments 1 and 2 demonstrated that adjectives derived from nouns by the addition of *-ed* (e.g., *talented*) are harder to recognize than genuinely inflected verbs (e.g., *consulted*). Given that the most common function of *-ed* is to inflect a verb, the finding was interpreted as showing that possessional adjectives are treated as though they have a verb stem. The question can then be asked as to why such an analysis creates difficulties in recognition, and the answer to this lies in the way in which possessional adjectives are actually represented. Two possibilities were proposed.

The most straightforward account is that a whole-word lemma exists for a possessional adjective, and that this is activated via the lemma for its noun stem along with a lemma representing the possessional function of *-ed* (as seen in Figure 1). The relative difficulty in recognizing the pseudo-verb-stem possessional adjectives arises from competition between the inflectional function of *-ed* (i.e., its “completion” function) and its derivational function (i.e., deriving a possessional adjective from its noun stem). However, the results of Experiment 3, opposed such an account. When the stem was falsely used as a verb by adding the suffix *-ing* (e.g., *talenting*), more errors in nonword classification were made than when the stem was a noun that could not be used as a pseudo-verb-stem (e.g., *infanting*). If *talented* were recognized through a noun representation for *talent*,

there would have been no reason for its *-ing* version to be mistakenly accepted as a word more often than any other noun suffixed with *-ing*. Moreover, there would have been no reason for the observed negative correlation between lexical decision responses to the pseudo-verb-stem words tested in Experiment 2 and the *-ing* suffixed nonwords tested in Experiment 3 created from the same stems.

The data from all three experiments are instead consistent with the alternative, linguistically more interesting account, namely, where the possessional adjective is treated as the past participle of a bound verb that has been ornatively generated from its noun stem and is represented separately from it (see Figure 2). The difficulty in recognizing the pseudo-verb-stem possessional adjectives arises from competition between the two activated lemmas (i.e., noun and verb) that is resolved by assessing the functional information associated with those lemmas to determine that it is the less frequently used verb lemma that is the appropriate one. The increased difficulty in recognizing pseudo-verb-stem words that was shown in Experiment 1 when the nonword distractors had real word stems (e.g., *infanted*) compared to nonsense stems (e.g., *sproulded*), is explained in terms of the former always having to go beyond the stage where it is merely established that a lemma for the stem exists, hence necessarily engaging the full function-based processes required to establish that the activated lemma is appropriate.

In relation to Experiment 3, the fact that the bound lemma corresponds to a verb will make its inappropriate combination with the verbal suffix *-ing* more word-like than when a noun that has no bound version is combined with *-ing*. In this way, pseudo-*ing* nonwords (e.g., *talenting*) will be harder to reject than noun-*ing* nonwords (e.g., *infanting*), as was demonstrated. Importantly, the negative correlation between responses to the pseudo-verb-stem words of Experiment 2 and the pseudo-*ing* nonwords of Experiment 3 can be readily explained because the easier it is to activate the bound lemma, the easier it will be to recognize the pseudo-verb-stem word through that lemma, but the harder it will be to establish that an inappropriate verbal suffix (i.e., *-ing*) should be rejected.

The proposed account is described in terms of lemmas being associated with different grammatical categories, along with functional information that defines the syntactic combinability of particular suffixes with particular stems. A problem with such an account, however, is that readers do not appear to be sensitive to the grammatical category of a stem when it comes to combining it with an affix, at least in the case of derivational affixes. This is seen in a study by Burani, Dovetto, Spuntarelli, and Thornton (1999) using Italian materials, where the difficulty in classifying an inappropriately suffixed stem as a nonword was unaffected by the grammatical compatibility of the stem and suffix. To give an English example, the nonword *infantment* would be just as hard to classify as a nonword as would *infantful*, even though the suffix *-ment* only ever combines with a verb while *-ful* readily combines with a noun (which is what the stem *infant* is). Longtin and



Meunier (2005), using French materials, also report that the grammatical acceptability of an incorrect combination of a stem with a derivational suffix has no impact on the ability of that nonword to prime lexical decision responses to its stem. Such findings raise the possibility that grammatical category is not actually stored in lexical memory and, therefore, is not a factor when a reader is considering the combinability of a stem with a suffix.

The alternative to the lexical storage of grammatical category is that conceptual rather than syntactic information is taken into consideration when establishing how the morphemes of a sentence combine together. Vigliocco, Vinson, Druks, Barber, and Cappa (2011) summarize research that favors this possibility. According to such a perspective, it is whether the meaning of the word refers to such things as a short-term action or a long-term state that determines whether it corresponds to a verb or a noun respectively. That is, according to this account, the framework depicted in Figure 2 should not include grammatical class amongst the functional information associated with the lemma for a stem, but rather it is semantic information that helps to establish whether a stem can take a particular suffix or not. Such a modification would not change the essential features of that framework, namely, that possessive adjectives are treated as inflected verbs and that they are recognized after decomposition followed by recombination at the functional level.

## Concluding remarks

The way in which polymorphemic words are represented and retrieved from lexical memory is still an open question (see e.g., Taft, 2015). The present research focuses on a special type of word, possessional adjectives, and draws conclusions not only about how such words in particular might be represented in lexical memory, but also about the way in which the system might be conceptualized more broadly. The results support the idea that possessional adjectives are treated as verbs inflected with the past participle, and that the lexically stored representation for that verb is only ever used in that capacity. More broadly, the results support the position that affixed words, or at least inflected words, do not have a form-based whole-word representation. Such whole-word representations are found in dual-pathway models in which whole-word access is conducted alongside decomposition (e.g., Bertram, Schreuder, & Baayen, 2000; Diependaele, Morris, Serota, Bertrand, & Grainger, 2013; Schreuder & Baayen, 1995), and even in models that incorporate obligatory decomposition (e.g., Crepaldi et al., 2010). If affixed words did have a form-based whole-word representation, there would be no reason for pseudo-verb-stem words to be treated any differently to genuine verb-stem words because both types of word would be successfully recognized

through that representation. However, not only are the former harder to recognize than the latter, but this is particularly the case when detailed consideration needs to be given to the way in which the stem combines with the suffix (i.e., in order to discriminate the real words from the nonword distractors). Such a recombination stage should never be called upon if the words could be discriminated from the nonwords purely on the basis of whether a form-based whole-word representation existed or not.

The theoretical model used to conceptualize how possessional adjectives might be represented in lexical memory adopts a framework that is concrete in the sense that it incorporates explicit representations of the units that are involved in lexical processing. Such a “lexicon-based” approach contrasts with recent theoretical frameworks that center upon mathematical models that capture the relationship between orthographic input and semantic output, with the putative morphological structure emerging from this without any explicit representation. The most notable of these “amorphous learning” accounts is the Naïve-Discrimination Learning (NDL) model proposed by Baayen Milin, Filipovic Durdevic, Hendrix, and Marelli (2011) where the input takes the form of simple grapheme combinations which, over a series of learning events, develop an association with meaning based not only on the frequency of their co-occurrence, but also on the number of other meanings associated with those grapheme combinations.

The NDL model could potentially explain the difficulty in recognizing possessional adjectives in terms of the fact that the ending, *-ed*, is not being associated with its usual function. However, the model also needs to provide an explanation for the finding that the difficulty with such words increases when the nonword distractors have real-word stems, and also that responses to such words correlate negatively with nonword classifications when the *-ed* is replaced by *-ing*. While it is conceivable that the NDL model would be able accommodate such results, they are certainly not issues that would be considered were it not for experiments of the type reported here that only emerge from a consideration of the nature of lexical representations. With lemmas providing a localist representation of the relationship between form and function, the lexicon-based framework might be seen as a way of modeling a system that develops along the same lines as NDL, but one which describes what is in the “black box”, hence being explicit enough to allow a clearer understanding of the way in which polymorphemic words might be recognized. So, rather than treating morphological processing merely as a topic to which the principles of mathematics can be applied, the approach favored here makes it easier to envisage the nature of lexical representation, hence firmly maintaining the study of morphological processing within the domain of research into language use and the mental lexicon.

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## Appendix

The following are the words used in Experiment 1.

- Pseudo-verb-stem:     anguished, barbed, beaked, bearded, bigoted, conceited, cultured, diseased, domed, fabled, famed, freckled, frenzied, gloved, gowned, helmeted, hooded, mannered, mustached, plumed, privileged, quilted, renowned, salaried, skilled, talented, tiered, wretched
- Genuine verb-stem:   boasted, cascaded, churned, clanged, coached, colluded, consulted, coughed, crawled, drilled, explored, galloped, gauged, glanced, glared, harmed, hiked, limped, marveled, mastered, relished, rioted, scheduled, snared, sneezed, struggled, swaggered, trudged

The following are the words used in Experiment 2.

- Pseudo-verb-stem:   armoured, barbed, bearded, columned, diseased, domed, fated, freckled, frenzied, furred, helmeted, hooded, horned, mannered, moneyed, orphaned, principled, privileged, propertied, renowned, salaried, talented, toothed, whiskered, wooded

Genuinely inflected: absences, achieves, analysed, avoids, buttoning, cautioning, coughed, crewed, diagnosed, dynamited, fetched, gossiping, harmed, jockeyed, laced, murdered, negotiating, paraded, perks, roomed, sketched, sniffled, strangled, sweated, yells

The following are the nonwords used in Experiment 3.

Pseudo-ing: armouring, barbing, bearding, columning, diseasing, doming, fating, freckling, frenzying, furring, helmeting, hooding, horning, manning, moneying, orphaning, principling, privileging, propertying, renowning, salarying, talenting, tooothing, whiskering, wooding

Noun: arcading, aunting, choiring, crystallizing, deathing, duning, dusking, eventing, foddering, gianting, infanting, iteming, liquidating, maiding, memorying, merchanting, meteoring, methoding, partridging, pluralling, porching, studenting, surgeoning, swording, verdicting

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