The dislike of regular plurals in compounds

Phonological familiarity or morphological constraint?*

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English speakers disfavor compounds containing regular plurals compared to irregular ones. Haskell, MacDonald and Seidenberg (2003) attribute this phenomenon to the rarity of compounds containing words with the phonological properties of regular plurals. Five experiments test this proposal. Experiment 1 demonstrated that novel regular plurals (e.g., *loonks-eater*) are disliked in compounds compared to irregular plurals with illicit (hence *less* frequent) phonological patterns (e.g., *leevk-eater*, plural of *loovk*). Experiments 2–3 found that people show no dispreference for compounds containing nouns that merely sound like regular plurals (*e.g.*, *hose-installer* vs. *pipe-installer*). Experiments 4–5 showed a robust effect of morphological regularity when phonological familiarity was controlled: Compounds containing regular plural nonwords (e.g., *gleeks-hunter*, plural of *gleek*) were disfavored relative to irregular, phonologically-identical, plurals (e.g., *breex-container*, plural of *broox*). The dispreference for regular plurals inside compounds thus hinges on the morphological distinction between irregular and regular forms and it is irreducible to phonological familiarity.

Keywords: compound, inflection, morphology, phonology

In explaining patterns of language, it is virtually impossible to avoid couching generalizations in terms of grammatical categories such as noun, verb, adjective, phrase, clause, word, root, stem, and suffix. Virtually all theories of grammar invoke productive combinatorial rules that manipulate variables or symbols for such categories (e.g., Chomsky, 1980; Prince & Smolensky, 1993/2004). In contrast, connectionist models have tried to account for certain phenomena of language by associating sounds, meaning elements, or both according to their statistics in the language, with no representations of grammatical categories (e.g., Rumelhart & McClelland, 1986).

The Mental Lexicon 2:2 (2007), **129–181**.

Inflectional morphology has been a key case study in this debate. Many languages distinguish between regular (e.g., *rat–rats*) and irregular (e.g., *mouse–mice*) inflection. The words-and-rules theory (Pinker, 1999), a psychological implementation of symbol-manipulating theories of grammar, attributes the difference to the distinction between the grammar and the lexicon. Regular inflection is generated by a mental operation that combines grammatical variables productively (informally, a "rule"), in this case, a stem and a suffix ($[rat]_{N}$ + $[\text{-}s]_{PLURAL} \rightarrow [[rat]_{N}[\text{-}s]_{PLURAL}]_{N}$). Irregular inflection consists of storing and retrieving lexical items directly (e.g., *mice* stored as the plural of *mouse*). Connectionist accounts of inflection, in contrast (e.g., Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Rumelhart & McClelland, 1986) eliminate grammatical operations over variables and generate both regular and irregular inflection by associating the phonological features of a stem with the phonological features of the inflected form.

The debate concerning the computation of regular forms has been informed by behavioral and neurological dissociations between regular and irregular inflection (for recent reviews, see McClelland & Patterson, 2002; Pinker & Ullman, 2002a, 2002b). One such dissociation is observed in compounding. Most noun-noun compounds in English append the base form of a noun to some other noun, as in *birdwatcher* and *love song*. The final noun or head (e.g., *song*), identifies the referent of the compound; the initial noun or nonhead (e.g., *love*), serves as a kind of modifier or argument of the head. Even when the referent of the nonhead is semantically interpreted as plural, the base form of the noun (homophonous with the singular) is preferred. As Pinker (1999) puts it, "we speak of *anteaters*, *birdwatchers*, *Beatle records*, *Yankee fans*, *two-pound bags*, *three-week vacations*, and *all-season tires*, even though it's ants that are eaten, birds that are watched, all four Beatles that played on Sgt. Pepper's and the white album, and so on" (p. 178). Interestingly, the reluctance to use plural nonheads is not manifested by irregulars, as we see in contrasts like *mice-infested* (cf. **rats-infested*), *teethmarks* (cf. **claws-marks*), and *men-bashing* (cf. **guys-bashing*).

The reluctance to use regular plurals in standard word-word compounds (as opposed to phrase-word compounds, a distinct kind we will consider later) manifests itself in several kinds of data. Compounds containing regular plurals are far less frequent than ones containing irregular plurals (Haskell, MacDonald, & Seidenberg, 2003) and are judged as less acceptable both by linguists (Kiparsky, 1982) and by adult experimental subjects (Senghas, Kim, & Pinker, 2007; Senghas, Kim, Pinker, & Collins, 1991). The distinction between the acceptability of regular and irregular plurals in compounds manifests itself early in development (Alegre & Gordon, 1996; Clahsen, Rothweiler, Woest, & Marcus, 1992; Gordon, 1985). Interestingly, compounds containing plurals of either kind are so rare that young children are unlikely to have heard them. The fact that such children nonetheless admit only irregular plurals into experimentally elicited compounds led Gordon (1985) to suggest that whatever aspect of the language system that gives rise to the interaction between regularity and compounding may be innate.[1] This suggestion is supported by the recent report that children with grammatical specific language impairment, which probably has a genetic cause, fail to respect the distinction (van der Lely & Christian, 2000). Whether the dislike of regular plurals in compounds is, in fact, innate remains to be seen. Our interest here is in whether the dislike of compounds like *rats-eater* is due to a constraint against regular plurals in compounds — an issue that is logically distinct from questions concerning the origins of that constraint.

According to the words-and-rules theory, the difference between regular and irregular plurals inside compounds is significant because it exemplifies a qualitative difference between the psychological processes that generate regular and irregular forms. Word-word compounds exclude plurals that are generated as complex inflected words by the grammar, but admit plurals that are stored in the lexicon as simple roots or stems. According to the original theory that attempted to account for the phenomenon (Kiparsky, 1982), words are generated by three ordered components or "levels" of rules. The first level includes rules of derivational morphology that effect changes in stem phonology, including irregular patterns. The second includes rules of regular derivational morphology and compounding. The third includes rules of regular inflectional morphology. Irregulars can appear in compounds because they are generated at Level 1, which can feed the compounding rule in Level 2; regulars cannot, because they are generated at Level 3, too late to be fed into the compounding rule.

Level-ordering theory has been shown to have certain technical and empirical difficulties (Kenstowicz, 1994; Selkirk, 1982; Spencer, 1991), and today most linguists opt for a simpler alternative in which irregular and regular forms are categorized as different types of morphological objects (Pinker, 1999; Selkirk, 1982; Spencer, 1991;Williams, 1981; see also Kiparsky, 2004, for a revision of level-ordering theory that incorporates distinctions among lexical strata in optimality-theoretic framework). Irregulars are generally "roots," that is, basic sound-meaning pairings that are not composed productively out of simpler meaningful elements (more precisely, they are categorized as X^{-2} forms in the hierarchy of words and phrases delineated by X-bar theory, for review, see Borer, 1998). Regular forms, in contrast, are "words": fully derived and inflected forms ready for insertion into syntactic phrases. (In X-bar notation, they are represented by the X^0 category.) Rules of derivation and compounding impose selection restrictions on the kinds of word forms they may combine (Aronoff, 1976; Fabb, 1988). The main noun compounding rule in English, in particular, combines roots (X^{-2} forms) or stems (that is, bare uninflected words, or X^{-1} forms) but not full words (X^0). As a consequence, they can combine an irregular plural, but not a regular plural, with a head noun. This theory avoids most of the problems of the original level-ordering theory while maintaining a distinction among kinds of morphological forms which encompasses the regular-irregular distinction.

The basic idea that the language system respects morphological distinctions has been recently challenged by Haskell et al. (2003) based on an alternative analysis of the interaction between compounding and regularity. Haskell et al. argue that the constraint on compounding does not in fact depend on regularity or any other morphological distinction but only on the statistical properties of modifier-noun combinations in the input to the speaker (Haskell et al. refer to nonheads as "modifiers"). In particular, speakers learn at least two statistical contingencies. One is based on semantics, namely that modifiers rarely specify multiple entities. The other is based on phonology, namely that modifiers rarely have "the phonological structure typical of a regular plural" (p. 12). These and other conditions combine monotonically and their sum determines the acceptability of a compound in graded fashion.

In support of the semantic condition, Haskell et al. (2003) show that, regardless of whether a nonhead is regular or irregular, speakers prefer the singular to the plural form (that is, *mouse-eater* is rated as sounding better than *mice-eater*, and *rat-eater* is rated better than *rats-eater*). This effect, all sides agree, falls out of an interaction between the semantics of compounding and the semantics of bare nouns. Compounds tend to refer to kinds, not individuals: a *cat-lover* loves not one cat but cats in general. The base form of English nouns are not so much singular, referring to one individual, as unmarked for number, referring to the kind denoted by the noun (Berent, Pinker, Tzelgov, Bibi, & Goldfarb, 2005; di Sciullo & Williams, 1987). As a result, in most cases the base form of the noun is more semantically appropriate in the compound.

This main effect of number, however, cannot account for the *interaction* between number and regularity: When a plural *is* used in a compound, an irregular sounds far better than a regular (though this is not true for compounds containing the singular versions). The interaction was confirmed in the ratings gathered by Senghas et al. (1991, 2007) and by Haskell et al. (2003). Haskell et al. therefore must explain the problem with regular plural nonheads in terms of the rarity of nonheads with the phonological properties of regular plurals. Haskell et al. show that, in large corpora, prenominal adjectives in noun phrases rarely sound like regular plurals.[2] This could lead children to generalize that "modifiers" (which Haskell et al. use to refer interchangeably to prenominal adjectives and to nonheads in compounds) cannot sound like regular plurals, i.e., with a final *-s*, *-z*, or *-ez*, depending on the preceding segment of the stem.

To show that these phonological statistics affect speakers' judgments, Haskell et al. (2003) present two findings. The first is that pluralia tantum nouns (e.g., *trousers*) are rated as less acceptable in compounds than singular controls (e.g., *jacket*). Since many grammatical theories (e.g., Kiparsky, 1982) analyze these as stored irregular plurals (because *trousers* is not a plural of *trouser*), yet speakers still dislike them, the speakers must have been turned off by their regular-sounding phonology. Haskell et al. therefore conclude that it is phonology, not regularity, that taints a compound. The second finding, also found independently by Senghas et al. (1991, 2007) is that a class of irregular plurals ending in fricatives such as *loaf-loaves* and *thief-thieves* are disfavored in compounds (such as *loaves-basket*), just like fully regular plurals. Once again, the forms are irregular yet sound like regulars, suggesting to Haskell et al. that regular-sounding phonology, not regularity itself, is the cause of the unacceptability of regular-containing compounds.

Both phenomena, however, have alternative explanations. Because pluralia tantum nouns are grammatically plural and contain the regular plural suffix, people may analyze these nouns as having the morphological structure of regular plurals (albeit not ones that are composed productively by adding a suffix to a free-standing singular stem). Indeed Bock, Eberhard, Cutting, Meyer, and Schriefers (2001), studying the speech error in which people make a verb agree in number with a nearby noun rather than the subject (e.g., *The advertisement for the razors were…*), showed that pluralia tantum nouns that are close to a verb induce such errors (e.g., *The advertisement for the scissors were…*) more often than do singular nouns (e.g., *The advertisement for the razor were…*). This suggests that despite their lack of a singular base, pluralia tantum nouns (e.g., *scissors*) may be represented as plurals, and hence may sometimes be given the structure of regularly inflected plurals (e.g., $[[\text{scissor}]_N\ [\text{s}]_{\text{plural}}]_N$). It is conceivable that the availability of this representation might vary, depending on task demands, semantic properties of specific nouns, and individual differences. For instance, morphological decomposition could be preempted by activating nouns that match the pseudo-stem (e.g., the activation of *blue*, identical to the pseudo-stem of *blues*). This might account for the intermediate acceptability of such nonheads in off-line tasks (which allow for full lexical activation) relative to productive regular plurals. Nonetheless, the speech error data clearly demonstrate that pluralia-tantum nouns are sometimes represented as morphologically plural. Accordingly, the unacceptability of such nouns in plural might well be due to their representation as morphologically plural, rather than their phonological frequency.

The lowered acceptability of regressive voicing plurals (e.g., *loaves*) may have a similar cause. Senghas et al. (1999, 2007; see also Pinker, 1999, p. 53), who first reported this effect, note that it has a simple explanation. Lieber (1980) argued that such plurals are composed of an irregular bound stem *thieve-* which is then subject to the regular pluralization process (This is consistent with the analysis of irregularity in Berent, Pinker, & Shimron, 2002, in which complex words are not classified as "regular" or "irregular" in their entirety, but rather may contain an irregularly listed component in the presence of other modifications that are regular. Specifically, they found that regularly-suffixed Hebrew nouns that undergo phonological changes to the stem exhibit several psychological hallmarks of regular plurals). Since these forms are analyzed as having the structure of regular forms (X^0), they are not allowed into compounds. Moreover there is some independent evidence for Lieber's theory. These bound stems, as predicted, can be found in other derived forms, both standard forms in the dictionary — *to calve*, *to house*, *to interleave*, *short-lived* (pronounced [laIvd]), *to sheave*, *to shelve*, *to thieve*, *thievery* — and in sporadic productive usages, as in (1):

(1) Any "Life" of Samuel Johnson — the most be-Lived of writers … — must begin where any book does: with the title page.

An Introduction to Elvish (book title on J. R. Tolkien's fictitious elf language)

Make like a tree and leave!

Jane Fonda, 54, told the *Chronicle* that "… the few things I regret in my life are … not having put enough time into mothering, wiving, taking care of the inner life."

Because *thieves* may be a product of regular inflection, not just any noun that sounds like a regular, the unacceptability of *thieves-hangout* does not demonstrate the speakers are sensitive to phonology rather than morphology.

While there is no strong evidence that the constraint on regular plurals in compounds is due to their rare phonology, there is substantial evidence against it. In particular, there are numerous compounds with singular nonheads that sound just like regular plurals but which are perfectly acceptable: *rose garden*, *praiseworthy*, *prize-fight*, *breezeway*, *schmooze-fest*, *Ray Charles record*, *Mars probe*, *box-cutter*, *axe-murderer*, *Katz paper*, *Burl Ives concert*, *Ask-Jeeves user*, *foxhole*, *sex-manual*, *six-gallon jar*, *apocalypse novel*, *corpse counting*, *eclipse warning*, *ellipse formula*, *synapse recording*. Not only is there nothing unnatural-sounding about these compounds (as we will confirm in Experiments 2 and 3), but unlike compounds referring to multiple entities (i.e., the referents of regular plurals), they show no tendency to lose their final *-s* or *-z*: compare *Beatle records* with **Ray Charle records*, *bird-watcher* with **fokhole*.

To work around this problem, one might appeal to some nonlinear interaction between the phonological and semantic factors, so that only if a word is semantically plural does the regular-sounding phonology come into play. But this option is not compatible with Haskell et al.'s hypothesis. They stress that the graded nature of the constraints gives rise to a continuum of judgments of compounds depending on how many "strikes against them" the various conditions exact. The fact that they count as evidence for their theory a pure semantic effect of plurality, independent of phonology (namely, that singulars are preferred in compounds to plurals) shows that each constraint is claimed to exert an independent effect. The lack of such an effect for singulars with regular-sounding phonology (as can be perceived in these examples, and as we shall demonstrate in Experiments 2 and 3) is therefore problematic. Nonetheless, in Experiments 4–5 we will explicitly test the possibility that a nonlinear interaction between phonology and semantics is responsible for the effects of irregularity.

Another option for Haskell et al. is to state the condition so that it applies not to unanalyzed phonological strings but to strings as juxtaposed with their singular forms. What is held to be rare in compounds would not be words that end in *-s* or *-z* but words with such endings that "preserve and incorporate a singular form" (Haskell et al., 2003, p. 17). This suggestion, however, contradicts their earlier claim that mere "phonological similarity to regular plurals" is the effective cue. Moreover it represents an abandonment of the key claim of the theory. A representation of a plural that distinguishes the suffix from the stem and that identifies the stem as being a distinct singular noun is simply a morphological representation (e.g., $[[\text{dog}]_N\ [\text{s}]_{\text{plural}}]_N$), and the avoidance of morphological representations and exclusive reliance on phonological and semantic ones is Haskell et al.'s central hypothesis. That, for instance, is why they tally the phonological features of adjectives (which are not even nouns, and have no trace of a singular noun inside them) as being relevant to speakers' perception of the acceptability of plural nouns inside compounds. In any case, the distinction between forms that contain the base and those that are not is unlikely to cause the dislike for regular plurals in compounds. German speakers dislike regular nonheads in compounds despite the fact that both regular and irregular plurals include the singular base (e.g., Clahsen et al., 1992). A similar effect occurs in English examples such as *oxen power*, which is acceptable (see Pinker, 1999, p. 179, for a citation) despite containing the singular *ox*, and *dice-thrower*, which is acceptable despite containing the singular *die*.

In the following experiments, we provide new empirical tests which directly dissociate the effects of phonological familiarity and morphological regularity. Experiment 1 systematically manipulates the phonological familiarity and regularity of the nonhead, and shows that regularity has a robust effect on judgments of plurals which cannot be reduced to phonological familiarity and indeed does not even interact with that factor. Experiments 2–5 assess the effect of regularity for nonheads that sound like regular plurals. These findings show that phonological unfamiliarity in general, and the phonological properties of regular plurals in particular, do not taint the acceptability of compounds. Conversely, the morphological regularity of the nonhead does taint the acceptability of compounds when phonological familiarity and plural semantics is controlled.

Experiment 1: Compounds with Unattested Consonant Clusters

The phonological familiarity hypothesis, proposed by Haskell et al. (2003) predicts that the acceptability of nonhead plurals in compounds should depend on the frequency of their phonological properties in compounds, in particular, the frequency of *-s* and *-z*-final forms, not their regularity (regularity being a relation defined with respect to a morphological rule). However, the evidence presented by Haskell and colleagues to support this hypothesis invariably confounds the phonological structure of the nonehad with its morphological regularity.

To separate the effects of phonological familiarity of nonheads from the morphological representation of nonheads (which are ordinarily confounded in English), one must examine whether *other* phonological patterns that are unfamiliar[3] are disfavored, since there is no reason that the effect of phonological familiarity should be confined to nonheads that are regular or regular-sounding. The following experiment tests this prediction by contrasting the effect of phonological familiarity with morphological regularity.

To manipulate phonological frequency, we constructed novel nouns containing clusters that are either legal, hence relatively frequent in the language and in compounds (e.g., *loonk*) or nouns with clusters that are illegal and hence rare (e.g., *loovk*). For each noun, we next formed a regular plural (*loonks*, *loovks*) and an irregular plural (*leenk*, *leevk*, following the pattern found in *foot–feet*, *goose–geese*, and *tooth–teeth*; see Table 1).

Table 1. An illustration of the target words used in Experiment 1

	ILLEGAL		LEGAL	
	Singular	**Plural**	**Singular**	**Plural**
Irregular	*loovk*	*leevk*	*loonk*	*leenk*
Regular	*loovk*	*loovks*	*loonk*	*loonks*

Each of these four plurals was incorporated in a brief context story followed by an elicitation of acceptability ratings for plural and singular versions of the noun in a compound, as in (2) (blank lines represent page breaks in the presentation of the story to participants).

(2) The *loovk* is a new diet pill that works miracles.

Two *loovks* a day can make you lose up to ten pounds. An overdose of the pill can be quite dangerous, however.

One patient has recently died after taking five ____.

The first signs of an overdose include an intense headache, nausea, and a rash that appear soon after three or more pills are taken.
Doctors recognize these ailments as the **loovk-disease**. ______
Doctors recognize these ailments as the **loovks-disease**. ______

The phonological (connectionist) and morphological (words-and-rules) theories make opposite predictions with respect to the acceptability of these plurals in compounds. The phonological account predicts that the acceptability of the plural nonhead should depend on its phonological familiarity, especially its familiarity in compounds, regardless of its morphological status. Speakers never hear compounds like *leevk-eater* (since *leevk* contains an illicit consonant cluster), but they sometimes hear compounds like *loonks-eater* (since it overlaps phonologically with *box-cutter*, *tax-exempt*, *politics-ridden*, and so on).[4] If, as Haskell et al. (2003) predict, speakers' intuitions reflect their experience with the phonological structure of modifiers, then *loonks-eater* should be more acceptable than *leevk-eater.*

In contrast, the morphological account predicts an independent effect of being a product of regular morphological composition. Although phonological familiarity could play some role (since anything that is less familiar might be rated as less natural, across the board), its contribution should not subsume the effect of morphological regularity. Accordingly, when the phonology of the noun in isolation is controlled for, compounds with illegal irregular plurals (*leevk-disease)* should be more acceptable than legal regular plurals *(loonks-disease*).

Method

Participants. Twenty-four Florida Atlantic University students who were native English speakers and skilled readers took part in this experiment in partial fulfillment of a course requirement.

Materials. The target words were generated from 32 pairs of novel singular nouns. Half the pairs had a CCVC structure and half a CVCC structure. Phonologically legal pair members had attested English clusters (e.g., *loonk*, *ploon*), whereas phonologically illegal members had an unattested cluster (e.g., *loovk*, *ptoon*).[5] The bases were then used to form irregular plurals (by changing their vowel, *oo*, to *ee*, e.g., *loonk–leenk*) and regular plurals (by adding *-s*, e.g., *loonk–loonks*). The statistical properties of these plurals are listed in Table 2. Bigram count (the number of words that match the target on length, and share with it any combination of

Table 2. The statistical properties of the plural targets in Experiment 1

	Bigram count	Bigram frequency	Neighbors' number	Neighbors' frequency
Illegal irregular	96	2017	.22	2.5
Illegal regular	145	1669	0	0
Legal irregular	128	3305	.69	21.3
Legal regular	193	2350	.12	2.2

adjacent two letters at the same position) and bigram frequency (the summed frequency of the words sharing the target's two-letter combinations) were calculated based on Kucera and Francis (1967). Neighborhood counts (i.e., the number of words sharing all but one of the target's letters) were computed based on an on-line unix dictionary and the SpellGuard dictionary, whereas neighbor frequency (the summed frequency of the target's neighbors) was calculated based on Kucera and Francis (1967). Illegal irregular targets had significantly lower bigram count ($F_2(1, 31) = 70.94$, $MSE = 2139$, $p < .0002$) and bigram frequency ($F_2(1, 31) = 5.37$, $MSE = 329232$, $p < .03$) than legal regular targets. These targets did not differ significantly on the number of neighbors ($F_2(1, 31) < 1$, $MSE = .141$) or their summed frequency ($F_2(1, 31) < 1$, $MSE = 89.77$).

Each of the resulting 32 quadruples of plural targets (legal regular, legal irregular, illegal regular and illegal irregular) was incorporated in a brief context story (Appendix A). The first and second sentence introduced the target's singular and plural forms. Morphological number was disambiguated by using number words or quantifiers. In the third sentence, participants were prompted to generate the plural form that they had just read. The final sentence elicited ratings for two compounds, one containing a singular nonhead, one containing a plural nonhead, their order counterbalanced. Members of each plural quadruple were presented with a given context story according to a Latin square, which avoided multiple presentations of a given story to a single participant and balanced the number of regularity × phonology conditions per participant and quadruple.

To assess the inherent acceptability of the novel words, we also obtained ratings for those words presented in short non-compound sentences. All words were preceded by number words or quantifiers (e.g., *One loovk is dangerous; Groups of many leevk are dangerous*). The 32 matched plural quadruples were separated into four counterbalanced lists, presented in a random order.

Procedure. The experiment included two parts. In the first part, participants were presented with a printed booklet that included the 32 stories. After reading the first sentence in each story, which introduced the target word in a context, participants were asked to pronounce the word silently, attending to each of its letters. To assure that participants had committed the plural form from memory, each section of the story, including the one prompting them for the plural form, was printed on a separate page, and participants were asked not to turn the pages backwards. When they reached the last page of a story, the participants were presented with two underlined compounds, one with the singular word as its nonhead one with the plural as the nonhead. They were asked to rate the compounds as to "how they sound" on a 1–7 scale (1 = very bad, 7 = excellent) using their "gut feeling." To illustrate the task, we first presented them with two practice stories. In the second part of the experiment, participants rated the acceptability of the novel word in non-compound sentences using the same 1–7 scale. Participants were tested in groups of up to eight people.

Results and Discussion

a. Target rating in compounds. The first analysis examines whether people extend the constraint against regular plurals to compounds containing novel nouns, including illegal-sounding ones. The acceptability ratings of legal and illegal-sounding targets in compounds were first submitted to separate ANOVA's (regular/irregular × singular/plural) using participants (*F*1) and items (*F*2) as random variables, as well as the minF' (Clark, 1973). The findings for legal and illegal words were virtually identical (see Figure 1). The Regularity × Plurality interaction was significant with both legal words (see Table 3i-c) and illegal words (see Table 3ii-c). Simple main effects showed that participants gave higher ratings to singular targets

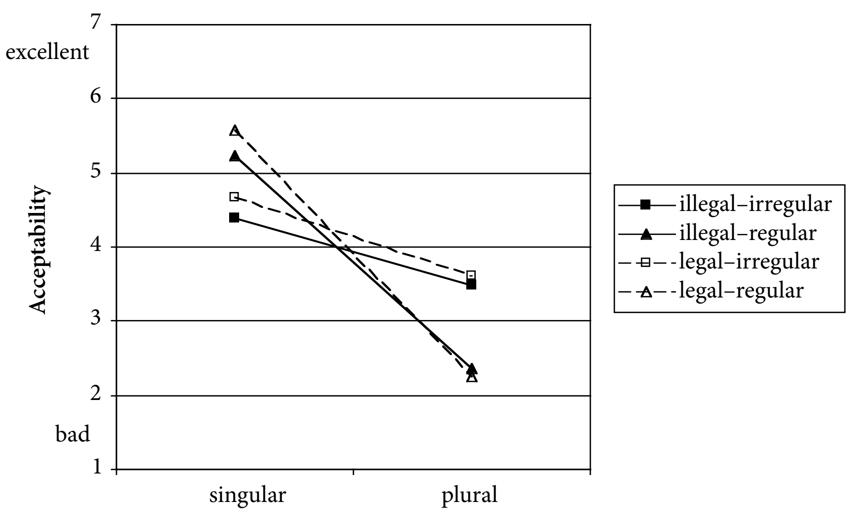

Figure 1. Mean acceptability ratings of the target in compounds as a function of plurality, regularity and phonological legality in Experiment 1.

than to plural targets both with irregular nouns (see Table 3i-f, and 3ii-f) and with regular nouns (see Table 3i-g, and 3ii-g).

The simple effects confirm the findings of Senghas et al. and Haskell et al. (2003) that in general, speakers prefer singular to plural nonheads in compounds, both with regular and with irregular nouns. However, the interaction indicates that the dislike of plurals in compounds was about three times larger for regular nouns ($\Delta = 3.3$ legal, $\Delta = 2.7$ illegal) than for irregular nouns ($\Delta = 1.1$ legal, $\Delta = 0.9$ illegal). Indeed, it is a crossover interaction, in which irregular plurals were judged as sounding better in the compounds than regular plurals, even though in their singular forms the *regular* forms were judged as sounding better.[6] This confirms the original claim by linguists such as Kiparsky (1982) that regular plurals are disfavored in compounds. Moreover, there is no sign of a three-way interaction (see Table 3iii-g), suggesting that any effect of phonological familiarity is independent of the Plurality × Regularity interaction that embodies the linguistic phenomenon of interest. Regular plurals were disliked in compounds even when their phonological form was more frequent than that of irregular plurals, i.e., when legal regular plurals (e.g., *loonks*, $M = 2.2$) are compared with irregular illegal plurals[7] (e.g., *leevk*, $M = 3.5$, a difference of 1.3). The 95% confidence intervals constructed for the difference between the means were 0.63 and 0.52, for participants and items, respectively.[8] This finding directly contradicts the prediction of the phonological familiarity hypothesis.

b. Did participants attend to the targets' sounds? To ensure that participants did not simply ignore the phonological ill-formedness of the printed materials, we examined how well they rated them outside the compound construction (e.g., *Groups of many leevk are dangerous*), and how well they remembered the plural form. As expected, phonologically illegal plurals were rated ($M = 2.90$) significantly lower than the legal plurals ($M = 4.29$, see Table 3iv-a), and this difference was not further modulated by regularity (see Table 3iv-c). However, participants were able to correctly produce phonologically illegal plurals on the majority of the trials ($M = 84.6\%$). Participants also generated regular plurals ($M = 81\%$) more accurately than irregular plurals ($M = 91.4\%$, see Table 3v-b), irrespective of phonological legality (see Table 3v-c).

To ensure that preference for irregular over regular plurals in compounds is not simply due to the fact that they did not treat irregular plurals as plurals, we re-analyzed the rating of plurals in compounds while excluding all the nouns for which participants failed to generate the correct plural form. The results remain unchanged. Participants favored irregular ($M = 3.63$) over regular plurals in compounds ($M = 2.32$, see Table 3vi-b), and this preference did not interact with phonological legality (see Table 3vi-c). In particular, plurals that are phonologically

Table 3. Analysis of variance results for Experiment 1

	Comparison	Source of variance			By Participants		By Items		Min F'	
					Df	F1 Value	Df	F2 value	Df	minF' value
i.	Acceptability of legal nouns in compounds	ANOVA	a.	Regularity	1, 23	4.00	1, 31	3.01	1, 50	1.72
			b.	Plurality	1, 23	55.81*	1, 31	120.62*	1,51	38.16*
			c.	Regularity x plurality	1, 23	28.39*	1, 31	28.78*	1,53	14.29*
		Simple main effects	d.	Regularity for singulars	1, 23	16.97*	1, 31	11.35*	1,48	6.80*
			e.	Regularity for plurals	1, 23	27.20*	1, 31	36.03*	1,54	15.50*
			f.	Plurality for irregulars	1, 23	7.91*	1, 31	16.07*	1,52	5.30*
			g.	Plurality for regulars	1, 23	91.90*	1, 31	112.00*	1,54	50.48*
ii.	Acceptability of illegal nouns in compounds	ANOVA	a.	Regularity	1, 23	2.13	1, 31	0.85	1,40	0.61
			b.	Plurality	1, 23	42.62*	1, 31	75.8*	1,53	27.28*
			c.	Regularity x plurality	1, 23	16.29*	1, 31	33.9*	1,52	11.00*
		Simple main effects	d.	Regularity for singulars	1, 23	12.24*	1, 31	11.90*	1,53	6.03*
			e.	Regularity for plurals	1, 23	16.39*	1, 31	33.5*	1,52	11.00*
			f.	Plurality for irregulars	1, 23	5.18*	1, 31	10.02*	1,52	3.41
			g.	Plurality for regulars	1, 23	62.93*	1, 31	116.17*	1,53	40.82*
iii.	Acceptability of legal vs. illegal nouns in compounds	ANOVA	a.	Legality	1, 23	3.98	1, 31	2.36	1,46	1.48
			b.	Regularity	1, 23	3.65	1, 31	4.18*	1,54	1.95
			c.	Legality x regularity	1, 23	1.28	1, 31	0.20	1,30	0.17
			d.	Plurality	1, 23	55.07*	1, 31	166.83*	1,48	41.40*
			e.	Legality x plurality	1, 23	2.47	1, 31	1.24	1,44	0.83
			f.	Regularity x plurality	1, 23	30.01*	1, 31	62.6*	1,52	20.28*
			g.	Legality x regularity x plurality	1, 23	0.33	1, 31	0.27	1,51	0.15
iv.	Ratings of plurals outside compounds	ANOVA	a.	Legality	1, 23	36.06*	1, 31	131.8*	1,46	28.31*
			b.	Regularity	1, 23	0.38	1, 31	0.48	1,54	0.21
			c.	Legality X regularity	1, 23	0.45	1, 31	0.25	1,45	0.16

v.	The accuracy of generating plurals	ANOVA	i.	Legality	1, 23	3.63	1, 31	1.25	1,38	0.93
			ii.	Regularity	1, 23	5.61*	1, 31	15.2*	1,49	4.10*
			iii.	Legality x regularity	1, 23	0.07	1, 31	0.03	1,40	0.02
vi.	The acceptability of plurals in compounds (provided that they are produced correctly)	ANOVA	a.	Legality	1, 22	0.0	1, 31	0.05	1, 31	0.00
			b.	Regularity	1, 22	26.85*	1, 31	48.2*	1,52	17.24*
			c.	Legality x regularity	1, 22	0.00	1, 31	0.04	1,37	0.00
vii.	Acceptability of plurals with legal vs. illegal coda clusters in compounds	ANOVA	a.	Legality	1, 23	0.20	1, 15	0.10	1,38	0.07
			b.	Regularity	1, 23	3.18	1, 15	2.06	1,38	1.25
			c.	Legality x regularity	1, 23	0.13	1, 15	0.02	1,31	0.02
			d.	Plurality	1, 23	45.99*	1, 15	73.32*	1,32	28.26*
			e.	Legality x plurality	1, 23	5.21*	1, 15	2.75	1,38	1.80
			f.	Regularity x plurality	1, 23	15.75*	1, 15	23.5*	1,32	9.43*
			g.	Legality x regularity x plurality	1, 23	1.01	1, 15	0.89	1,37	0.47
		Simple main effects	h.	Regularity for singulars	1, 23	7.54*	1, 15	11.10*	1,33	4.49*
			i.	Regularity for plurals	1, 23	17.95*	1, 15	17.51*	1,37	8.86*
			j.	Plurality for irregulars	1, 23	9.93*	1, 15	23.22*	1,27	6.96*
			k.	Plurality for regulars	1, 23	77.75*	1, 15	80.45*	1,36	39.54*
viii.	The acceptability of plurals in compounds (corrected for their acceptability outside compounds)	ANOVA	a.	Legality	1, 23	28.76*	1, 31	85.03*	1,48	21.49*
			b.	Regularity	1, 23	21.69*	1, 31	45.24*	1,52	14.78*
			c.	Legality x regularity	1, 23	0.10	1, 31	0.09*	1,53	0.05
ix.	The acceptability of plurals with coda clusters in compounds (corrected for their acceptability outside compounds)	ANOVA	a.	Legality	1, 23	25.02*	1, 15	36.98*	1, 32	14.92*
			b.	Regularity	1, 23	13.90*	1, 15	10.71*	1, 38	6.05*
			c.	Legality x regularity	1, 23	0.20	1, 15	0.17	1, 37	0.09

Note. Significant effects are marked by an asterisk.

illegal ($M = 3.63$) were preferred over regular plurals that are phonologically legal ($M = 2.28$, a difference of 1.35; for comparison, the 95% confidence intervals constructed around the difference between the means were 0.44 and 0.48, for participants and items, respectively.).

c. The acceptability of nonheads with rare coda clusters. We also examined the possibility that there really is a decrement caused by phonologically illegal forms but that it is specific to the coda, which is the locus of the plural suffix, and diluted in the entire stimulus set, half of which put the illegal clusters in the onset, half in the coda. When we analyze only the items with legal vs., illegal codas, the results are unchanged (see Table 4). Plurals were disfavored relative to singulars with both irregular and regular nouns, but the magnitude of the plural dislike for regular nouns ($\Delta = 2.7$) was over twice that of irregular nouns ($\Delta = 1.23$). Accordingly, the ANOVA (2 legality × 2 regularity × 2 plurality) yielded a significant interaction of regularity × plurality (see Table 3vii-f). Crucially, there was no evidence for a three way interaction (see Table 3vii-g), suggesting that the relative unacceptability of regular plurals was unaffected by their phonological frequency. Once again, irregular plurals that are phonologically-illegal ($M = 3.5$) were significantly more acceptable than regular plurals that are phonologically-legal ($M = 2.2$, a difference of 1.3; for comparison, the 95% confidence intervals constructed for the difference between the means were 0.59 and 0.78, for participants and items, respectively).[9]

The experimental findings demonstrate that irregular plurals with illicit phonological patterns (and, hence, patterns that are rare to nonexistent in compounds) are judged as more acceptable in compounds than regular plurals with phonological patterns that are frequent in the language as a whole and not uncommon in compounds. This pattern was obtained even when we controlled for the acceptability of the nouns in isolation, and even with words whose unfamiliar patterns are in their codas. These results speak against the hypothesis that the unacceptability of regular plurals in compounds is due to their phonological rarity in compounds. Moreover, the distinction between regular and irregular plurals in compounds did not interact with their phonological familiarity. This is consistent with the assumption that morphological regularity and phonology are additive

Table 4. Mean acceptability ratings of targets with coda clusters in compounds in Experiment 1

	irregular		**regular**	
	singular	**plural**	**singular**	**plural**
Illegal	4.5	3.5	4.9	2.6
Legal	4.7	3.3	5.5	2.2
Mean	4.6	3.4	5.2	2.5

factors that come from different processing components, and hence that regularity cannot be reduced to phonology. The lack of an interaction also casts doubt on the possibility that the effects of phonological familiarity act in some nonmonotonic or strongly nonlinear fashion in combination with other factors.

The findings strengthen our earlier point that the acceptability of compounds containing regular-sounding singular nouns (such as *box-cutter*, *rose garden*, *synapse-counting* and *prizefight*) is problematic for the claim that regular-sounding phonology is a significant contributor to the unacceptability of regular plurals in compounds. Indeed, the phonological frequency of such regular-sounding singulars is far higher than that of the unattested clusters used in our experiment. Given that such extremely rare forms have no effect on the acceptability of regular and irregular plurals, it seems unlikely that the smaller contrast in phonological familiarity exhibited by the regular and irregular plurals themselves could account for the contrast. The following experiments test this prediction directly.

Experiments 2–4 specifically investigate the acceptability of nonheads that sound like regular plurals in compounds. Experiment 2 examines whether singular nonheads that are regular-sounding, such as *hose*, are disfavored relative to frequency- and semantically-matched controls, such as *pipe*. Experiment 3 repeats the manipulation with phonologically-matched controls, such as the singulars *hose* and *hoe*. These experiments test whether the phonological properties of the nonhead modulate the acceptability of the compound when regularity is held constant. Experiments 4 and 5 perform the complementary manipulation: we contrast regular (e.g., *gleeks*, plural of *gleek*) and irregular (e.g., *gleex* plural of *gloox*) nonheads that are matched on their phonology. If the acceptability of nonheads depends on their phonological familiarity in compounds, then regular-sounding nonheads should be disfavored relative to controls (in Experiments 2 and 3), and homophonous regular and irregular plurals should be equally acceptable (in Experiments 4 and 5).

Experiment 2: Compounds with Singular Nouns that Sound like Regular Plurals and Semantically Matched Singular Controls

Experiment 2 compares singular nonheads that resemble a regular plural (e.g., *hose*) with controls that do not sound like a regular plural (e.g., *pipe*) but that are matched for their semantic properties and word frequency (as in (3)). If the unacceptability of regular plurals in compounds (compared to irregular plurals) is caused by their phonological properties, then such properties should also taint compounds containing *singular* nouns: *hose-installer* should sound worse than *pipe-installer.*

(3) John works for General Electric. His job is to install hoses on washing machines.
His wife jokingly calls him the *hose-installer*. ____________

John works for General Electric. His job is to install hoses on washing machines.
His wife jokingly calls him the *hoses-installer*. ___________

John works for General Electric. His job is to install pipes on washing machines.
His wife jokingly calls him the *pipe-installer.* ____________

John works for General Electric. His job is to install pipes on washing machines.
His wife jokingly calls him the *pipes-installer.* ____________

Method

Participants. Twenty Florida Atlantic University students who were native English speakers participated in the experiment in partial fulfillment of a course requirement.

Materials. The materials included 24 pairs of existing English nouns. One pair member had the phonological form of a regularly-inflected plural: it ended with an *s* preceded by an unvoiced non-strident consonant, or with a *z*, preceded by a vowel or a glide. The other pair member was a singular noun that did not sound like a regular plural. The pair members were matched for their meaning and the frequency of the singular form (Francis & Kucera, 1982). The frequency of the regular-sounding nouns and control nouns were 44.25 ($SD = 59.16$) and 43.12 ($SD = 53.24$), respectively, and their mean lengths in syllables were 1 ($SD = 0$) and 1.37 ($SD = .65$), respectively.

Each target was incorporated in a brief story (Appendix B). The penultimate sentence in the story introduced the noun in its plural form. In the final sentence, the target was presented in compounds in either its singular or plural forms, and participants were asked to rate its acceptability in the compound. Pair members were presented with the same story in a Latin Square design, which avoided multiple presentations of a target noun for a single participant, and balanced the number of regular-sounding and control nouns and the number of singular and plural nouns for each participant and item pair. Each list presented the two types of nouns with the same story. To separate the repetitions of a story, the experimental list was divided into two blocks, such that a given story never repeated within a block.

Procedure. Participants were asked to read the stories and rate the compounds at their end as to "how they sound" on a 1–7 scale (1 = very bad, 7 = excellent) using their "gut feeling." To illustrate the task, we first presented them with two practice stories.

Results and Discussion

Acceptability ratings of regular-sounding nouns and controls in compounds were submitted to a 2 Type × 2 Plurality ANOVA (see Table 5i). The critical comparison concerns singular nouns. If compounds containing regular plural nonheads are tainted by the phonological rarity of the plural forms in compounds, then compounds containing regular-sounding singulars such as *hose*, *tax*, and *phase* should be less acceptable than semantically matched controls such as *pipe*, *toll*, and *step.* An inspection of the means (see Figure 2) show that the prediction is falsified: compounds with nonheads that sounded like regular plurals were rated identically to compounds with nonheads that did not sound like regular plurals, both with means of 4.8. The interaction between noun type and plurality was not significant (see Table 5i-c) nor was the simple main effect of noun type for singulars (see Table 5i-d).[10]

To rule out the possibility that participants liked the compounds with regular-sounding nonheads because some of these nonheads were actually homophonous with regular plurals (e.g., *hose* with *hoes*), we separated these from the items that had no plural homophones, such as *blaze* (for a results of their separate ANOVA,

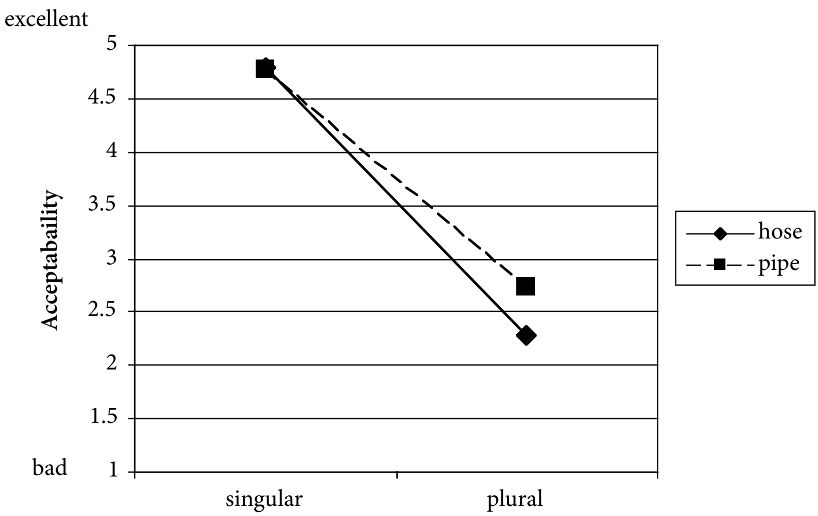

Figure 2. Mean acceptability ratings of the target in compounds as a function of plurality and phonological similarity to regular plurals in Experiment 2.

Table 5. Analysis of variance results for Experiment 2

	Comparison	Source of variance			By Participants		By Items		Min F'	
					Df	F1 Value	Df	F2 value	Df	minF' value
i.	Acceptability of "hose" vs. "pipe" type nouns in compounds	ANOVA	a.	Type	1, 19	5.69*	1, 23	7.68*	1, 42	3.27
			b.	Plurality	1, 19	74.10*	1, 23	225.48*	1, 36	55.77*
			c.	Type x Plurality	1, 19	2.61	1, 23	0.89	1, 31	0.66
		Simple main effects	d.	Type for singulars	1, 19	0.01	1, 23	0.22	1, 26	0.01
			e.	Type for plurals	1, 19	8.20*	1, 23	5.73*	1, 39	3.37
			f.	Plurality for "hose"-type nouns	1, 19	95.18*	1, 23	94.58*	1, 42	47.44*
			g.	Plurality for controls	1, 19	36.16*	1, 23	89.43*	1, 38	25.75*
ii.	Acceptability of "hose" vs. "pipe" type nouns in compounds (including only nouns that are not homophonous to existing plurals)	ANOVA	a.	Type	1, 19	11.00*	1, 7	2.78	1, 25	2.22
			b.	Plurality	1, 19	68.53*	1, 7	198.27*	1, 12	50.93*
			c.	Type x Plurality	1, 19	2.85	1, 7	3.35	1, 19	1.54
		Simple main effects	d.	Type for singulars	1, 19	0.10	1, 7	0.16	1, 17	0.06
			e.	Type for plurals	1, 19	5.96*	1, 7	8.51*	1, 17	3.51
			f.	Plurality for "hose"-type nouns	1, 19	83.58*	1, 7	74.70*	1, 22	39.45*
			g.	Plurality for controls	1, 19	21.29*	1, 7	68.38*	1, 12	16.24*
iii.	Acceptability of "hose" vs. "pipe" type nouns in compounds as a function of their homophony	ANOVA	a.	Homophony	1, 19	13.59*	1, 22	2.79	1, 27	2.31
			b.	Type	1, 19	8. 94*	1, 22	6.96*	1, 39	3.91
			c.	Homophony x Type	1, 19	1.92	1, 22	0.06	1, 20	0.06
			d.	Plurality	1, 19	78.67*	1, 22	228.40*	1, 35	58.52*
			e.	Homophony x Plurality	1, 19	4.00	1, 22	2.44	1, 37	1.51
			f.	Type x Plurality	1, 19	3.33	1, 22	1.59	1, 35	1.08
			g.	Homophony x Type x Plurality	1, 19	1.14	1, 22	1.21	1, 41	0.59

Note. Significant effects are marked by an asterisk

see Table 5ii). A test of the simple main effect showed that the ratings of these nonhomophones (5.2) were not lower than those of their non-regular-sounding controls, such as *spark* (5.06, see Table 5ii-d). Accordingly, an Analysis of Variance (2 homophony × 2 type × 2 plurality) showed no interaction between homophony and noun type (see Table 5iii-c) or between homophony, noun type, and plurality(see Table 5iii-g).

The identical rating of acceptability for compounds with regular-sounding and non-regular-sounding singular nouns like *hose-installer* and *pipe-installer* contrasts with the robust disadvantage of regular relative to irregular plural nouns (e.g., *rats-eater vs. mice-eater*). For instance, in Experiment 1 (the legal noun condition), the disadvantage of regular plural nonheads relative to singulars was 3.3 points, whereas for irregular plurals, it was only 1.1 points. Haskell and colleagues (2003) attribute this disadvantage of regular plurals to the unfamiliarity with the *-s* final phonology of the nonhead. Our finding of an absence of an effect of -s-final phonology calls their explanation into question.

Experiment 3: Compounds with Singular Nouns that Sound like Regular Plurals and Phonologically Matched Singular Controls

Experiment 3 offers another test of the phonological familiarity hypothesis by comparing the acceptability of regular-sounding singulars (e.g., *hose*) to phonologically-matched controls that lack the *s/z* consonant in their coda (e.g., *hoe*) and whose plurals are therefore homophonous to the singular counterpart (*hose/hoes*) or highly similar to it (e.g., *breeze/trees*, *sex/sacks*). These nouns were incorporated in short stories as in (4). If the acceptability of nonheads in compounds is affected by their phonological familiarity, then regular-sounding singulars should be disfavored relative to the controls.

(4) Chris has five garden hoses.
I call him the <u>hose-collector</u>.

Chris has five garden hoses.
I call him the <u>hoses-collector</u>.

Chris has five garden hoes.
I call him the <u>hoe-collector</u>.

Chris has five garden hoes.
I call him the <u>hoes-collector</u>

Method

Participants. Twenty Florida Atlantic University students who were native English speakers participated in the experiment in partial fulfillment of a course requirement.

Materials. The materials comprised 20 pairs of existing monosyllabic English nouns (see Appendix C). One member had a phonological form that is compatible with that of a regularly-inflected plural (i.e., the noun either ended with *s* preceded by an unvoiced non-strident consonant, or it ends with a *z* preceded by a vowel or a glide). The control member was closely matched to the pseudo-stem of their regular-sounding mate, so that their plurals would be homophonous or closely similar to their singular counterparts. They were either minimal pairs (e.g., *hose–hoe*, 7 pairs), rhymes (*rise–lie*, 8 pairs), onset and coda-matched (*box–book*, 4 pairs), or onset-similar (e.g., *vase–bee*, one pair). The frequency counts of the regular-sounding singular targets and their singular controls were 48 ($SD = 63$) and 47 ($SD = 72$), respectively, (Francis & Kucera, 1982).

The pair members were next incorporated in brief stories (see Appendix C). The final sentence in each story contained a compound in either the singular form or the plural form, and the participants were asked to rate it. Because pair members differed in meaning, it was impossible to present all pairs within the same story. Nonetheless, the stories of the pair members were closely matched for the position of the target words, length and structure. The structure of the stories, the design and procedure are as described in Experiment 2.

Results and Discussion

The acceptability of regular-sounding nouns and controls in compounds were submitted to a 2 Type × 2 Plurality ANOVA (see Table 6i). The pattern of results is almost identical to those of Experiment 2 (see Figure 3): Once again, there is no evidence that regular-sounding singulars (e.g., *hose*, $M = 4.2$) are disfavored in compounds relative to their controls (e.g., *hoe*, $M = 4.1$, see Table 6i-d). Likewise, there was no interaction between noun type and plurality (see Table 6i-c). This speaks against the hypothesis that one contributor to the disadvantage of regular as compared to irregular plurals in compounds is the fact that the regular plurals end in *-s*.[11]

As in Experiment 2, we assessed the possibility that the absence of any dislike of the regular-sounding plurals was due to their homophony with existing plurals (e.g., *hose* and *hoes*) by dividing the items into homophonous and nonhomophonous sets. A separate analysis of the non-homophnouns nouns yielded the same results (for the ANOVA results, seeTable 6ii). Once again, among nonhomophonous nouns, regular-sounding singulars (e.g., *blaze*, $M = 4.3$) did not differ from

Table 6. Analysis of variance results for Experiment 3

	Comparison	Source of variance			By Participants		By Items		Min F'	
					Df	F1 Value	Df	F2 value	Df	minF' value
i.	Acceptability of "hose" vs. "hoe" type nouns in compounds	ANOVA	a.	Type	1, 19	0.74	1, 23	0.16	1, 27	0.13
			b.	Plurality	1, 19	48.03*	1, 23	165.01*	1, 29	37.20*
			c.	Type x Plurality	1, 19	2.08	1, 23	3.40	1, 20	1.29
		Simple main effects	d.	Type for singulars	1, 19	0.53	1, 23	0.21	1, 32	0.15
			e.	Type for plurals	1, 19	2.83	1, 23	2.77	1, 38	1.40
			f.	Plurality for "hose"-type nouns	1, 19	27.15*	1, 23	101.84*	1, 28	21.43*
			g.	Plurality for controls	1, 19	52.57*	1, 23	61.54*	1, 38	28.35*
ii.	Acceptability of "hose" vs. "hoe" type nouns in compounds (including only nouns that are not homophonous to existing plurals)	ANOVA	a.	Type	1, 19	2.59	1, 6	0.633	1, 25	0.51
			b.	Plurality	1, 19	35.25*	1, 6	87.63	1, 11	25.14*
			c.	Type x Plurality	1, 19	0.01	1, 6	0.591	1, 6	0.01
		Simple main effects	d.	Type for singulars	1, 19	0.70	1, 6	0.028	1, 20	0.03
			e.	Type for plurals	1, 19	1.47	1, 6	3.298	1, 12	1.01
			f.	Plurality for "hose"-type nouns	1, 19	17.35*	1, 6	40.35*	1, 12	12.13*
			g.	Plurality for controls	1, 19	29.35*	1, 6	17.38*	1, 23	10.91*
iii.	Acceptability of "hose" vs. "hoe" type nouns in compounds as a function their homophony with existing plurals	ANOVA	a.	Homophony	1, 19	0.48	1, 18	0.08	1, 25	0.06
			b.	Type	1, 19	1.45	1, 18	0.39	1, 28	0.31
			c.	Homophony x Type	1, 19	2.54	1, 18	0.67	1, 28	0.53
			d.	Plurality	1, 19	44.61*	1, 18	176.30*	1, 27	35.60*
			e.	Homophony x Plurality	1, 19	5.68*	1, 18	2.69	1, 33	1.82
			f.	Type x Plurality	1, 19	.42	1, 18	2.92	1, 36	0.37
			g.	Homophony x Type x Plurality	1, 19	0.73	1, 18	0.00	1, 19	0.00

Note. Significant effects are marked by an asterisk

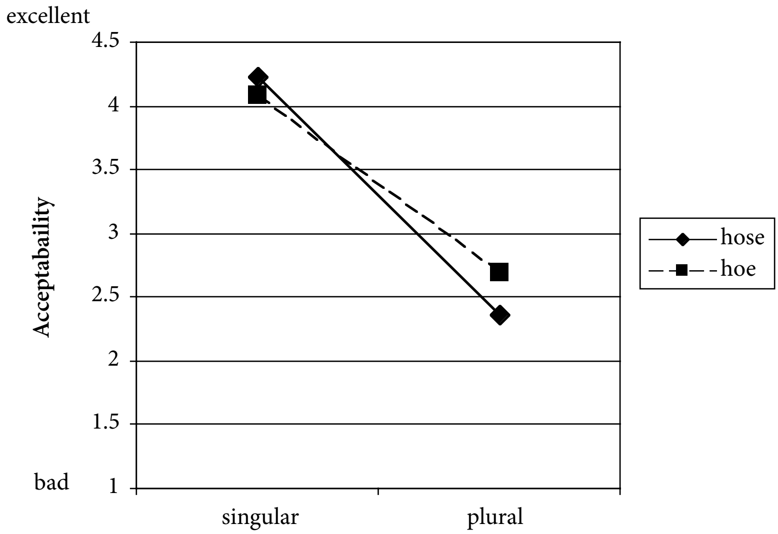

Figure 3. Mean acceptability ratings of the target in compounds as a function of plurality and phonological similarity to regular plurals in Experiment 3.

controls (e.g., *play*, $M=4.6$, see Table 6ii-d). Similarly, an ANOVA comparing homophonous vs. nonhomophonous nouns (2 homophony × 2 type × 2 plurality, see Table 6iii) yielded no interaction between noun type (i.e., regular-sounding *hose* versus control *hoe*) and homophony (see Table 6iii-c), nor a three-way interaction among noun type, plurality, and homophony (see Table 3iii-g).

Experiment 4: Compounds with Homophonous Regular and Irregular Plurals

Experiment 4 reports another test of the hypothesis that regularity itself, not phonology or semantics, is the cause of the regular-irregular difference in compounds containing plurals. Because it is impossible to unconfound these factors perfectly with existing words, we devised a set of nonwords that does so, specifically, pairs of novel nouns with homophonous regular and irregular plurals, differentiated by their singular forms and their spellings, such as *gleek-gleeks* and *gloox-gleex* (the phonological alternation seen in existing English irregulars *foot-feet*, *tooth-teeth*, and *goose-geese*, see Table 7).

The words were tested using the stories and procedure of Experiment 1. An example of the stories is shown in (5). If the lower acceptability of regular relative to irregular plurals in compounds is due to their phonological properties, then these homophonous regular and irregular forms should be equally acceptable.

Table 7. An illustration of the target nouns used in Experiment 4

	singular	**plural**
regular	*gleek*	*gleeks*
irregular	*gloox*	*gleex*

Conversely, if morphological regularity is the cause, then regular plurals should be less acceptable than irregular plurals even when they are fully matched on their phonology and semantics. Note that this design allows us to test for the possibility that some nonlinear interaction between -s-final phonology and plural semantics underlies the regular-irregular contrast.

(5) The *gleek* is a mean bird found in the tropics. A flock of twenty *gleeks* may attack and kill its prey.

The New York Times posted a report of a wild cat that was recently killed by ten ___________.

Fearing an attack on their lives, this report greatly concerned the
gleek-hunters _____
gleeks-hunters _____

Method

Participants. Eighteen Florida Atlantic University students who were native English speakers participated in the experiment in partial fulfillment of a course requirement.

Materials. The experimental materials consisted of 20 pairs of monosyllabic nonwords, presented as either regular or irregular nouns (see Appendix D). The regular and irregular plurals had the same phonological form. Irregular plurals were formed by changing the *oo* in the singular to *ee* in the plural. All the irregular nouns ended with a consonant homophonous to the appropriate allomorph of the regular plural suffix, either *s* (preceded by *k*) or *z* (preceded by a vowel). The regular plurals were homophonous with the irregular plurals; they differed solely on the spelling of the last consonant, namely with an *-s* (e.g., *gleeks*). The regular singular was the same form but without the *-s* (e.g., *gleek*). The nouns were incorporated in the stories employed in Experiment 1. To elicit acceptability ratings for plural nouns outside of compounds, they were incorporated in short sentences that disambiguated their number using numerals or quantifiers (e.g., *The New York Times reported an attack by 20 gleeks.)*.

Procedure. The procedure was identical to that of Experiment 1.

Results and Discussion

Figure 4 shows that even when their plurals are homophonous, regular plurals taint the acceptability of a compound to a far greater extent than irregular plurals (3.3 versus 0.2 rating points). An ANOVA (2 regularity × 2 plurality) yielded a significant interaction (see Table 8i-c), and tests of simple main effects show that regular plurals were rated significantly lower than regular singulars (see Table 8i-f) and significantly lower than the (phonologically identical) irregular plurals (see Table 8i-e). The small difference between the compounds containing irregular singulars and irregular plurals was not significant (see Table 8i-g).

To ensure that participants actually treated the irregular plurals as plurals, we examined how accurately they generated them in the part of the procedure that elicited the plurals from memory. The participants recalled the correct irregular plurals on most trials ($M = 91.1\%$), though they were somewhat less accurate than they were in recalling the regular plurals (the difference was significant in the analysis by items, but not in the analysis by participants (see Table 8ii). As an additional precaution against the possibility that participants didn't mind the compounds with irregular plurals simply because they sometimes didn't treat them as plurals, we re-analyzed the ratings of the compounds after excluding all the nouns for which the participant failed to recall the correct plural form. The results were unchanged (see Table 8iii): pluralizing a regular noun made a compound sound

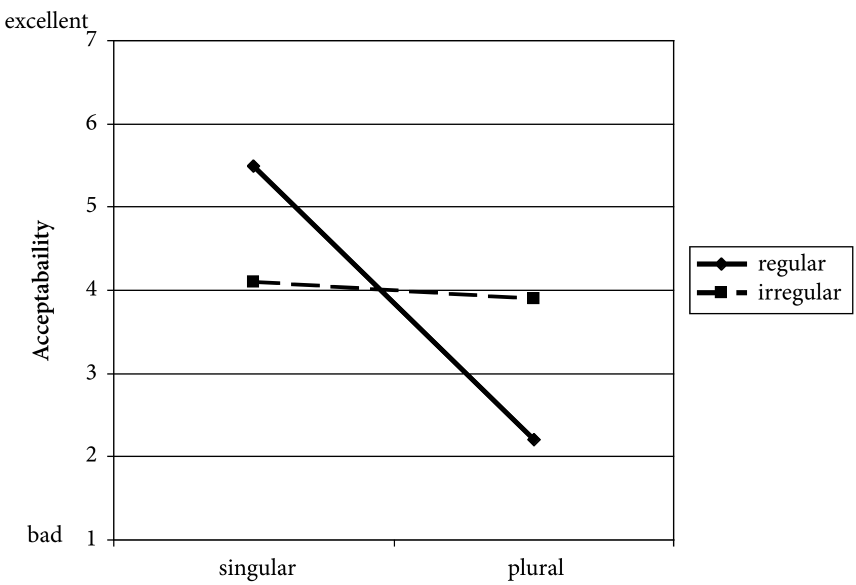

Figure 4. Mean acceptability ratings of the target in compounds as a function of regularity and plurality in Experiment 4.

Table 8. Analysis of variance results for Experiment 4

	Comparison	Source of variance			By Participants		By Items		Min F’	
					Df	F1 Value	Df	F2 value	Df	minF’ value
i.	Acceptability of nouns in compounds	ANOVA	a.	Regularity	1, 17	0.70	1, 19	0.31	1, 30	0.21
			b.	Plurality	1, 17	29.82*	1, 19	165.84*	1, 26	25.28*
			c.	Regularity x plurality	1, 17	40.96*	1, 19	133.73*	1, 29	31.36*
		Simple main effects	d.	Regularity for singulars	1, 17	23.02*	1, 19	36.78*	1, 35	14.16*
			e.	Regularity for plurals	1, 17	53.02*	1, 19	90.66*	1, 35	33.45*
			f.	Plurality for irregulars	1, 17	88.88*	1, 19	466.40*	1, 26	74.65*
			g.	Plurality for regulars	1, 17	0.16	1, 19	0.65	1, 28	0.13
ii.	The accuracy of generating plurals	ANOVA		Regularity	1, 17	3.36	1, 19	18.26*	1, 26	2.84
iii.	Acceptability of nouns in compounds (given that their plural is correctly produced)	ANOVA	a.	Regularity	1, 17	0.28	1, 19	0.18	1, 33	0.11
			b.	Plurality	1, 17	28.22*	1, 19	159.08*	1, 25	23.97*
			c.	Regularity x plurality	1, 17	47.76*	1, 19	131.19*	1, 31	35.02*
		Simple main effects	d.	Regularity for singulars	1, 17	28.79*	1, 19	36.08*	1, 36	16.01*
			e.	Regularity for plurals	1, 17	53.90*	1, 19	92.63*	1, 34	34.07*
			f.	Plurality for regulars	1, 17	90.89*	1, 19	412.51*	1, 27	74.48*
			g.	Plurality for irregulars	1, 17	0.09	1, 19	0.81	1, 23	0.08
iv.	Rating of plurals outside compounds	ANOVA		Regularity	1, 17	7.66*	1, 19	13.68*	1, 34	4.91*
v.	Rating of nouns in compounds, corrected for acceptability outside compounds	ANOVA		Regularity	1, 17	53.62*	1, 19	86.58*	1, 34	33.11*

vi.	Acceptability of nouns in compounds (including only nouns with legal spelling)	ANOVA	a. Regularity	1, 17	2.53	1, 7	0.73	1, 11	0.57
			b. Plurality	1, 17	47.33*	1, 7	113.81*	1, 26	33.43*
			c. Regularity x plurality	1, 17	16.03*	1, 7	24.55*	1, 24	9.70*
		Simple main effects	d. Regularity for singulars	1, 17	9.03*	1, 7	7.65*	1, 19	4.14*
			e. Regularity for plurals	1, 17	18.65*	1, 7	21.61*	1, 22	10.01*
			f. Plurality for regulars	1, 17	72.68*	1, 7	255.21*	1, 26	56.57*
			g. Plurality for irregulars	1, 17	1.08	1, 7	1.44	1, 23	0.62
vii.	Acceptability of nouns with legal vs. illegal spellings in compounds	ANOVA	a. Legality	1, 17	0.68	1, 18	0.25	1, 28	0.18
			b. Regularity	1, 17	1.13	1, 18	0.46	1, 29	0.33
			c. Legality x regularity	1, 17	2.62	1, 18	0.55	1, 24	0.45
			d. Plurality	1, 17	33.97*	1, 18	128.90*	1, 27	26.89*
			e. Legality x plurality	1, 17	1.93	1, 18	2.38	1, 35	1.06
			f. Regularity x plurality	1, 17	36.76*	1, 18	121.53*	1, 28	28.22*
			g. Legality x regularity x plurality	1, 17	0.27	1, 18	0.40	1, 34	0.16
viii.	Acceptability of nouns in compounds on the first presentation of their spelling body	ANOVA	Regularity	1, 17	17.73*	—			

Note. Significant effects are marked by an asterisk.

much worse than singulars (5.5 versus 2.2; see Table 8iii-f), whereas pluralizing an irregular noun made a compound only slightly worse (4.0 versus 3.9, Table 8iii-g). Accordingly, the interaction between regularity and plurality was statistically significant (Table 8iii-c).

To ensure that the dislike of regular plurals inside compounds is not simply a carry-over of a dislike of the regular plurals across the board (perhaps because of their spelling), we adjusted the acceptability ratings of the compounds by subtracting the ratings of the nouns in non-compound sentences (and adding the constant six to obtain positive numbers). In fact, in the non-compound sentences (e.g., *I have five gleex/gleeks*), the regular plurals ($M = 4.8$) were preferred over the irregular ones ($M = 4.1$, Table 8iv) a trend opposite to their ratings in compounds. Accordingly, when the ratings of the nouns in compounds are adjusted by the ratings of the same nouns in isolation, the disadvantage of regular ($M = 3.5$) compared to irregular plurals ($M = 5.8$) only increased (Table 8v). Thus, participants disfavor regular over irregular plurals in compounds even when the targets are matched for their phonological form and their acceptability in isolation

We also examined two additional counterexplanations for the effect of morphological regularity. The first possibility is that the advantage of irregular plurals is an artifact of their spelling patterns. Twelve of our irregulars had *-oox* in the singular and *-eex* in the plural, two spelling patterns which never appear in standard written English, in contrast to *-eek* and *-eeks*. Perhaps speakers attend to spelling patterns and have somehow learned that the sequence of graphemes *eek*, but not the sequence of graphemes *eeks*, may appear in compounds, whereas they have no evidence one way or another for *oox* and *eex*.[12] Though the presence of a regularity effect in three studies of preliterate children (Clahsen et al., 1992; Gordon, 1985; van der Lely & Christian, 2000) shows that orthography is an unlikely explanation, we tested it in these data by dividing the items into subsets with illegal spelling patterns, like *gloox*, and with legal spelling patterns, like *drooze*. Even when the analysis is confined to items with legal spelling patterns, regular plurals ($M = 2.1$) were rated significantly lower than irregular plurals ($M = 3.75$, see Table 8vi-e), and lower than regular singulars ($M = 5.5$, Table 8vi-f). A comparison of these subsets yielded no three-way interaction among regularity, singular/plural, and legal/illegal (see Table 8vii-g).

We then tested for the possibility that the effect of morphology is due to priming, triggered by the multiple repetitions of spelling bodies (rimes) in the experiment. We thus analyzed the results of the *first presentation* of each of the two rimes, that is, the first pair of words with *-oox/eex* and the first pair of words with *-ooze-eeze*, a total of 4 data points per participant. For half of the subjects, the two rimes were first presented as regular plurals; for the other half, they were first presented as irregular plurals; the results must thus be analyzed by collapsing over the two counterbalancing conditions. The findings from this small subset still showed a significant dislike of regular plurals ($M = 1.9$) compared to irregular plurals ($M = 4.2$, see Table 8 viii).

Experiment 5: Compounds with Homophonous Regular and Irregular Plurals Presented Aurally

The findings of Experiment 4 show that regular plurals are disliked in compounds compared to phonologically identical irregular plurals. However, the regular and irregular plurals necessarily differed on their spelling, and one might argue that speakers accepted (say) irregular *gleex* in a compound because *gleex* does not look plural, unlike *gleeks.* Though analyses of the legally spelled items of Experiment 4 show that this interpretation is unlikely, Experiment 5 seeks to further minimize the effect of orthographic factors by replicating Experiment 4 using an aural presentation of the items. If the constraint on regular plurals in compounds concerns their morphological structure, then regular plurals should be disliked relative to irregular plurals despite equating them for their phonological form, meaning, and physical presentation.

Method

Participants. Eighteen Florida Atlantic University students who were native English speakers participated in the experiment in either partial fulfillment of a course requirement or for payment.

The design and procedure identical to those of Experiment 4, except that the materials were read to participants by an experimenter. In the first part of the experiment, the target was introduced in a short story which exemplified the plural form. Midway throughout the story, participants were asked to produce the plural form from memory (to assure they had encoded it correctly) and then rate the singular and plural forms in compounds. Participants indicated their rating on a blank page, which did not specify the target's spellings. After they rated the target words in compounds, they were asked to rate the acceptability of singular and plural targets in non-compound sentences. The sentences were narrated aloud in a random list, and participants wrote their rating on a blank page. Unlike Experiment 4, we obtained ratings for both the singular and the plural form of each noun, in order to control for the acceptability of the forms in non-compound context. Participants were tested one at a time.

Results and Discussion

Mean ratings of nouns in compounds was first analyzed by means of 2 Regularity × 2 Plurality ANOVA's. The means are presented in Table 9. As in Experiment 4, the acceptability of singulars and plurals in compounds depended on whether they were regular or irregular, resulting in a significant interaction of regularity and plurality (see Table 10i-c). Tests of simple main effects showed that the compounds with regular plurals were rated as significantly worse than their singular counterparts (see Table 10i-f). The regular plurals, moreover, were rated as worse than their phonologically identical — irregular counterparts, a difference that was significant by items, and marginally so by participants (see Table 10i-e). Not only did compounds containing irregular plurals not show a decrement compared to the same compounds with the irregular singular, but they were actually rated higher them, a difference which was significant by items (see Table 10i-g). The unusual advantage of these plurals may be explained by the fact that the singular noun itself was disliked, even when not in a compound. Singular nouns presented in isolation were disliked compared to their plural counterparts (see Table 10ii-b), and this dislike was stronger for the irregular singulars ($\Delta = .63$) than for the regular singulars ($\Delta = .32$), though the interaction between regularity and plurality was not significant, see Table 10ii-c). People may have disliked the irregular singulars because their coda cluster made them more phonologically marked, (e.g., *gloox* vs. *gleek*) or because their rime (e.g., *oox*) was so rare. Either way, the dislike of irregular singulars in compounds simply carries over a dislike of those singulars in isolation.

Table 9. Target acceptability in compound and non-compound sentences in Experiment 5

		Singular	Plural
In compounds	Regular	4.6	3.5
	Irregular	3.5	4.0
In non-compound sentences	Regular	3.5	3.9
	irregular	3.0	3.6

To correct for the acceptability of the nouns in isolation, we adjusted the ratings of the compounds by subtracting the ratings of the nouns in isolation (and adding the constant six to obtain positive numbers), and submitted the means to a 2 Regularity × 2 Plurality ANOVA's. The corrected acceptability ratings are shown in Figure 5. The regularity × plurality interaction was significant (see Table 10iii-c). Compounds containing regular plurals were rated significantly lower than those with singulars (see Table 10iii-f), whereas compounds containing irregular plurals were not rated significantly lower than those with singulars (see Table 10iii-g). Crucially, compounds with regular plurals were disliked compared to their phonologically and physically identical irregular counterparts (see Table 10iii-e).

Table 10. Analysis of variance results for Experiment 5

	Comparison	Source of variance			By Participants		By Items		Min F'	
					Df	F1 Value	Df	F2 value	Df	minF' value
i.	Acceptability of nouns in compounds.	ANOVA	a.	Regularity	1, 17	5.67*	1, 19	2.43	1, 30	1.70
			b.	Plurality	1, 17	1.22	1, 19	2.25	1, 34	0.79
			c.	Regularity x Plurality	1, 17	11.35*	1, 19	13.73*	1, 36	6.21*
		Simple main effects	d.	Regularity for singulars	1, 17	16.51*	1, 19	12.12*	1, 34	6.99*
			e.	Regularity for plurals	1, 17	4.07	1, 19	4.75*	1, 36	2.19
			f.	Plurality for regulars	1, 17	7.17*	1, 19	10.70*	1, 35	4.30*
			g.	Plurality for irregulars	1, 17	3.58	1, 19	5.19*	1, 35	2.12
ii.	Ratings of nouns outside compounds	ANOVA	a.	Regularity	1, 17	2.45	1, 19	13.16*	1, 26	2.06
			b.	Plurality	1, 17	8.09*	1, 19	12.36*	1, 35	4.89*
			c.	Regularity x Plurality	1, 17	0.86	1, 19	2.01	1, 32	0.60
iii.	Ratings of nouns in compounds corrected for their acceptability outside compounds	ANOVA	a.	Regularity	1, 17	0.33	1, 19	0.83	1, 32	0.24
			b.	Plurality	1, 17	6.18*	1, 19	10.05*	1, 35	3.83
			c.	Regularity x Plurality	1, 17	8.46*	1, 19	7.00*	1, 35	3.83
		Simple main effects	d.	Regularity for singulars	1, 17	1.71	1, 19	2.34	1, 36	0.99
			e.	Regularity for plurals	1, 17	4.91*	1, 19	7.39*	1, 35	2.95
			f.	Plurality for regulars	1, 17	10.32*	1, 19	13.07*	1, 36	5.77*
			g.	Plurality for irregulars	1, 17	0.19	1, 19	0.22	1, 36	0.10
iv.	The accuracy of generating plurals	Regularity			1, 17	8.00*	1, 19	8.88*	1, 36	4.21*

v.	Rating of nouns in compounds (provided the plural is produced correctly and corrected for rating outside compound)	ANOVA	a.	Regularity	1, 17	0.49	1, 19	1.15	1, 32	0.34
			b.	Plurality	1, 17	6.13*	1, 19	8.96*	1, 35	3.64
			c.	Regularity x Plurality	1, 17	11.15*	1, 19	8.61*	1, 35	4.86*
		Simple main effects	d.	Regularity for singulars	1, 17	2.31	1, 19	2.40	1, 36	1.18
			e.	Regularity for plurals	1, 17	4.97*	1, 19	9.21*	1, 34	3.23
			f.	Plurality for regulars	1, 17	11.36*	1, 19	14.17*	1, 36	6.31*
			g.	Plurality for irregulars	1, 17	0.00	1, 19	0.00	1, 27	0.00
vi.	Ratings of nouns in compounds (including only nouns with legal spellings)	ANOVA	a.	Regularity	1, 17	0.34	1, 7	0.14	1, 24	0.10
			b.	Plurality	1, 17	1.42	1, 7	0.86	1, 23	0.54
			c.	Regularity x Plurality	1, 17	15.26*	1, 7	3.48	1, 23	2.83
		Simple main effects	d.	Regularity for singulars	1, 17	2.68	1, 7	1.45	1, 24	0.94
			e.	Regularity for plurals	1, 17	5.65*	1, 7	4.61*	1, 21	2.54
			f.	Plurality for regulars	1, 17	5.01*	1, 7	2.52	1, 24	1.67
			g.	Plurality for irregulars	1, 17	0.35	1, 7	0.64	1, 15	0.23
vii.	Ratings of nouns with legal vs. illegal spellings in compounds	ANOVA	a.	Regularity	1, 17	2.92	1, 18	5.80*	1, 32	1.94
			b.	Plurality	1, 17	0.47	1, 18	0.68	1, 34	0.28
			c.	Regularity x Plurality	1, 17	0.00	1, 18	0.05	1, 20	0.00
		Simple main effects	d.	Regularity for singulars	1, 17	4.29	1, 18	8.48*	1, 32	2.85
			e.	Regularity for plurals	1, 17	0.34	1, 18	0.76	1, 31	0.24
			f.	Plurality for regulars	1, 17	10.08*	1, 18	7.79*	1, 34	4.39*
			g.	Plurality for irregulars	1, 17	1.93	1, 18	0.99	1, 31	0.65
viii.	Rating of nouns in compounds on the first presentation of their spelling body	Regularity			1, 17	3.61				

Note. Significant effects are marked by an asterisk

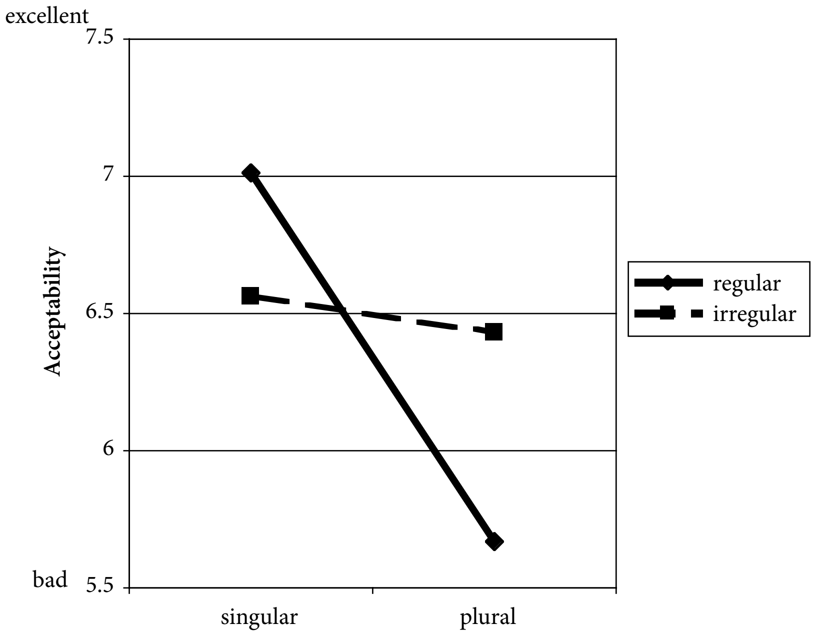

Figure 5. Mean acceptability ratings of the target in compounds as a function of regularity and plurality in Experiment 5 (corrected for the acceptability of targets outside compounds).

As in Experiment 4, to ensure that the dislike of regular plurals in compounds is not due to participants' mistaking them for singulars, we re-analyzed these data while excluding all trials in which a participant failed to generate the correct plural. Participants were overall quite accurate, though as expected, they were more accurate with regular ($M = 98.9\%$) than with irregular plurals ($M = 92.8\%$, see Table 10iv). Accordingly, when erroneous trials are excluded from the previous analysis (correcting for the acceptability of targets in non-compound sentences), the results remain unchanged. The regularity × plurality interaction was significant (see Table 10v-c). The simple main effect of plurality was significant for regular nouns (see Table 10v-f), but not for irregular ones (see Table 10v-g). Regular plurals were disliked compared to irregular plurals (see Table 10v-e). These results demonstrate that the dislike of regular plurals in compounds obtains even when regular and irregular plurals are matched for their phonology and meaning, and in the absence of any cues from spelling.

As in Experiment 4, we separated compounds with the rare *oox* spelling pattern from those with legal (i.e., more common) *ooze* spelling pattern, corrected for acceptability in isolation. Among the items with the legal spelling pattern, regular plurals ($M = 5.9$) were rated significantly lower than both regular singulars ($M = 7.3$, see Table 10vi-f) and irregular plurals ($M = 6.9$, see Table 10vi-e). In contrast, irregular plurals were not rated significantly lower than irregular singulars ($M = 6.5$, see Table 10vi-g). Accordingly, across all the items there was no significant interaction among regularity, plurality, and spelling pattern (see Table 10vii-g).

And once again we tested the first presentation of each rime in a compound, a total of 4 data points per participant (corrected for acceptability in isolation), collapsed across the two lists. Despite the reduction in power, the pattern of results remains essentially unchanged: regular plurals ($M = 5.8$) were rated lower than irregular plurals ($M = 7.3$), a trend that approached significance (see Table 10viii, $p < .05$, one tail).

General Discussion

Five experiments examined whether people's greater tolerance for irregular than for regular plurals in compounds is a product of the irregular-regular difference itself (as predicted by theories that attribute morphological representations to the language system) or of the relative unfamiliarity of the phonological properties of the regular plural (as predicted by theories that posit only statistical correlations among semantic and phonological features). Experiment 1, which used novel nouns, showed that irregular plurals with infrequent phonological patterns (e.g, *deevk*, plural of *doovk*) are judged as more acceptable in compounds than regular plurals with phonological patterns that are more frequent in the language as a whole and more frequent as the nonhead element in compounds (e.g., *doonks*, plural of *doonk*). Moreover, regularity did not even interact with phonological familiarity, casting doubt on the hypothesis that these factors act on a common stage of linguistic processing. Experiments 2 and 3 used existing nouns to isolate the phonological contrast that allegedly taints compounds with regular plurals. These studies showed that regular-sounding singulars (e.g., *hose*) do not taint compounds compared to semantically and frequency-matched controls (e.g., *pipe*) or compared to phonologically-matched controls (e.g., *hoe*). Experiments 4 showed that a regular plural (e.g., *gleeks*, plural of *gleek*) sounds worse in a compound than an irregular plural with the identical sound (e.g., *gleex*, plural of *gloox*), and Experiment 5 replicated this finding while eliminating any cues from spelling.[13] In this case, both the *-s*-final phonology of the plural noun and its plural semantics were equated while regularity was manipulated; the robust advantage for the irregular plurals therefore is neither an epiphenomenon of phonology nor of some nonlinear interaction between phonology and plural semantics.[14]

Aside from its inconsistency with the present experimental data, and the fact that the phenomena cited in its favor have alternative explanations (as noted in the introduction), there are problems with Haskell et al.'s (2003) characterization of the linguistic experience that they claim shapes people's perception of compounds.

Haskell et al. (2003) argue that people learn the restriction on the phonological form of the nonhead in compounds by tracking the phonological properties of "modifiers" in their linguistic experience.

This analysis assumes that speakers generalize the statistical properties of adjective-noun sequences to noun-noun compounds — an assumption crucial for the success of Haskell et al.'s (2003) computational demonstration. Haskell and colleagues show that the performance of their connectionist model correlates with human rating of nonheads in compounds. However, the model in question was trained on the distinction between adjectives versus nonadjectives, not the distinction between existing versus nonexisting compound nonheads. Because adjectives rarely end in *z* or in unvoiced *s*-final consonant clusters (the phonological signatures of regular plurals), the model could capitalize on fortuitous property of modifiers to distinguish between different types of nonheads.

The assumption that learners generalize the properties of modifiers to nonehads is unlikely, however. These two constructions are very different. They have different stress patterns: compare *a black board* with *a blackboard*. They have different semantics: in *rice-eater*, the word *rice* is not modifying *eater* the way *big* modifies *boy* in *big boy* (as if to narrow down the class of eaters to those that have something to do with rice). The nonheads in such compounds are in fact not "modifiers" but *arguments*: a rice-eater is something that eats rice. Adjective-noun sequences and noun-noun compounds also have different syntactic properties: most prenominal adjectives can also appear as predicates, as in *this boy is big*, but no compound nonheads can, as in **this eater is rice*. Finally, the two constructions have different selection restrictions: though Haskell et al. (2003) show that adjectives are correlated with certain phonological patterns (which we suspect are largely epiphenomena of adjectival morphology such as *-able*, *-ive*, and *-ish*, combined with a rarity of s/z-final stems), no such restrictions apply to compound nonheads, which can incorporate any name and hence virtually any sound (e.g., *Bach record*, *Shevardnadze supporter*). A learner who generalized the statistics of one construction to the other (as Haskell et al. require to explain the dispreference for regular plural phonology in compounds) would soon obliterate these distinctions. This is an example of how the properties of phonological sequences, which are the grist for most connectionist models, fail to explain the widespread generalizations in language that hinge on grammatical categories.

Haskell et al.'s (2003) remaining argument against a grammatical explanation of the dispreference for regular plurals inside compounds is that there are many counterexamples to that generalization, such as *enemies list* and *publications catalogue* (a phenomenon that has long been discussed in the literature, e.g., Gordon, 1985; Kiparsky, 1982; Selkirk, 1982). Haskell et al. claim that such counterexamples undermine the grammatical theory and support a connectionist alternative that eschews all grammatical representations. But this is problematic. Haskell et al's own data (like ours and those of Senghas et al.) show that the disliking of compounds containing regular plurals compared to ones with closely matched irregular plurals is a robust effect. Accordingly, examples of regular plurals in compounds present a separate case, distinct from the compounds studied by Haskell and colleagues and our present experiments. Given the failure of the connectionist alternative to account for the robust dislike of regular plurals in most compounds, it is doubtful it can be vindicated by such counter-examples. Both cases can be accommodated by theories that propose different mechanisms for the formation of regular and irregular plurals.

One well-motivated explanation has been proposed by Alegre and Gordon (1996) and Senghas et al., (1991, 2007; see Pinker, 1999). According to this theory, English has at least two compound constructions, one of which conjoins a stem or a root to a noun (hence disallowing a regular plural), the other of which conjoins an entire *phrase* to a noun (as in *seat-of-the-pants reasoning* and *bottom-of-the-birdcage taste*; Lieber, 1980) and hence allows a regular plural (since a regular plural is a one-word phrase). This theory can explain both the well-documented dispreference for regular plurals in compounds and the possibility of counterexamples, but is not vacuous because it identifies independent structural and semantic criteria that distinguish stem compounds (which disallow regulars) from phrase compounds (which allow them). Compounds such as *torn receipt envelope* are ambiguous between a stem compound ([torn] [receipt-envelope], a torn envelope for receipts) and a phrasal compound ([torn receipt]-[envelope], an envelope for torn receipts). But when the nonhead is pluralized (*torn receipts envelope*), both children and adults interpret it only as a phrasal compound (an envelope for torn receipts; Alegre & Gordon, 1996; Senghas et al., 1991, 2007) — exactly the kind that is predicted to allow regular plurals. In addition, Alegre and Gordon identified a semantic criterion that attaches to the different constructions, further motivating the distinction between the two kinds of compounds. When the pluralrized nonhead forms part of a stem-compound (hence, disallowed in compounds, e.g., *rats-eater*), the plural refers to different individuals of a single type (e.g., many individual rats). In contrast, when the pluralized nonhead forms part of a phrase (hence, attested in compounds, e.g., *publications-catalog*), the plural refers to different types (e.g., different types of publications, rather than different tokens of a single type of publication). Thus, the apparent counter-examples to the restriction on regular plurals in compounds have a principled explanation within theories that distinguish the formation of regular and irregular plurals. Such theories can accommodate not only those counter examples but also the basic dislike of regular plurals in non-phrasal compounds, which Haskell et al.'s (2003) phonological account fails to explain.

The phonological account of compounding proposed by Haskell et al. (2003) follows previous attempts to capture the distinction between regular and irregular forms in terms of the statistics of the phonological properties of the lexical items. These explanations cite differences in the frequency of regular and irregular types (e.g., Rumelhart & McClelland, 1986), their distribution in phonological space (e.g., Plunkett & Nakisa, 1997), and the phonological faithfulness of the inflected form to the base (e.g., Stemberger, 1995, 1998). These proposals are challenged by the persistent effect of morphological regularity in languages that break these phonological correlations. German has a regular plural that applies to a minority of types (Clahsen, 1999; Marcus, Brinkmann, Clahsen, Wiese, & Pinker, 1995); Hebrew has a regular default despite overlapping distributions of regular and irregular forms in phonological space (Berent, Pinker, & Shimron, 1999) and despite similar degrees of phonological faithfulness (Berent et al., 2002).

In the present case, too, when a larger range of languages is examined it is not clear that regular and irregular plurals will even turn out to differ in the frequency of their phonological forms in compounds. For instance, the German regular plural suffix, *s*, is homophonous to a linking morpheme that is frequently used in compounds. Nonetheless this regular suffix is reliably avoided in compounds (Clahsen et al., 1992). Likewise, Dutch disallows the regular -s plural in compound, but allows the -s suffix as a linking morpheme or diminutive (Collins, 1991). The present results demonstrate that even in a language in which morphological regularity shows some correlation with phonological frequency, when they are experimentally separated phonological frequency cannot account for the regular/irregular distinction.

These observations follow from the theory that the distinction between regular and irregular inflection reflects a distinction between simple lexical items stored in memory and complex forms generated by productive operations that combine grammatical categories. Because regular inflection operates over such variables, it cannot be reduced to the statistical distribution of regular forms in the lexicon and their phonological properties.

Notes

* This research was supported by NIH grant 1R29 DC03277 to the first author, and NIH grant HD-18381 to the second author. We are grateful to Gila Ghavami and Samantha Murphy for their help in the construction of the materials and running participants. We also thank Ruben Bouissa, and Sylvie Clerie, for their technical assistance, Matt Pastizzo, for assistance in computing the statistical properties of the targets, and Colin Phillips, for discussion of this work.

1. The hypothesis that the constraint against regular plural nonheads is innate has been challenged by recent evidence showing that (a) English-monolinguals do produce some regular plurals in ungrammatical compounds (e.g., *ring-bells*, referring to a bell-ringer; Nicoladis & Murphy, 2004), and (b) English-French Bilinguals are more likely to produce regular plural nonheads in noun-noun compounds compared to monolingual counterparts (Nicoladis, 2003). We do not find this evidence convincing. Both demonstrations might well reflect a failure to represent the structure of compounds. Specifically, constructions like *ring-bells* (in reference to a bell-ringer) reflect erroneous identification of the head as the left-constituent (*ring* = head, *ring-bells* = a type of ring), instead of the right element (*bell* = head, *ring-bells* = a type of bells) — the grammatical structure of English noun-noun compounds. In the case of French-English bilinguals, such errors might well be due to interference from French, in which compounds are predominantly left-headed. Because such errors indicate a misinterpretation of the nonhead, the use of regular plurals as the right-most element does not violate the constraint against plural nonheads in compounds. Moreover, the main question under consideration is not whether the constraint on compound formation is violable. Instead, the question is whether the constraint is sensitive to morphological regularity: Is the avoidance of nonheads with regular plurals *stronger* than irregular plurals. Both studies (Nicoladis, 2003; Nicoladis & Murphy, 2004) demonstrate that children are more likely to produce nonheads corresponding to irregular plurals compared to regular plurals.

2. For obscure reasons probably rooted in history, common English adjectives (with the exception of *wise*) virtually never end in *z* or in an unvoiced *s*-final consonant cluster (Francis & Kucera, 1982), which are the phonological signatures of regular plurals.

3. There are multiple ways to define phonological familiarity. Haskell et al. (2003) first define their phonological constraint in terms of "whether a potential modifier has the phonological structure typical of a regular plural" (p. 131). As stated, this is difficult to evaluate, since by their own hypothesis the learner has no access to the category "regular plural," and hence cannot use it as a criterion to partition phonological space. Fortunately, their operational definition hints at a different hypothesis but one more consistent with their overall theory: "The phonological constraint arises from the fact that exposure to nouns and adjectives provides information regarding the phonological structure of modifiers" (p. 139). This in turn can be interpreted in two ways: that speakers learn the phonological properties of nouns and adjectives in the language as a whole, and infer that the same properties apply to nonhead members of compounds, *or* that speakers learn the phonological patterns that specifically discriminate acceptable versus unacceptable nonheads. Our materials test both of these interpretations: Our phonologically unfamiliar nonheads are phonologically infrequent in the language as a whole as well as in compounds, specifically.

4. There are three kinds of *s*- and *z*-final words in compounds: nonheads whose roots end in those phonemes, such as *box-cutter*; nonheads that are pluralia tantum forms, such as *blues-rocker*, and nonheads that are apparent exceptions to Kiparsky's generalization and are actual regular plurals, as in *parks commissioner* and *drinks cabinet* (Selkirk, 1982; in the General Discussion we will discuss how these apparent counterexamples bear on the hypotheses). To verify that compounds with *s*- and *z*-final nonheads are likely to be part of a speaker's past linguistic experience, we extracted all the hyphenated nouns and adjectives in the Brown corpus (Francis & Kucera, 1982) and then searched for ones with a *z* or *s*-final consonant cluster before the hyphen. There were about ninety of them, including *always-present*, *politics-ridden*, *materials-handling*, *rose-pink*, *tax-exempt*, *six-point*, and *hands-off*, out of about three thousand hyphenated forms, presumably a large enough number and proportion to have been registered by English speakers as possible phonological patterns in compounds.

5. In most cases (30 of the 32 pairs), the legality of the onset/coda clusters concerns either their phonological or orthographic form. The only exception is two pairs whose legal member ends with an *-ng* — a coda that corresponds to a single phoneme.

6. Because these regular and irregular singulars were identical, and they were presented in identical contexts, this difference must be due to the acceptability of their plural counterparts — the fact that regular plurals were strongly disliked compared to irregular plurals. Thus, when compared to a highly unacceptable plural (i.e., regular), the same singular is rated more favorably than when compared to a more acceptable one (i.e., irregular).

7. To assure that this finding is not caused by differences in the inherent acceptability of the plural targets in isolation, we adjusted the acceptability ratings by subtracting the phonological rating of a plural target in isolation from its rating in a compound and adding the constant six (to obtain positive numbers). The findings remained unchanged. The ANOVA's revealed a significant effect of phonological legality (see Table 3viii-a), and regularity (see Table 3viii-b), but there was no trace of an interaction (see Table 3viii-c). Illegal irregular plurals ($M = 6.67$) were favored over legal regular plurals in compounds ($M = 3.95$, a difference of 2.72; for comparison, the 95% confidence interval constructed for the difference between the means were 0.48 and 0.50, for participants and items, respectively).

8. Note that these confidence intervals are constructed for the *difference* between means, rather than for *absolute* means. Loftus and Masson (1994) showed that these two types of confidence intervals are related by a factor of $\sqrt{2}$. They further demonstrated that the difference between any two sample means is significant by a two-tailed t-test if and only if it exceeds the confidence interval constructed for the difference between those means (using the same alpha level). Accordingly, we test the reliability of the observed differences between means against the confidence intervals constructed for those differences.

9. As expected, targets with illegal codas ($M = 2.8$) were rated significantly lower than those with legal codas ($M = 3.7$) in non-compound sentences. The acceptability of nouns with coda clusters in compounds remain unchanged after correcting for the acceptability of the plural in non-compound sentences (see Table 3ix): illegal irregular plurals ($M = 6.8$) were significantly more acceptable than legal regular plurals ($M = 4.4$, for comparison, the 95% confidence intervals constructed for the difference between the means were 0.70 and 0.77, for participants and items, respectively).

10. Virtually identical results obtained in an independent study in which twenty-four participants rated the singular and plural versions of each compound in the same test item, one above the other: mean rating of 6.1 for the compounds with regular-sounding singulars, 5.9 for the semantically matched controls.

11. Virtually identical results obtained in an independent study in which twenty-four participants rated the singular and plural versions of each compound in the same test item, one above the other: mean rating of 6.1 for the compounds with regular-sounding singulars, 5.8 for the phonologically matched controls.

12. It is not clear on this account why speakers would not *disfavor* the irregular plural because of its rarity, but we attempt to rule out the account anyway.

13. Our findings also challenges a lexical alternative to the constraint on compound formation (Buck-Gengler, Menn, & Healy, 2004). In that view, people are more likely to produce irregular than regular nonheads because they are slower to access the preferred singular alternative for irregular singulars compared to regular ones. It is unclear how this proposal specifically accounts for compound formation, since irregular singulars elicited slower response also in non-compound context (Buck-Gengler et al., 2004; Experiment 3). In any case, our findings demonstrate that the dislike of regular plural nonheads persists even when neither regular nor irregular form is lexically stored.

14. Note that under the words-and-rules theory it is not *impossible* for a compound to be tainted by phonological properties of nonheads that are unusual in that position; it's just that such effects, even if they were demonstrated, cannot explain away the effects of regularity.

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Appendix A. The set of targets and compound stories used in Experiment 1

(The singular and plural targets presented with each story across lists are indicated in parenthesis)

Story 1.
(dooshp/deeshp/dooshps // doorp/deerp/doorps)
The doorp is a flower that is frequent in northern Europe. I like making large bouquets of 20 doorps. I also prepare smaller floral arrangements of two or three____ for weddings. Brides simply cannot resist the scent of a fresh doorps-bouquet/doorp-bouquet

Story 2.
(noovk/neevk/noovks // noolk/neelk/noolks)
The noovk is a chocolate cookie. My son simply cannot resist eating them. Last night, I baked twenty neevk and left them in the kitchen. The next morning I found only two ______ left. It wasn't difficult to guess where they went when my son woke up complaining of a bad stomach-ache. My son will be known as the noovk-eater/neevk-eater.

Story 3.
(toolg/teelg/toolgs // toong/teeng/toongs)
A toolg is a yellow butterfly found in the spring. Arielle counted 100 teelg the other day as she sat quietly observing the insects. Yesterday, she spent her time observing them again and this time found that over 20 ______ had died overnight. When she sat down to observe them again today, her grandfather called her a beautiful teelg-watcher/toolg-watcher

Story 4.
(gnoog/gneeg/gnoogs // gloog/gleeg/gloogs)
The gnoog is a bird that is common in South Florida. It migrates to the North in flocks of up to 100 gneeg. This winter, I spotted a nest with four ___in my garden.To protect the birds, I installed a <u>gnoog-feeder</u>/<u>gneeg-feeder</u>.

Story 5.
(shmoon/shmeen/shmoons // shroon/shreen/shroons)
A shroon is a very small hut in which more than eight people live. In a field about as big as a football field, there can be over 50 shroons. The other day, a total of 25_____ were added to a field. The local newspaper has recently named these concentrations of small huts the <u>Shroons-villages</u>/<u>shroon-villages</u>

Story 6.
(boonf/beenf/boonfs // boont/beent/boonts)
A boont is a magical watch that has the ability to take the owner to another dimension. Daryl owns two beent, both of which were passed on to him by his grandfather. The other day, on his way to school, he met a strange little creature that happened to own three _____. When Daryl approached him, the creature explained to him that he was the <u>boont-maker</u>/<u>beent-maker</u>

Story 7
(fnoot/fneet/fnoots // snoot/sneet/snoots)
The fnoot is a mean bird found in the tropics. A flock of twenty fnoots may attack and kill its prey. The New York Times posted a report of a wild cat that was recently killed by ten_______. Fearing an attack on their lives, this report greatly concerned the <u>fnoots hunters</u>/<u>fnoot hunters</u>.

Story 8.
(ptoon/pteen/ptoons // ploon/pleen/ploons)
The ptoon is a dangerous bacterium that causes serious diseases. One ptoon multiplies into a colony of 10 million pteen within minutes. Accordingly, scientist must exercise great caution while growing large numbers of _____ in the lab. To prevent diseases, they must be stored in a sealed <u>ptoon-container</u>/<u>pteen-container</u>

Story 9.
(pnoom/pneem/pnooms // snoom/sneem/snooms)
Snoom is a flower used to make tea that cures headaches. It usually takes three sneem to make a cup of tea. Mary's headaches are so bad she makes her tea using six ________. This wonderful tea is often called the headache tea, but its formal name is <u>Sneem-Tea</u>/<u>Snoom-Tea</u>

Story 10.
(mroob/mreeb/mroobs // proob/preeb/proobs)
A mroob is a name given to people who are addicted to coffee. Research studying a large group of mreeb found that they suffer from chronic heart problems and migraines. When we consider that for every five persons there are three ______, we must encourage people to watch their caffeine intake. If we are not careful, we may become the <u>mroob-society</u>/<u>mreeb-society</u>.

Story 11.
(moofk/meefk/moofks // moork/meerk/moorks)
A moofk is the name of a man that guards the palace doors. Usually there are three moofks at the doors to prevent intruders. However, when the moon is not shinning, there tends to be at

least a dozen _______ guarding the doors. Because these men are strong and brave, parents encourage their sons to join the Moofks-order/Moofk-order

Story 12.
(loofk/leefk/loofks // looft/leeft/loofts)
A loofk is a monthly celebration in Bali. There are a total of 12 leefk a year
Depending on financial conditions, some families will host up to six ______. The most extravagant celebrations take place in the summer, and they are known by the Balian people as the loofk-feasts/leefk-feasts.

Story 13.
(foolg/feelg/foolgs // foong/feeng/foongs)
A foolg is a ring of honor given to men and women for honesty, bravery, courage or integrity. There is a man by the name of Carl who has earned 12 foolgs in the course of his lifetime. Yesterday, his children received a sum of three ______: one for bravery, one for courage, and one for honesty. Today, the newspaper has named these wonderful people the foolgs-family/foolg-family

Story 14.
(tloon/tleen/tloons/troon/treen/troons)
Scientists have discovered a new sub-atomic particle called the troon. An atom contains 15 treen. These 15 sub-atomic particles are arranged in three groups containing five _____ each. Physics textbooks call them the troon-structures/treen-structures.

Story 15.
(bdoon/bdeen/bdoons // bloon/bleen/bloons)
Heart-rate changes can now be detected by a special implant called a bloon. To assess the patient's condition, two bloons must be implanted in his chest. These devices are inexpensive, as they can be mass-produced at a rate of up to two hundred _____a day. To assess the patients' heart condition accurately, it is important to obtain readings from the two devices simultaneously by connecting them to a bloons-monitor/bloon-monitor.

Story 16.
(ktoop/kteep/ktoops // kloop/kleep/kloops)
The kloop is a special type of diamond that is extremely rare and expensive. There are only ten kloops in the whole world. Four ___ are incorporated in a beautiful crown, worn by Queen Elizabeth at her coronation. A report in the newspaper suggests that two of these precious stones are missing. A large reward will be granted to anyone that helps catch the kloop-thief/kloops-thief.

Story 17.
(dvook/dveek/dvooks // drook/dreek/drooks)
Drook is the name of a new, powerful, massaging shower. Allie has three drooks in each of the bathrooms in her house and wishes to buy another one for her new bathroom. Unfortunately, the store only has a few _____ left that are already on reserve. If she's really desperate, she will have to call and order one from the drooks-company/drook-company

Story 18.
(doovk/deevk/doovks // doonk/deenk/doonks)
The doonk is an ancient musical instrument used in German folk-dance music. Unfortunately,

there are only thirty doonks remaining today. They need constant maintenance, as they break easily. My folk-music band had four ___, but three of them are broken. I will have to travel to Germany to have them repaired in a doonk-shop/doonks-shop

Story 19.
(gmood/gmeed/gmoods // smood/smeed/smoods)
Smood is the name of a large scoop designed for many servings. Mrs Williams owns three smeed as she often hosts large parties. For her birthday, she asked her family to give her four more ______. She feels that in order to host larger parties, she will need more "smeed-ware"/ "smood-ware"

Story 20.
(znoog/zneeg/znoogs // snoog/sneeg/snoogs)
A recent paper in the journal *Science* suggests that dyslexia may be caused by a mutation. in the snoog chromosome. Dyslexics appear to have three sneeg, instead of two. There is also evidence that patients with three ___exhibit some speech disorders. It is hoped that such disorders may be diagnosed early on by detecting the three chromosomes in a snoog-test/sneeg-test.

Story 21.
(boofk/beefk/boofks // booft/beeft/boofts)
The booft is an oval shaped container used by the ancient Mayan for the purposes of storage. In a recent excavation in south Mexico, archeologists have discovered ten beeft. Two of the __ were severely damaged, but the remaining eight were found in good shape. After careful inspection, they will be transferred to the museum, where they will be exhibited in the beeft-collection/booft-collection.

Story 22.
(koonf/keenf/koonfs // koonk/keenk/koonks)
The koonk is a beautiful silk skirt made in New Orleans. In my visit there, I bought a dozen koonks. Two __are for myself, and the rest are for my five daughters.But when I left the country, I was interrogated for two hours by customs. I suppose my luggage made me appear like a koonk-smuggler/koonks-smuggler.

Story 23.
(gnoop/gneep/gnoops // gloop/gleep/gloops)
The gnoop is a special type of oyster found in the Mediterranean Sea. It is endangered specie, as there are only 300 gnoops still alive. Water contamination further results in the death of up to ten ______ every year. To protect the remaining animals, the Italian government has launched a special initiative known as the gnoops-program/gnoop-program

Story 24.
(loovk/leevk/loovks // loonk/leenk/loonks)
The loovk is a new diet pill that works miracles. Two loovks a day can make you lose up to ten pounds. An overdose of the pill can be quite dangerous, however. One patient has recently died after taking five___.The first signs of an overdose include an intense headache, nausea, and a rash that appear soon after three or more pills are taken. Doctors recognize these ailments as the loovk-disease/loovks-disease.

Story 25.
(kmoog/kmeeg/kmoogs // kloog/kleeg/kloogs)
A kmoog is a precious jewel found in a small village.The village people export millions of kmeeg every year to the surrounding countries. This year, however, they were only able to export a few thousand _____. To increase production, the village will train more kmeeg-polishers/Kmoog-polishers.

Story 26.
(mloof/mleef/mloofs // ploof/pleef/ploofs)
On the Island of Hawaii, there is a tree called a mloof that is often used to build houses. The habitants of the island cut an average of 15 mloofs a day. It is estimated that there are only one thousand _______ left on the island. Due to this estimate, the leaders of the Island have restricted the operations of the mloof cutters/mloofs cutters.

Story 27.
(moovk/meevk/moovks // moonk/meenk/moonks)
The moovk is a magic wand. A magician must stock several moovks because they can be easily damaged and are hard to make. Houdini, who makes all his magic equipment, could only make two _____ a year. To protect his six precious moovks Houdini always kept them in a special protective box called the moovks-carrier/moovk-carrier

Story 28.
(roofk/reefk/roofks // roonk/reenk/roonks)
The roofk is a special knife used by medieval knights in duals. A knight always used four reefk in duals. Two____ were carried by the knight and two by his assistant. They were kept in a special pouch called the roofk-carrier/reefk-carrier

Story 29.
(loonf/leenf/loonfs // loont/leent/loonts)
On the planet Neptune, a day is known as a loont. A week consists of eight leent rather than seven as it is for the planet Earth. The citizens of the planet work five _____ a week and spend the other three doing various activities essential to the maintenance of their planet. When they have accomplished all their required tasks, they spend the rest of their time leent-dreaming/loont-dreaming.

Story 30.
(dgoob/dgeeb/dgoobs // droob/dreeb/droobs)
The dgoob is a string instrument used in some Brazilian villages along the Amazon River In one village, there are three types of dgoobs: a bass, middle, and an upper range. A player usually masters one, or at most two ___. My friend Pedro, however, liked the instrument so much that he learned to play all three. People in the village call him the dgoob-master/dgoobs-master

Story 31.
(moonf/meenf/moonfs // moolf/meelf/moolfs)
When a child experiences intense fear in the middle of the night, it is said that he has experienced a moolf. Some children will experience five moolfs a week, at which point they will be taken to a doctor. The doctor will most likely teach the child some relaxation techniques. If the child still experiences several more _____, she must return for another visit. At that point, she is likely to be diagnosed with a form of depression called moolfs-sickness/moolf-sickness

Story 32.
(tooshp/teeshp/tooshps // toolp/teelp/toolps)
The toolp is a beautiful tree that gives lots of shade and nice fruits. I planted four teelp in my backyard, but two of them quickly died. It turns out hundreds of __ have been struck by a mysterious bug that destroys the tree's leaves. To protect the two remaining in my yard, I covered them in a special toolp-tent/teelp-tent

Appendix B. The set of targets and compound-stories used in Experiment 2

(The two target-pairs presented with each story across lists are indicated in parenthesis)

Story 1.
(blaze/blazes // spark/sparks)
Radioactivity is the newest weapon of choice for terrorists. A lab in Texas has developed a new type of clothing that protects against blazes of radioactivity. It is called the blaze-protector/blazes-protector // spark-protector/sparks-protector.

Story 2.
(breeze/breezes // storm/storms)
The cold north breezes devastated my rose garden. Last week, I read about a solution to my problem. To shield the flowers, I will install a breeze-protector/breezes-protector // storm-protector/storms-protector.

Story 3.
(tax/taxes // toll/tolls)
One of the most tedious jobs one could have is collecting income taxes. I always feel sorry for tax-collectors/taxes-collectors // toll-collectors/tolls-collectors.

Story 4.
(sex/sexes // gender/genders)
Taylor's dissertation compared brain functioning in men and women. Her study was among the first to demonstrate sex-differences/sexes-differences // gender-differences/genders-differences in brain activity

Story 5.
(vase/vases // pot/pots)
Because of the deep religious significance of pottery, the Navajo Indians spend many years learning how to make pots. It is a great honor to be chosen to become a vase-maker/vases-maker // pot-maker/pots-maker.

Story 6.
(hoax/hoaxes // joke/jokes)
On the Candid Camera show, a policeman approached tourists on the street, asking them to submit their money so that he could register the bills' numbers. The policeman took the bills and disappeared, to the dismay of the poor hoax-victims/hoaxes-victims // joke-victims/jokes-victims.

Story 7.
(phase/phases // step/steps)
When Mary was writing her dissertation, she was constantly trying to classify the various phases of child development. She wouldn't stop talking about the subject. Her annoyed husband called her the phase-classifier/phases-classifier // step-classifier/steps-classifier.

Story 8.
(hose/hoses // pipe/pipes)
John works for General Electric. His job is to install hoses on washing machines. His wife jokingly calls him the hose-installer/hoses-installer // pipe-installer/pipes-installer.

Story 9.
(fox/foxes // wolf/wolves)
My dog scares the wolves away from my farmhouse. He is the perfect fox-chaser/foxes-chaser // wolf-chaser/woles-chaser.

Story 10.
(mix/mixes // blend/blends)
I like drinking coffee at Starbucks because they sell several mixes of beans. Their coffee is the mix-winner/mixes-winner // blend-winner/blends-winner.

Story 11.
(nose/noses // thigh/thighs)
The center for disease control has issued a warning about a dangerous epidemic. In early stages, patients show a red rash on their thighs. Many clinics are now overwhelmed with scared patients complaining about nose-rashes/noses-rashes // thigh-rashes/thighs-rashes.

Story 12.
(cause/causes // loss/loses)
After a building toppled over in New York City, the government sent out a disaster team to investigate the losses. This disaster team was called the cause-evaluators/causes-evaluators // loss-evaluators/losses-evaluators.

Story 13.
(gaze/gazes // stare-stares)
It is now possible to diagnose early stages of glaucoma by repeatedly examining patient's stares into ultra-violate light. Many hospitals are now purchasing the diagnostic tool, known as the gaze-detector/gazes-detector // stare-detector/stares-detector.

Story 14.
(clause/clauses // article/articles)
My landlord is very tricky. Last year, I brought my lease contracts to my lawyer, because he is so good at spotting hidden articles. I call him the clause-finder/clauses-finder // article-finder/articles-finder.

Story 15.
(maze/mazes // web/webs)
While at the science museum, a group of students were trying to decode words from mazes of letters in a puzzle. Mike was the only one to decode the words. His friends called him the maze-decoder/mazes-decoder // web-decoder/webs-decoder

Story 16.
(quiz/quizzes // puzzle/puzzles)
Dan has an uncanny ability to answer any question on word puzzles. His friends call him the quiz-master/quizzes-master // puzzle-master/puzzles-master.

Story 17.
(fax/faxes // copy/copies)
John's work description is rather simple: He sits near the fax machine and distributes the incoming faxes to his co-workers mailboxes. John is known as the fax-man/faxes-man // copy-man/copies-man.

Story 18.
(size/sizes // shape/shapes)
The post office has purchased a state of the art machine that can sort every piece of mail by various shapes. Conveniently enough, the machine is called the size-machine/sizes-machine // shape-machine/shapes-machine.

Story 19.
(praise/praises // compliment/compliments)
Four-year-old Susie will do anything to get praises from her father. He calls her the praise-getter/praises-getter // compliment-getter/gomplements-getter.

Story 20.
(prize/prizes // award/awards)
Mary's son won prizes in the national competitions of Math and Physics. The proud mother cannot help show everyone the photo of the happy prize-winner/prizes-winner // award-winner/awards-winner.

Story 21.
(box/boxes // pack/packs)
FedEx workers must be careful not to lift heavy boxes, as this can result in damage to their back. To minimize the risk of injury, the company now provides workers with special box-lifters/boxes-lifters // pack-lifters/packs-lifters.

Story 22.
(rose/roses // flower/flowers)
My Aunt Mary has wonderful roses in her garden. She is among the most famous rose-growers/roses-growers // flower-growers/flowers-growers in the country.

Story 23.
(bruise/bruises // sore/sores)
My friend Aaron loves to play football, but always comes home full of sores. I sent him down the street to the all-natural store, which sells a wonderful cream that works wonders on face and body sores — they disappear without leaving a mark. I call it the bruise-healer/bruises-healer // sores-healer/sore-healer.

Story 24.
(rise/rises // drop/drops)
My favorite part about roller-coaster rides are the drops — I cannot stop screaming while we are going down. Last weekend, I spent eight hours on these Thunder Mountain at Disney World. At the end of the day, the operator thought I was a rise-addict/rises-addict // drop-addict/drops-addict.

Appendix C. The set of targets and compound-stories used in Experiment 3

Story 1.
Chris has five garden hoses. I call him the hose-collector/hoses-collector.

Story 2.
My grandmother is obsessed with putting things in order. She especially loves to sort by color all of her prized roses. I call her the rose-organizer/roses-organizer.

Story 3.
My friend Eileen will only live in high rises. I call her a rise-addict/rises-addict.

Story 4.
My landlord has hidden in my lease contract many nasty clauses. I call him the clause-hider/clauses-hider.

Story 5.
Detectives can now determine if a person is lying by tracking their gazes during questioning. This new technique is called the gaze-attractor/gazes-attractor.

Story 6.
The shelf in my office is full of empty boxes. I am known as the box-horde/boxes-horde.

Story 7.
It is well recognized that the male and female sexes differ on many cognitive abilities, but the source of this effect is poorly understood. Much research has attempted to explain the source of sex-differences/sexes-differences.

Story 8.
Last year, H&R Block took care of my taxes. Luckily they gave me a tax-refund/taxes-refund.

Story 9.
The post office has purchased a state of the art machine that can sort every piece of mail by various sizes and weights. Conveniently enough, the machine is called the size-machine/sizes-machine.

Story 10.
Four-year-old Danny will do anything to get praises from his mother. She calls him the praise-getter/praises-getter.

Story 11.
Dr. Aaron is a dermatologist that prepares a special cream for clearing out skin bruises. I call him the bruise-expert/bruises-expert.

Story 12.
Amanda has already had three raises this year. I call her the raise-seeker/raises-seeker.

Story 13.
My friend Greg loves to sit near the fireplace — he can watch the blazes for hours. I call him the blaze-lover/blazes-lover.

Story 14.
My friend Emily is an antique vase dealer. She is very successful, but has no room in her small office, so she often has me keep some of her vases. She calls me her vase-keeper/vases-keeper.

Story 15.
My sheep are afraid of foxes and will avoid them at all costs. I call them the fox-avoiders/foxes-avoiders.

Story 16.
When my Dad used to work for the phone company, he had to find the right phone line in the mazes of cables and circuits. I called him the maze-expert/mazes-expert.

Story 17.
My flowers have been devastated by the cold north breezes. Last week, I found a solution to my problem. I went to Home Depot and bought a breeze-protector/breezes-protector.

Story 18.
An extravagant costly building in mid-town toppled over as soon as construction ended. A disaster-expert was sent to the site to investigate the causes. He is called the cause-evaluator/causes-evaluator.

Story 19.
When Mary was writing her dissertation in Psychology, she wouldn't stop talking to her poor husband about the various phases of child development. He called her the phase-fanatic/phases-fanatic.

Story 20.
At work, John sits near the fax machine and distributes the incoming faxes to his co-workers. John is known as the fax-man/faxes-man.

Story 21.
Chris has five garden hoes. I call him the hoe-collector/hoes-collector.

Story 22.
My grandmother is obsessed with putting things in order. She especially loves to sort all of her buttons, pins and clips in rows. I call her the row-organizer/rows-organizer.

Story 23.
My friend Eileen constantly lies. I call her a lie-addict/lies-addict.

Story 24.
A National Geographic team has discovered a rare wild cat that can hide its claws. They call it the claw-hider/claws-hider.

Story 25.
Calvin Kline has come up with a new perfume that is said to attract guys to women. The new perfume is called the guy-attractor/guys-attractor.

Story 26.
The shelf in my office is full of cognition books. I am known as the book-horde/books-horde.

Story 27.
Farmers have long recognized that potatoes differ in quality depending on the sacks in which they are stored, but the source of this effect is poorly understood. Much research has attempted to explain the source of sack-differences/sacks-differences.

Story 28.
When I got my order from Office depot, I was shocked to discover they had accidentally sent me 10,000 boxes of tacks. Luckily they gave me a tack-refund/tacks-refund.

Story 29.
Scientists have invented a machine that can detect depression by recording the number of sighs a person emits in a hour. Conveniently enough, the machine is called the sigh-machine/sighs-machine.

Story 30.
Four-year-old Danny loves to help his pre-school teacher in getting food-trays off the tables after lunch. She calls him the tray-getter/trays-getter.

Story 31.
Aaron owns a beer refinery that makes two hundred brews. I call him the brew-expert/brews-expert.

Story 32.
My dog. loves to sit outside and soak up the sun rays all morning. I call him a rays-seeker/ray-seeker.

Story 33.
My friend Greg loves theater — he has seen hundreds of plays throughout his life. I call him the play-lover/plays-lover.

Story 34.
My friend Emily has a bee-hive in her yard. She likes honey, but she is terrified of getting stung, so she asked me to help her keep the bees. She calls me the bee-keeper/bees-keeper.

Story 35.
My lab rats are afraid of electrical shocks and will avoid them at all costs. I call them the shock-avoiders/shocks-avoiders.

Story 36.
When my Dad and I used to go sailing, he could name each of the little bays on the shore-line. I called him the bay-expert/bays-expert.

Story 37.
The cold winter winds have devastated my oak trees. Last week, I found a solution to my problem. I went to Home Depot and bought a tree-protector/trees-protector.

Story 38.
My cat has been limping for about a year, but none of the veterinarians I visited could find out the reason. Yesterday, my husband discovered she had two sprained paws. He is now called the paw-evaluator/paws-evaluator.

Story 39.
When Mary was working for Barnet Bank, she wouldn't stop telling her poor husband about the various types of banking fees and investments. He called her the fee-fanatic/fees-fanatic.

Story 40.
John has been homeless for over ten years and moves in and out of shacks frequently. John is known as the shack-man/shacks-man.

Appendix D. The set of regular-sounding nouns and their controls used in Experiment 4

Regular		Irregular	
Singular	**Plural**	**Singular**	**plural**
breek	breeks	broox	breex
pleek	pleeks	ploox	pleex
preek	preeks	proox	preex
dreek	dreeks	droox	dreex
sweek	sweeks	swoox	sweex
smeek	smeeks	smoox	smeex
steek	steeks	stoox	steex
treek	treeks	troox	treex
gleek	gleeks	gloox	gleex
gweek	gweeks	gwoox	gweex
kleek	kleeks	kloox	kleex
skeek	skeeks	skoox	skeex
dree	drees	drooze	dreeze
gwee	gwees	gwooze	gweeze
swee	swees	swooze	sweeze
smee	smees	smooze	smeeze
spee	spees	spooze	speeze
shree	shrees	shrooze	shreeze
shlee	shlees	shlooze	shleeze
sree	srees	srooze	sreeze