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TECHNICAL REPORT

The quick brown fox run over one lazy geese: Phonological and morphological processing of plurals in English

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Robert A. Liebscher
Cognitive Science, UCSD
Vol. 15, No.2; December 2003

The relationship between language and coverbal gesture in aphasia
Eva Schleicher
Psychology, University of Vienna & Cognitive Science, UCSD
Vol. 16, No. 1, January 2005

In search of Noun-Verb dissociations in aphasia across three processing tasks
Analía Arévalo, **Suzanne Moineau**
Language and Communicative Disorders, SDSU & UCSD, Center for Research in Language, UCSD
Ayşe Saygin
Cognitive Science & CRL, UCSD
Carl Ludy
VA Medical Center Martinez
Elizabeth Bates
Cognitive Science & CRL, UCSD
Vol. 17, No. 1, March 2005

Meaning in gestures: What event-related potentials reveal about processes underlying the comprehension of iconic gestures
Ying C. Wu
Cognitive Science Department, UCSD
Vol. 17, No. 2, August 2005

What age of acquisition effects reveal about the nature of phonological processing
Rachel I. Mayberry
Linguistics Department, UCSD
Pamela Witcher
School of Communication Sciences & Disorders, McGill University
Vol. 17, No.3, December 2005

Effects of Broca's aphasia and LIPC damage on the use of contextual information in sentence comprehension
Eileen R. Cardillo
CRL & Institute for Neural Computation, UCSD
Kim Plunkett
Experimental Psychology, University of Oxford
Jennifer Aydelott
Psychology, Birbeck College, University of London)
Vol. 18, No. 1, June 2006

Avoid ambiguity! (If you can)
Victor S. Ferreira
Department of Psychology, UCSD
Vol. 18, No. 2, December 2006

Arab Sign Languages: A Lexical Comparison
Kinda Al-Fityani
Department of Communication, UCSD
Vol. 19, No. 1, March 2007

The Coordinated Interplay Account of Utterance Comprehension, Attention, and the Use of Scene Information
Pia Knoeferle
Department of Cognitive Science, UCSD
Vol. 19. No. 2, December 2007

Doing time: Speech, gesture, and the conceptualization of time
Kensy Cooperrider, Rafael Núñez
Depatment of Cognitive Science, UCSD
Vol. 19. No. 3, December 2007

Auditory perception in atypical development: From basic building blocks to higher-level perceptual organization
Mayada Elsabbagh
Center for Brain and Cognitive Development, Birkbeck College, University of London
Henri Cohen
Cognitive Neuroscience Center, University of Quebec
Annette Karmiloff-Smith
Center for Brain and Cognitive Development, Birkbeck College, University of London
Vol. 20. No. 1, March 2008

The Role of Orthographic Gender in Cognition
Tim Beyer, Carla L. Hudson Kam
Center for Research in Language, UCSD
Vol. 20. No. 2, June 2008

The Role of Orthographic Gender in Cognition
Tim Beyer, Carla L. Hudson Kam
Center for Research in Language, UCSD
Vol. 20. No. 2, June 2008

Negation Processing in Context Is Not (Always) Delayed
Jenny Staab
Joint Doctoral Program in Language and Communicative Disorders, and CRL
Thomas P. Urbach
Department of Cognitive Science, UCSD
Marta Kutas
Department of Cognitive Science, UCSD, and CRL
Vol. 20. No. 3, December 2008

THE QUICK BROWN FOX RUN OVER ONE LAZY GEESE: PHONOLOGICAL AND MORPHOLOGICAL PROCESSING OF PLURALS IN ENGLISH

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Abstract

There is some evidence that semantics, conceptual features, and phonology interact with syntactic processing of words; however, other accounts suggest that in particular, irregular and regular English nouns and verbs, which differ in their phonology, are processed through different routes. The processing of regular and irregular nouns, and of pseudoplurals (nouns with the phonological form of a plural that are morphologically singular, such as cheese), was examined in a final-word sentence priming task. When the noun itself was repeated by participants in a grammatical or ungrammatical context (We saw one/three dog/dogs) regulars and irregular singulars showed a straightforward grammaticality effect, with repetition faster in grammatical sentences, while pseudoplurals and irregular plurals showed no grammaticality effect. When a verb following the noun was repeated in a grammatical or ungrammatical context (The dog/dogs runs/run) an interaction was found between number and grammaticality: both regular and irregular singulars showed a grammaticality effect, while regular and irregular plurals showed no or a reverse grammaticality effect; this was true both of university students and older participants. Pseudoplurals showed a straightforward grammaticality effect in the direction predicted by their morphology. It is concluded that the processing of nouns with conflicting morphology and phonology – such as irregular plurals and pseudoplurals – is influenced by both these features. However, previous studies (Bock & Eberhard, 1993) that have found irregular plurals and pseudoplurals do not differ from regulars in their processing may have been affected by aspects of the tasks or stimuli chosen.

Grammatical agreement and speech production

When producing a word as part of a sentence, many languages of the world require agreement in number, case, or grammatical gender between any given word and other words in the sentence. Some accounts of production of inflectional morphology suggest that this morphology is isolated from other aspects of word production (Caramazza, 1997; Levelt, Roelofs, & Meyer, 1999). Vigliocco and Hartsuiker (2002) however review interaction between different aspects of word retrieval during sentence production, and conclude that interaction between different levels of linguistic representation is highly influential in word production. Evidence for this comes from studies of spontaneous speech errors and from psycholinguistic experiments. Grammatical agreement can be influenced by a variety of factors, including conceptual properties such as distribution (Vigliocco, Hartsuiker, Jarema, & Kolk, 1996) and plausibility (Thornton & MacDonald, 2003); semantic number (Haskell & MacDonald, 2003), biological gender (Vigliocco & Franck, 2001), and general semantics (Ramscar, 2002).

Although phonology and morphology are rarely in one-to-one correspondence in languages, these also appear to be highly correlated. Corbett (1991), for example, analyses the correspondence between gender allocation and phonology and concludes that gender may be analysable in terms of phonology and semantics. In a corpus analysis and simulation, Mirkovic, MacDonald, & Seidenberg (2005) found that in Serbian, grammatical gender is correlated with both phonological and semantic properties of words.

There is in addition emerging experimental evidence which suggests that phonological properties of words strongly interact with processing of inflectional morphology, even though some earlier work on this interaction suggested that they did not (Bock & Eberhard, 1993). Gonnerman, Seidenberg, & Andersen (2007) used a priming paradigm and found that morphological priming in English depended on both semantic and phonological overlap between words, and that these two types of similarity interacted. Vigliocco and colleagues (Vigliocco, Butterworth, & Semenza, 1995; Vigliocco & Zilli, 1999) found that agreement errors increased when

the phonological realisation of a morpheme was invariant, compared to the same morpheme in words where there is variation between singular and plural nouns or masculine and feminine nouns. Franck, Vigliocco, Anton-Mendez, Collina, & Frauenfelder (2008) discuss research on phonology-morphology interaction and suggest that the phonology of the head noun, rather than of an intervener noun, in a sentence is the crucial factor in such interactions, although Haskell & MacDonald (2003) did find a small effect on grammatical number agreement of the morphology of a plural intervener noun. In a study comparing three Romance languages Franck et al. (2008) found that the phonological form of gendered nouns suffixes affected morphological processing – for example in Spanish, where most nouns that end -*a* are feminine, but some are masculine, masculine nouns with the inconsistent marker –*a* provoked more gender errors than masculine nouns with the consistent marker –*o*. Likewise, Alcock and Ngorosho (2004) found that grammatical processing of noun classes (resembling grammatical gender) in Kiswahili interacted with phonological processing, to the extent that grammatical agreement processing online appeared to be more influenced by the phonology of nouns than by their grammatical class. Vigliocco et al. (1995) suggest that English is not an ideal language for the investigation of phonological and morphological interaction, since few grammatical markers are found on English words.

However, it is possible to find groups of English words that share morphology but not phonology, or vice versa. Irregular plurals in English (such as *goose-geese*) are frequently found to be processed differently from regular plurals. It has been argued that this is due to the existence of separate processing mechanisms for regular words and irregular words – that regular words are processed (changed into plural or past tense, in the case of English) using rules but that irregular plural and past tense forms are stored in the lexicon (see, for example, Pinker, 2000). Other frameworks, however, including connectionist models, argue that there is a single system which processes both regular and irregular items. Haskell, MacDonald, & Seidenberg (2003), examining dispreference for compounds that contain regular plurals (*rats eater)*, in contrast with somewhat greater acceptance of compounds containing irregular plurals (*mice eater)* suggest that the crucial difference between regular and irregular plurals is the plural phonology found in regular plurals. While irregular plurals have plural semantics/morphology, regular plurals have both plural semantics/morphology and plural phonology. In addition, Haskell et al. found that irregular plurals were not as frequently found in compounds represented in corpora as irregular singulars were – irregular plurals have some of the features of regular plurals, but not all.

In attempting to address the phonology/syntax interaction in English, research can take advantage of these irregular plurals – nouns with plural semantics/morphology but no plural phonology. In addition it is possible to examine processing of another group of English words, termed *pseudoplurals*. This relatively small group consists of English words that have the phonological form of a plural but these words are not plural in morphology. Pseudoplurals end in tense vowel-/z/, voiced consonant-/z/, or voiceless consonant -/s/: examples are *cheese*, *adze*, and *ellipse*. Note that some words should be excluded from an experimental set of these words due to homophony with a genuine plural, such as *cokes-coax* or *rows-rose*. The set of genuine pseudoplurals is small in number as is the set of English irregulars. In addition, some irregular plurals end in /s/ or /z/ but do not have the phonological form of a plural (*geese, mice*) so can be included in an experimental set of irregular plurals; other irregular plurals however have a plural phonological form (*wives, knives*) so should be excluded. This means that the phonological cue for a plural is valid (few non-plurals take the phonological form of a plural) and frequent (few plurals are missing the phonological form of a plural) and hence reliable in English (Bates & MacWhinney, 1987).

In this study these three types of nouns – those with regular plurals, those with irregular plurals, and pseudoplurals – are compared in a grammatical priming paradigm. Participants are asked to repeat the final word in a sentence that either agrees grammatically, or does not agree, with the preceding word. These agreements are either be number-noun agreements such as:

> On the table I saw one/three *book/books*.

or noun-verb agreements such as:

> When the pile grows too big the book/books *falls/fall.*

Reaction time in repeating final words that agree grammatically with the preceding word will be compared with reaction time in repeating final words that do not agree grammatically. It is hypothesised that reaction times for regulars – both singular and plural – will be longer in ungrammatical than grammatical sentence contexts, and that this will also apply to irregulars in their singular form. However, reaction times for irregulars and for pseudoplurals will depend on whether their processing is influenced

by their morphology or by their phonology. Predictions under conditions in which each of these influences prevails are shown in Table 1. Given previous data from English and from other languages, it is hypothesised that phonology will have at least some influence on morphological processing. Detailed hypotheses are:

a) Agreement in sentences with regular singular and plural nouns, and irregular singular nouns, will be processed faster in grammatical sentences than in ungrammatical sentences.

b) Agreement in sentences with irregular plural nouns will not be processed faster in grammatical sentences than in ungrammatical sentences, as the phonology of these words will influence their processing. In this case, agreement in ungrammatical sentences will either be processed faster than in grammatical sentences (as if irregular plurals were singular nouns, if influenced only by their non-plural phonology) or at the same speed as in grammatical sentences (if influenced by both phonology and morphology).

c) Agreement in sentences with pseudoplurals will likewise not be processed faster in grammatical than ungrammatical sentences. For these nouns, agreement in ungrammatical sentences will again either be processed faster (as if the pseudoplurals were regular plurals, influenced only by their plural phonology) than in grammatical sentences, or at the same speed as in grammatical sentences (if influenced by both phonology and morphology).

Type of noun	Number	Morphology	Phonology	Comparisons	Predictions according to morphology	Predictions according to phonology
Regular	*Singular*	*Singular*	*Singular*	*G vs. U*	*G > U*	*G > U*
Irregular	*Singular*	*Singular*	*Singular*	*G vs. U*	*G > U*	*G > U*
Pseudoplural	*Singular*	*Singular*	Plural	*G vs. U and with Regular Singulars and Plurals*	*G > U; PS = R Sing.*	U > G; PS = R Plur.
Regular	*Plural*	*Plural*	*Plural*	*G vs. U*	*G > U*	*G > U*
Irregular	*Plural*	*Plural*	Singular	*G vs. U and with Regular Singulars and Plurals*	*G > U; I Plur. = R Plur.*	U > G; I Plur. = R Sing.

Table 1. *Types of nouns to be used in the study and comparisons to be made.*

G = Grammatical and U = Ungrammatical
R = Regulars, I = Irregulars
PS = Pseudoplurals.
Italics show conflicts between phonology and morphology.
G > U etc. show predictions with faster processing for G (Grammatical) than U (Ungrammatical).

Experiment 1 - Methods

Materials

A total of 20 words were chosen as stimuli in each of three categories: nouns that form regular plurals, nouns that form irregular plurals, and nouns that, in their singular form, have the same phonological form as a plural – *pseudoplurals*. These nouns all end in a tense vowel or voiced consonant followed by /z/ (such as *glaze*), or in a voiceless consonant followed by /s/ (such as *fox* – this group includes some that in general pronunciation end in /ts/ although this is not reflected in their spelling – such as *dance*). Pseudoplurals were excluded at this stage if their "singular" form was a real word (such as *nose – no*) or if they were homophones of third person singular present tense verbs (such as *rose – rows*). There is a limited number of such nouns in the English language and the regulars and irregulars were chosen to match the pseudoplurals for frequency, as far as possible, using Celex log10 frequencies (Kerkman et al., 1993). A total of 20 British-English speaking students taking Psychology classes were asked to rate the plurals of the irregular nouns, paired with a "regularised" plural (*mouse – mice – mouses*) along a five point scale ranging from 1 ("This is the only correct plural") to 5 ("Never heard this, you must have made it up"). For the irregular plurals chosen, the mean percentage of students choosing 1 or 2 ("This is correct but I've heard the other one") was 86.9% (s.d. = 10.14).

After excluding one very high frequency regular and one very low frequency pseudoplural, a one-way ANOVA showed no difference in Celex log10 frequencies between irregulars, regulars and pseudoplurals ($F_{2,56}$ = 1.43, p = .247). Sentences were therefore constructed using the regulars, irregulars, and pseudoplurals which ended in the noun preceded by a number, for example "The charity worker went to the high street and did one *collection*". For regulars and irregulars four forms of the sentence were written:

Singular noun, grammatical: "The charity worker went to the high street and did one *collection*"

Singular noun, ungrammatical: "The charity worker went to the high street and did three *collection*"

Plural noun, grammatical: "The charity worker went to the high street and did three *collections*"

Plural noun, ungrammatical: "The charity worker went to the high street and did one *collections*"

For pseudoplurals only singular noun, grammatical and singular noun, ungrammatical were written:

Grammatical: "To make the cake I bought one *mix*"

Ungrammatical: "To make the cake I bought three *mix*"

Regulars, irregulars, and pseudoplural singulars differ on two dimensions – morphology and phonology, with pseudoplurals having plural phonology but singular morphology. The plurals of singular pseudoplurals also have plural morphology as well as plural phonology, and hence in both respects resemble regular plurals: as regular plurals were already included in the experiment, regular pseudoplurals were not tested.

An additional 8 students were asked to rate the sentence with the singular, grammatical noun according to how well the final word completed the sentence on a scale of 1 to 5. There were no significant differences between word groups in how well the noun was judged to complete the sentence ($F_{2,56}$ = 1.21, p = .305). A further 7 students were asked to complete each sentence with a noun that fit; the proportion choosing the experimental noun was very low (mean of .71 nouns chosen out of 30) and there were no differences between word groups ($F_{2,56}$ = 2.37, p = .102).

The sentence stimuli were digitally recorded in their entirety by a female speaker (the author) with a short gap before the final word, to ensure a naturalistic intonation but also ease of auditory stimulus editing. The final word was then recorded by a male speaker separately, in a sentence-final intonation. The sentences were then edited using Audacity (a sound editing program) so that the same singular or plural token of each noun, in the male voice, appeared in each sentence containing that number of that noun. Each sentence therefore consisted of a nearly-complete sentence spoken in a female voice followed by a final noun spoken in a male voice. Sentences were then normalised for volume.

Participants

A total of 31 participants, all university students and hence with education up to the age of at least 18, completed the experiment. Participants were randomly assigned to each word list. Participants were either given a small payment for their time or, for Psychology students, were given credits that would translate into an opportunity to test participants themselves at a later date for credit. Two non-native English speakers were excluded immediately following testing.

Procedure

Four sets of recorded sentence sound files were created so that in each set for each regular and irregular noun one of the four sentence types was represented, with sentence types distributed randomly but evenly across the four sets. For pseudoplurals two sets contained the singular noun, grammatical sentence and two the singular noun, ungrammatical sentence. The order of sentences was randomised within each list and each participant heard one list.

Sentences were presented to participants using a computerised experimental environment running under Macintosh OSX. Participants were instructed to listen to each sentence and repeat the last word – the word spoken by a man – quickly and accurately, but not speaking until the final word had ended. It was explained that some sentences would end with a word that completed the sentence grammatically but that others would not; the participant should repeat the word exactly as they had heard it, and should try not to let such sentences bother them, but should repeat the word as they heard it. Participants were given five sentences (two with irregulars, one each with regulars and pseudoplurals) as practice items. Participants were seated so that they could not see the computer screen.

Voice reaction time to each sentence was measured using a custom button box. If participants started speaking before a word ended, or repeated the final word incorrectly, the instructions were repeated. If this happened more than once the practice was repeated. After each sentence in both practice and test session the experimenter pressed a key on the computer keyboard to indicate whether the response had been a correct repetition of the final word, or had been an incorrect repetition, had been spoken too early for the voice response box to register a response, or the participant had not spoken a response. After the experimenter coded each trial manually, there was a 2 second inter-trial interval.

The test session consisted of the remaining 18 sentences for each noun type presented in the same way, without a break – 54 trials in total. If participants spoke before the sentence had ended and hence the voice response box did not record a response, they were reminded up to three times to wait to make their response until they had heard all of the word. Likewise, if participants incorrectly repeated the word they were reminded to repeat exactly what they heard, without correcting any sentences, and asked if they would like the headphone volume increased. After three errors of either type no further reminders were made.

Analysis

Each participant's error rate was analysed and three further participants who made errors on more than 10% of trials were excluded. In total 26 participants (18 female) therefore contributed analysable data. These participants' mean age was 19.4 years (s.d. 0.78).

Analyses presented below are in the following form: F1/t1 are Participants analyses and F2/t2 are Items analyses. Items analyses are only presented where Participants analyses reached or approached ($p < .1$) significance. An alpha level of .05 was used and familywise Holm-Bonferroni corrections (Holm, 1979) were carried out on post-hoc ANOVAs and pairwise comparisons, taking each group of comparisons in each experiment (subjects analyses involving regular and irregular plurals, those involving pseudoplurals, and the two parallel sets of items analyses) to constitute separate "families".

Experiment 1 – Results

Comparison of the processing of irregulars to the processing of regulars

A 2 by 2 by 2 ANOVA was carried out examining the effects of grammaticality and of regularity, with regular and irregular words in plural and singular. Responses were slower to regulars than irregulars, and responses were slower to ungrammatical than grammatical sentences with regulars, but there was no overall difference between ungrammatical and grammatical sentences with irregulars; there was some difference between singular irregulars but none between plural irregulars on grammatical and ungrammatical sentences.

Significant main effects of grammaticality ($F1_{1,25} = 10.51$, $p = .003$, $\eta^2 = .30$, $F2_{1,136} = 4.36$, $p = .039$, $\eta^2 = .03$) and of regularity/type of noun were seen ($F1_{1,25} = 17.24$, $p < .001$, $\eta^2 = .41$, $F2_{1,136} = 6.01$, $p = .015$, $\eta^2 = .04$), as well as an interaction between grammaticality and noun type ($F1_{1,25} = 4.71$, $p = .040$, $\eta^2 = .16$, $F2_{1,134} = 5.21$, $p = .024$, $\eta^2 = .04$). An interaction between noun type, grammaticality, and number approached significance ($F1_{1,25} = 3.35$, $p = .079$, $\eta^2 = .12$, F2 n.s.). These data can be seen in Figure 1 (next page).

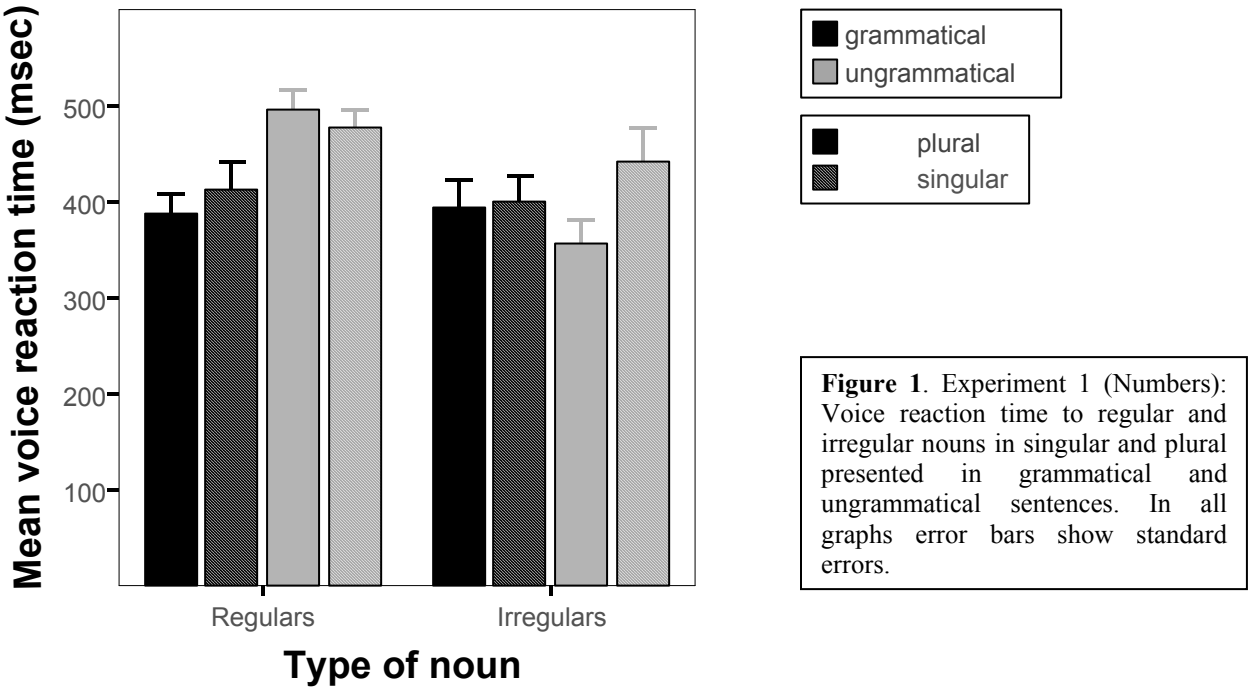

Figure 1. Experiment 1 (Numbers): Voice reaction time to regular and irregular nouns in singular and plural presented in grammatical and ungrammatical sentences. In all graphs error bars show standard errors.

Grammaticality effects within regulars and irregulars

Two sub-ANOVAs examined the effects of grammaticality and number within regulars and irregulars. Within regulars, a main effect of grammaticality was found ($F1_{1,25} = 16.11$, $p = .003$, $\eta^2 = .39$,$F2_{1,68} = 10.23$, $p = .017$, $\eta^2 = .14$) but no effect of number nor any interaction. Within irregulars, no significant effects of grammaticality or number nor any interaction were found.

Do irregular plurals behave like regular plurals?

Irregular nouns are not behaving exactly like regular nouns in showing a grammaticality effect: in fact, they show no overall grammaticality effect. If irregular plurals are being processed exactly as if they were plurals (according to their morphology), this grammaticality effect should have been found, and there should be no grammaticality/regularity interaction.

If, however, irregular plurals are being processed exactly as if they were singulars (according to their phonology), then the predictions from Table 1 are that:

1) *Irregular plurals in ungrammatical sentences should be processed* faster *than irregular plurals in grammatical sentences.* As shown above, no grammaticality effect was found.

2) *Processing of irregular plurals in morphologically ungrammatical but phonologically plausible sentences should be equivalent to processing of regular singulars in grammatical sentences.* So, processing of sentences such as "*The old lady had one grandchildren*" should not differ from those such as *"The old lady had one nephew";* and vice versa.

T-tests were carried out to examine prediction 2. Processing of regular singulars in grammatical sentences did not differ from processing of irregular plurals in ungrammatical sentences, but processing of regular singulars in ungrammatical sentences was significantly slower than processing of irregular plurals in grammatical (but phonologically implausible) sentences ($t1_{25} = 4.15$, $p = .003$, $d = 0.84$, t2 n.s.). These comparisons can also be seen in Figure 1. Irregular plurals are hence processed neither like regular plurals nor like regular singulars.

Comparison of the processing of pseudoplurals to the processing of regulars and irregulars

Irregular, regular and pseudoplural singular nouns, in grammatical and ungrammatical sentences, were compared in a 3 by 2 ANOVA (pseudoplurals were not presented in the plural). An effect of type of noun was seen that approached significance ($F1_{2,50} = 2.53$, $p = .090$, $\eta^2 = .09$, F2 n.s.) as well as a

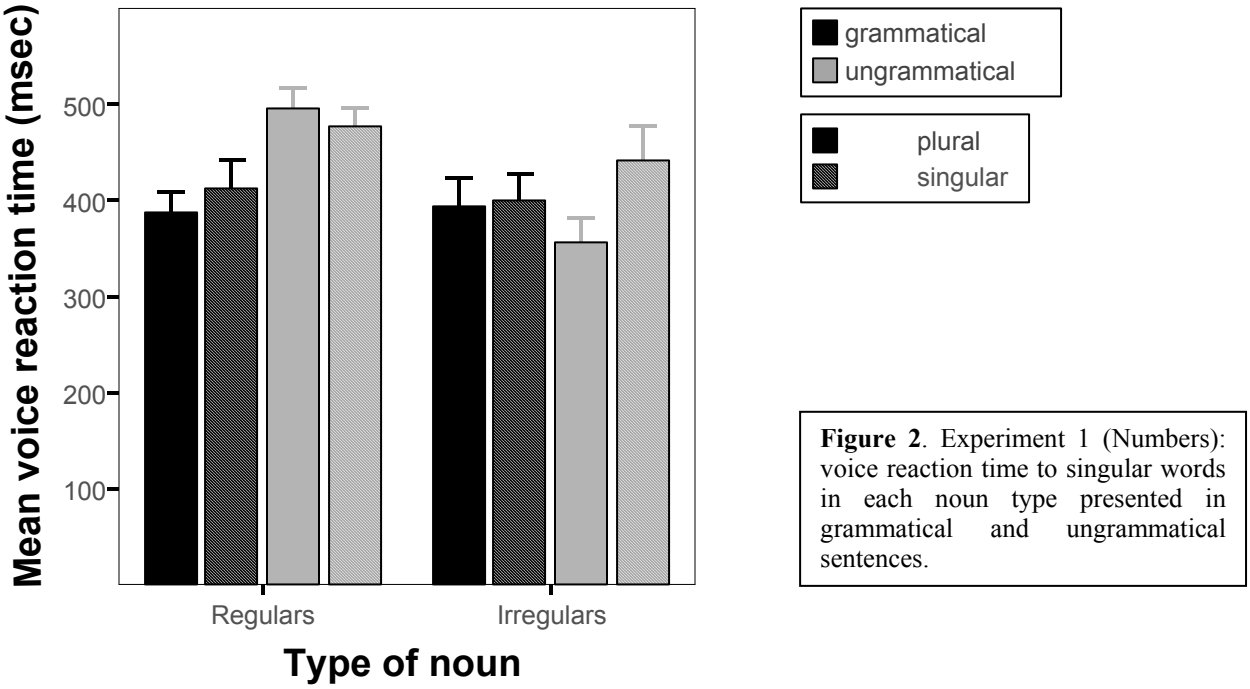

Figure 2. Experiment 1 (Numbers): voice reaction time to singular words in each noun type presented in grammatical and ungrammatical sentences.

significant effect of grammaticality ($F1_{1,25} = 5.32$, $p = .030$, $\eta^2 = .18$, F2 n.s.) but no significant interaction between the two. Reaction times were slower to regular nouns than to irregular nouns or pseudoplurals, and slower to ungrammatical sentences than to grammatical sentences. Post-hoc t-tests were carried out and revealed that for regular nouns there was a significant difference between grammatical and ungrammatical sentences ($t1_{25} = -4.01$, $p = .002$, $d = 0.80$, $t2_{64} = 3.32$, $p = .006$, $d = 0.83$), but there was no difference between grammatical and ungrammatical sentences for either irregular nouns or pseudoplurals. Data from these comparisons can be seen in Figure 2.

Do pseudoplurals behave like regular singulars?

If pseudoplurals are processed as if they were regular single nouns (according to their morphology) then they should show a grammaticality effect, with ungrammatical sentences being processed more slowly than grammatical sentences, like regular nouns. However, no such grammaticality effect is seen.

If, in contrast, they are processed as if they were plural nouns (according to their phonology) then the predictions of Table 1 are:

1) *Processing times for pseudoplurals in morphologically grammatical/phonologically implausible conditions should be* longer *than in morphologically ungrammatical/phonologically plausible conditions.* No grammaticality effect is seen in this comparison in either direction (see above), so this prediction is disconfirmed.

2) *Processing times for pseudoplurals in morphologically ungrammatical, but phonologically plausible, contexts should resemble those for regular plural nouns in grammatical contexts, and vice versa*.

T-tests were again carried out to examine prediction 2. Regular plural nouns in grammatical contexts ("On the counter in the shop I saw three *cakes*") were not processed faster than pseudoplurals in morphologically ungrammatical, but phonologically plausible contexts ("On the counter in the shop I saw three *cheese*"). However, the difference between regular plural nouns in ungrammatical contexts and pseudoplurals in morphologically grammatical, but less phonologically plausible contexts ("On the counter in the shop I saw one *cakes*" versus "On the counter in the shop I saw one *cheese*") was significant – pseudoplurals in grammatical contexts were processed faster ($t1_{25} = 3.02$, $p = .029$, $d = 0.59$, $t2_{36} = 2.77$, $p = .070$, $d = 0.90$). These data can be seen in Figure 3 (next page). Again, pseudoplurals were not processed either in the same way as regular singulars or in the same way as regular plurals.

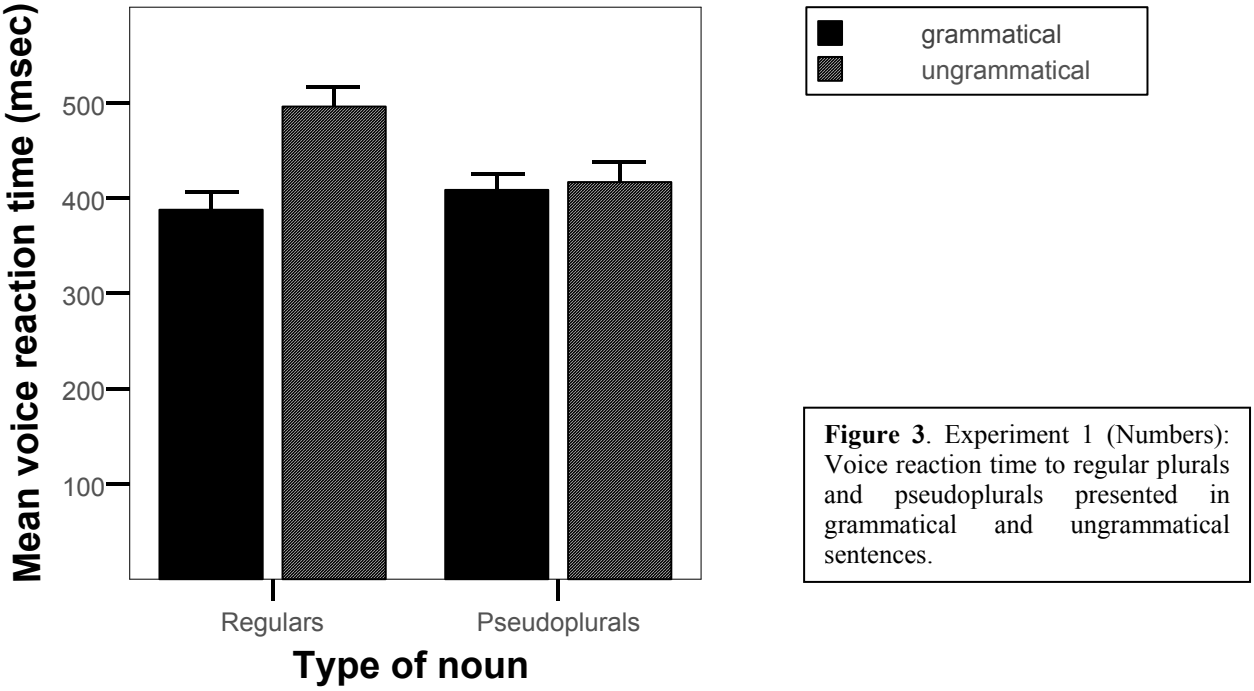

Figure 3. Experiment 1 (Numbers): Voice reaction time to regular plurals and pseudoplurals presented in grammatical and ungrammatical sentences.

Experiment 1 – Discussion

From this experiment, previous findings (Haskell et al., 2003) have been replicated showing that irregular plurals do not behave entirely like regular plurals. An ungrammatical context does not slow processing of irregular plurals significantly in the same way that it slows processing of regular plurals. In fact, irregular plurals in ungrammatical (but phonologically plausible) sentences are processed no more slowly than regular singular nouns in grammatical sentences – in other words, nouns with the same phonology in the same sentence context, but with different morphology.

Neither, however, do irregular plurals behave exactly like regular singulars. Processing of irregular plurals in morphologically grammatical contexts is faster than processing of regular singular nouns in the same contexts, where the singular nouns are morphologically ungrammatical *and* phonologically implausible.

In addition, it has been shown that pseudoplurals – words which are the opposite of irregular plurals, in that they are phonologically plural but morphologically singular – also behave neither exactly like regular singulars nor like regular plurals. Pseudoplurals do not show a grammaticality effect: processing of ungrammatical sentences such as "*On the counter in the shop I saw three cheese*" is no slower than processing of grammatical sentences such as "*On the counter in the shop I saw one cheese*". Likewise, processing of pseudoplurals in an ungrammatical, but phonologically plausible context is no slower than processing of regular nouns in a grammatical context.

Unlike Bock and Eberhard (1993) who found that words that phonologically resemble plurals were processed like regular singulars, here it can be seen that the phonology of pseudoplurals appears to be affecting their processing. In Bock and Eberhard's experiment some of the nouns used as pseudoplurals did not have the phonological form of a plural (e.g. *course*; this word ends in /s/ but the plural of the word *coor* would end in /z/); these comprise 26 out of the 30 pseudoplurals in their Experiment 1; 11 of these in addition end in lax vowel-/s/ (e.g. *kiss*); recall that English plurals that have a penultimate vowel generally have a tense vowel in this position, and in addition have final /z/ (e.g. *keys*). In Bock & Eberhard's Experiment 2, all of the pseudoplurals had the same phonological form as a genuine plural (*size/sighs*) but were presented visually. Either of these characteristics of the pseudoplurals in Bock and Eberhard's experiment could have prevented any pseudoplural effect from occurring – or alternatively, the visual presentation may have cued participants to process those pseudoplurals that were genuinely plural-like (four in Experiment 1 and all in

Experiment 2) as singulars, since pseudoplurals have singular orthography (none are spelled with an –s ending). However, Bock and Eberhard also failed to find a regularity effect in their Experiment 3, while other researchers using different paradigms have found parallel effects with irregular plurals (Haskell et al., 2003), so it is possible that using a different paradigm Bock and Eberhard's pseudoplural stimuli would show effects.

In the current experiment, pseudoplurals do not however show a grammaticality effect in the opposite direction either: processing of ungrammatical sentences is not faster than that of grammatical sentences. Likewise, processing of grammatical, phonologically implausible sentences is faster than processing of regular nouns in ungrammatical contexts.

From these results it seems that nouns need to resemble regular nouns both in phonology and in morphology for their processing to resemble regular nouns. Next, Experiment 2 will attempt to replicate this finding using a different sentence context, in which the singular and plural target nouns agree grammatically (or not) with a present tense verb.

Experiment 2 – Methods

Materials

Materials for Experiment 2 were constructed in the same way as for Experiment 1 except that sentences were of the form:

Singular noun, grammatical:
After a day of waiting, the meal *satisfies*.

Singular noun, ungrammatical:
After a day of waiting, the meal *satisfy*.

Plural noun, grammatical:
After a day of waiting, the meals *satisfy*.

Plural noun, ungrammatical:
After a day of waiting, the meals *satisfies*.

Sentences in Experiment 2 were also rated by 8 Psychology undergraduates for how well the final word completed the sentence, and a further 11 undergraduates provided a word to complete the sentence. Again there was no significant difference between noun groups in how well the final word of the sentence was judged to complete the sentence, nor in how frequently the raters chose the target verb as the sentence completion. As different verbs were used for each set of nouns, the frequency of the verbs chosen was also compared between the three noun types and no significant differences were found.

Participants

Participants were recruited from the same student participant pool and were compensated in the same manner. In total 29 participants completed this experiment, and data from four participants could not be used because participants made errors on more than 10% of trials. One further participant had to be excluded due to equipment failure, leaving data to be analysed from 24 participants (16 female; mean age 20.4 years, s.d. 2.45).

Procedure and analysis

Instructions to participants were the same as in Experiment 1, except that appropriate examples of sentences with grammatical and ungrammatical verb-noun agreements were presented. Analysis was as in Experiment 1.

Results

Comparison of the processing of irregulars to the processing of regulars

A 2x2x2 ANOVA compared reaction time to sentences containing regular versus irregular nouns, singulars versus plurals, and with grammatical versus ungrammatical noun-verb agreements. Regulars were processed faster than irregulars, and grammatical sentences faster than ungrammatical sentences. However, while ungrammatical singulars were processed more slowly than grammatical singulars, for plurals the pattern was reversed.

Main effects of type of noun ($F1_{1,23} = 20.10$, $p < .001$, $\eta^2 = .47$, $F2_{1,136} = 5.63$, $p = .019$, $\eta^2 = .04$) and of grammaticality ($F1_{1,23} = 6.89$, $p = .015$, $\eta^2 = .23$, F2 n.s.) as well as an interaction between number and grammaticality ($F1_{1,23} = 32.29$, $p < .001$, $\eta^2 = .58$, $F2_{1,136} = 15.19$, $p < .001$, $\eta^2 = .10$) were seen. Two separate sets of sub-ANOVAs were then carried out to examine irregulars and regulars independently, and to examine further the interaction between number and grammaticality.

Grammaticality effects within regulars and irregulars

For regular nouns, grammatical sentences were processed more quickly than ungrammatical sentences with singular nouns, and the opposite was true for plural nouns. A significant interaction between number and grammaticality was seen ($F1_{1,23} = 11.49$, $p = .025$, $\eta^2 = .33$, F2 n.s.).

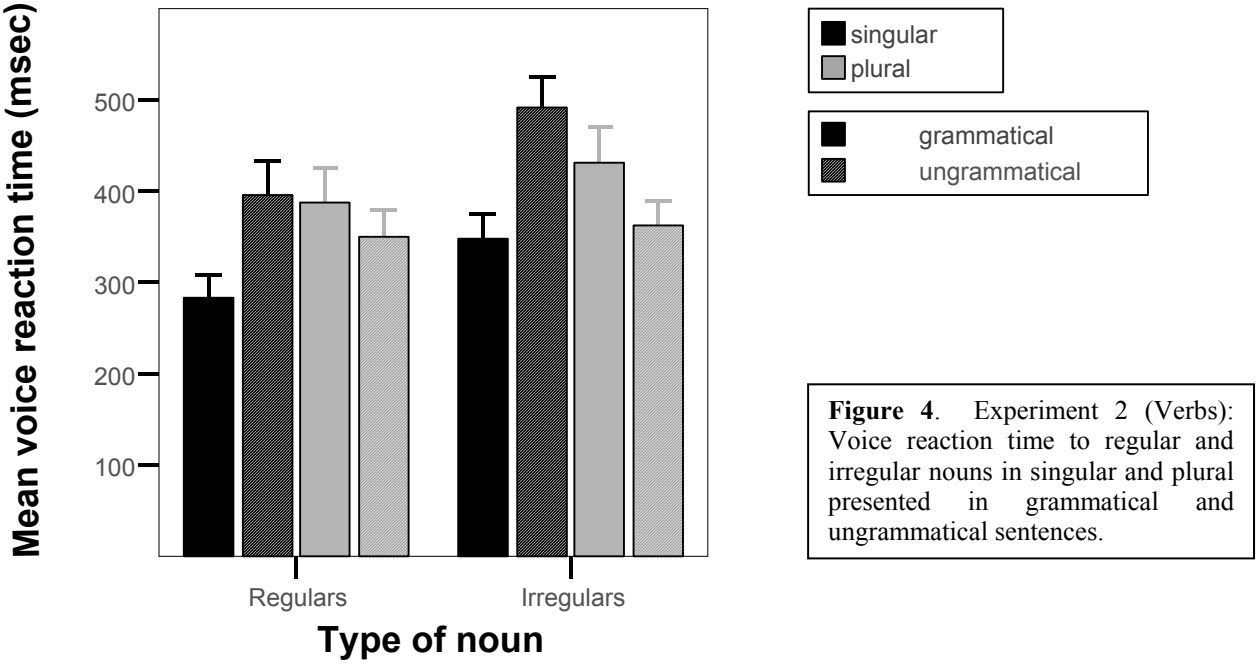

Figure 4. Experiment 2 (Verbs): Voice reaction time to regular and irregular nouns in singular and plural presented in grammatical and ungrammatical sentences.

For irregular nouns likewise, no difference between grammatical and ungrammatical sentences was found but singular grammatical sentences were processed faster than ungrammatical, and plural ungrammatical sentences were processed faster than grammatical. An interaction between number and grammaticality was found ($F1_{1,23} = 24.73$, $p = .001$, $\eta^2 = .52$, $F2_{1,68} = 10.36$, $p = .026$, $\eta^2 = .13$).

Grammaticality effects within singulars and plurals

For singular nouns, grammatical sentences were processed faster for both noun types, and regulars were processed faster than irregulars. Significant effects of grammaticality ($F1_{1,23} = 32.39$, $p < .001$, $\eta^2 = .59$, $F2_{1,68} = 25.07$, $p < .001$, $\eta^2 = .20$) and of type of noun ($F1_{1,23} = 14.26$, $p = .011$, $\eta^2 = .38$, F2 n.s.) were found but no interaction between the two.

For plural nouns, no effects of grammaticality or noun type and no interaction was found. In fact, rather than being processed more slowly ungrammatical sentences containing either irregular or regular plural nouns were processed *faster* than grammatical sentences, though the difference was not significant. The data from all of these comparisons can be seen in Figure 4 (above).

Do irregular plurals behave as if they were regular/according to their morphology?

If irregular plurals behave as if they were regular (are processed according to their morphology), then Table 1 predicts:

1) *a grammaticality effect should be seen whereby grammatical sentences should be processed faster than ungrammatical sentences*. However, when grammaticality in plurals is examined, there is no significantly faster processing for grammatical plurals: in fact, for both irregular and regular plurals *ungrammatical* nouns are processed faster than *grammatical* nouns. This difference is not significant but an was interaction found in the ANOVA above for irregular nouns which shows faster processing of ungrammatical than grammatical sentences with irregular plurals but the opposite for irregular singulars; the same interaction for regular nouns approaches significance.

However, if irregular plurals behave as if they were singulars, then Table 1 predicts:

> 1) *Processing of irregular plurals in ungrammatical sentences (which are morphologically plausible) will be* faster *than processing in grammatical (but*

morphologically plausible) sentences. There is a difference in this direction – ungrammatical sentences like "*Every school holiday the grandchildren visits*" are processed faster than grammatical sentences like "*Every school holiday the grandchildren visit*" – but this difference is not significant.

2) *processing of irregular plurals in ungrammatical sentences should mirror that of regular singulars in grammatical sentences, and vice versa.* Ungrammatical irregular plurals were however processed significantly more slowly than grammatical regular singulars ($t1_{23}$ = 4.20, p = .004, d = 0.90, t2 n.s.) and there was a trend in the same direction which did not reach significance for grammatical irregular plurals and ungrammatical regular singulars.

An additional possibility that was not predicted by the original hypotheses, nor hinted at by data from Experiment 1, must now also be considered:

Do regular plurals behave like regular singulars?

It appears that among regular plural nouns also, grammaticality differences are not seen in the expected direction. Table 1 predicts:

1) *For regular plural nouns, grammatical sentences will be processed significantly faster than ungrammatical sentences*. In fact, the opposite was found: ungrammatical sentences with regular plurals ("*Every summer the nephews visits*") were processed slightly faster than grammatical sentences with regular plurals ("*Every summer the nephews visit*"). This is in contrast to Experiment 1 where a strong grammaticality effect was seen in the expected direction for both singular and plural regulars.

It is possible that this anomalous finding is due to some effect of final phonological harmony – both regular plural nouns and singular verbs end in /s/ or /z/ (syllabic or non-syllabic). Phonological harmony of a variety of types exists in several languages, as well as in immature language, and can include place as and manner of articulation, but also voicing (as in the general English pronunciation of *newspaper* with /s/ rather than /z/) (Hansson, 2007). If this is the case then this effect should not be seen, or should not be as strong, with irregular plurals; in fact, the effect was seen, and there was no interaction between regularity and grammaticality among plurals – the effect was just as strong in each type of noun. However, the ungrammaticality effects in regulars and irregulars could be for different reasons: regular plural nouns could be exhibiting some form of phonological harmony, while irregular plural nouns could simply be behaving like their phonological analogues, regular singulars.

If this is the case, though, it is puzzling that such a phonological harmony effect does not prevent regular singular nouns from being processed faster with singular verbs, with which there is no phonological harmony ("*Every summer the nephew visits"*). It is also possible that for verb-noun pairs where the phonological harmony is complete, in that voicing is the same on both words (both words ending in /s/ or /z/: so in "*Every summer the nephews plays"* both *nephews* and *plays* end in /z/ but in "*Every summer the nephews visits*", *visits* ends in /s/), more difference would be found between grammatical and ungrammatical sentences. Although the final consonant in these pairs cannot change to accommodate phonological harmony (as in *newspaper)*, it is possible that the match or mismatch between the consonants could speed or slow processing even where there this consonant change mechanism does not exist. This possibility was examined however using an ANOVA examining the effects of grammaticality and phonological harmony in regular plurals but no effect of phonological harmony was seen, nor any interaction with grammaticality.

In Experiment 1, it was seen that pseudoplurals did not behave exactly like regular singulars, but nor did they behave exactly like regular plurals. Pseudoplurals share a phonological form with regular plurals and hence with singular verbs. However, they have singular morphology; if a similar effect is found with pseudoplurals this may still imply that this ungrammaticality effect is due to phonological harmony. Now, therefore, the processing of pseudoplurals will be examined.

Comparison of the processing of pseudoplurals to the processing of regulars and irregulars

Irregular, regular and pseudoplural singular nouns, in grammatical and ungrammatical sentences, were compared in a 3x2 ANOVA (pseudoplurals were not presented in the plural). Reaction times were fastest for regular nouns, slowest for irregular nouns, and intermediate for pseudoplurals. Reaction times were also slower for ungrammatical than grammatical sentences. Main effects of type of noun ($F1_{2,46}$ = 9.10, $p < .001$, $\eta^2 = .28$, $F2_{2,102} = 4.48$, $p = .014$, $\eta^2 = .08$) and of grammaticality ($F1_{1,46} = 45.59$, $p < .001$, $\eta^2 = .66$, $F2_{1,102} = 25.07$, $p < .001$, $\eta^2 = .20$) were found and but there were no interactions.

Post-hoc t-tests comparing grammatical and ungrammatical sentences for each type of noun

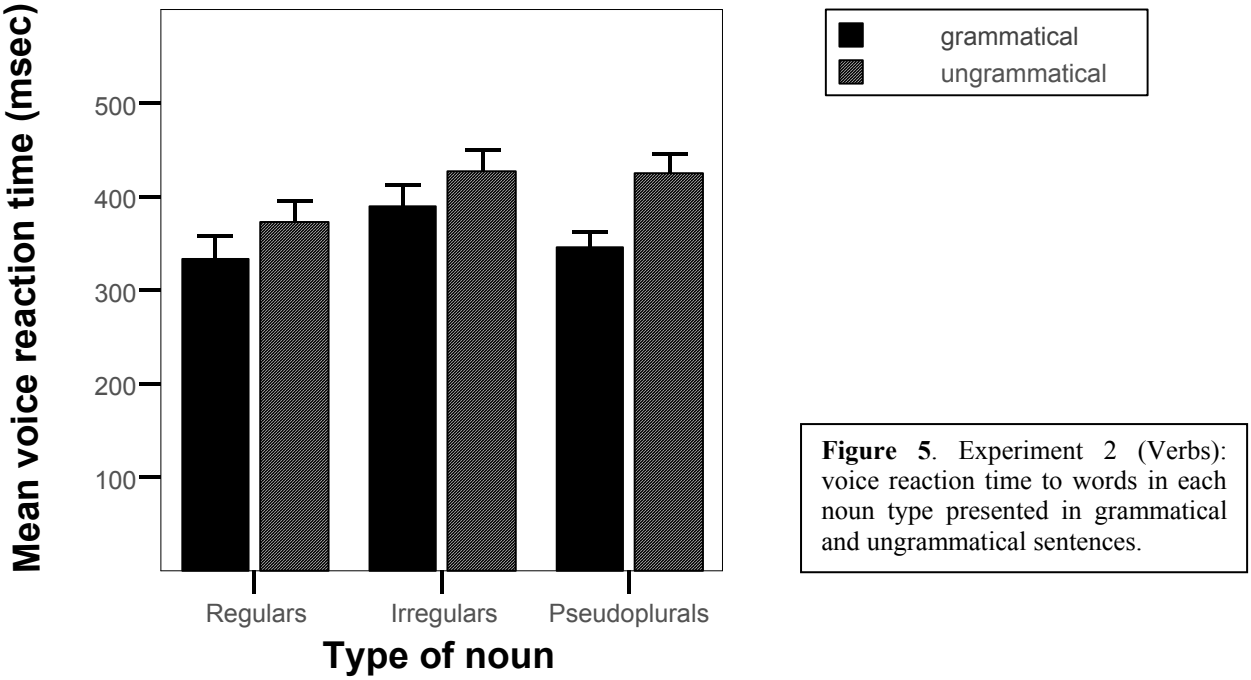

Figure 5. Experiment 2 (Verbs): voice reaction time to words in each noun type presented in grammatical and ungrammatical sentences.

showed, in contrast to Experiment 1, that an overall grammaticality effect was seen for regular nouns ($t1_{23} = 4.50$, $p = .001$, $d = 0.92$, $t2_{34} = 2.53$, $p = .096$, $d = 0.85$), for pseudoplurals ($t1_{23} = 5.26$, $p < .001$, $d = 1.08$, $t2_{34} = 3.09$, $p = .028$, $d = 1.03$) and for irregular nouns ($t1_{23} = 4.55$, $p = .001$, $d = 0.93$, $t2_{34} = 3.34$, $p = .016$, $d = 1.11$). Data from these comparisons can be seen in Figure 5 (above).

Do pseudoplurals behave like regular singulars?

If pseudoplurals behave like regular singulars, Table 1 predicts that:

> *1) Processing of ungrammatical sentences will be* slower *than processing of grammatical sentences, similarly to regular singulars.* An ANOVA examined regular singulars and pseudoplurals alone. Main effects of type of noun ($F1_{1,23} = 8.15$, $p = .036$, $\eta^2 = .26$, F2 n.s.) and of grammaticality ($F1_{1,23} = 36.57$, $p < .001$, $\eta^2 = .61$, $F2_{1,68} = 13.97$, $p = .003$, $\eta^2 = .17$) were seen, but no interaction. Pseudoplurals are therefore behaving in these sentences in the same way as regular singulars, although processing of pseudoplurals overall was slower than processing of regulars.

However, given the anomalous behaviour of regular plurals and the behaviour in Experiment 1 of pseudoplurals, it is worth examining in addition the question:

Do pseudoplurals behave like regular plurals?

Table 1 above predicts that if pseudoplurals are processed according to their phonology:

> *1) pseudoplurals will behave like regular plurals and that for both of these types of nouns sentences with plural verbs will be processed* faster *than sentences with singular verbs.* Recall that there was no such difference with regular plurals; in fact the opposite was found. A 2x2 ANOVA comparing regular plurals with pseudoplurals showed no effects of grammaticality or of noun type but a significant interaction between noun type and grammaticality ($F1_{1,23} = 14.83$, $p = .004$, $\eta^2 = .39$, F2 n.s.). Pseudoplurals were processed overall more similarly to regular plurals than to regular singulars: there was no difference in speed of processing between the two noun types, but ungrammatical regular plural sentences ("*In hot weather the cakes spoils*") and grammatical pseudoplural sentences ("*In hot weather the cheese spoils*") are both processed faster than the opposite type of sentence (grammatical regular plural sentences, "*In hot weather the cakes spoil*" and ungrammatical pseudoplural sentences, "*In hot weather the cheese spoil*"): these sentences resemble each other in the phonology of the noun, but not in their grammaticality. These data can be seen in Figure 6 (next page).

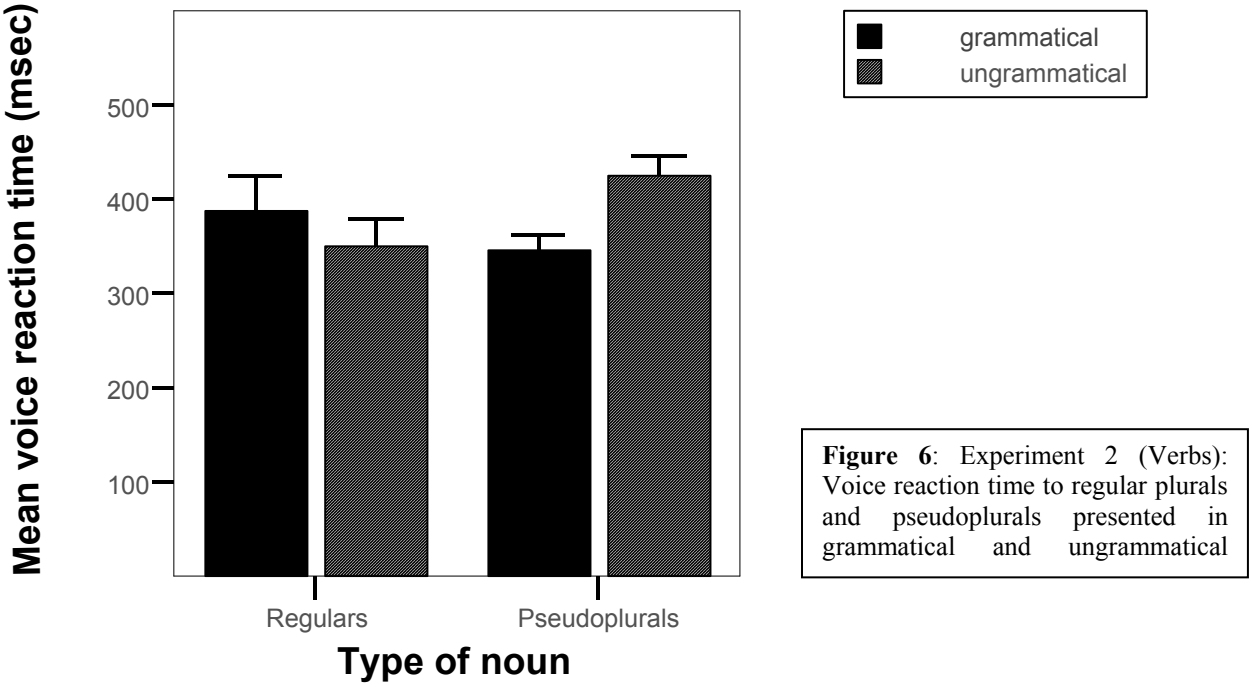

Figure 6: Experiment 2 (Verbs): Voice reaction time to regular plurals and pseudoplurals presented in grammatical and ungrammatical

Experiment 2: Discussion

Experiment 2 partially replicated the findings of Experiment 1: irregular plurals were processed as if they were regular singulars, in other words, according to their phonology rather than their morphology. However, surprisingly, regular plurals were also processed as if they were regular singulars: processing was slowed in *grammatical* sentences with regular plurals ("When they see a car the dogs *run*") compared to *ungrammatical* sentences with regular plurals ("When they see a car the dogs *runs*"). This difference was not significant, but recall in Experiment 1 there was a significant overall effect of grammaticality in regular nouns, including regular plural nouns.

Pseudoplurals were processed in a similar manner to both regular plurals and regular singulars: although it is not possible to entirely distinguish between the two, the overall speed of processing of pseudoplurals sentences was closer to that of regular plurals than that of regular singulars. Unlike in Experiment 1, therefore, pseudoplurals did show a significant grammaticality effect in the direction that would be predicted from their morphology.

Although based on off-line grammaticality judgments regular plurals should not show this pattern of processing, there are dialect effects that may explain these findings. The Northern Subject Rule (NSR – see, for example, McCafferty, 2003) describes the use of verbs with –s endings with all persons except for adjacent personal pronouns; so a plural noun adjacent to a singular verb would be acceptable. Although this agreement form was originally found in Northern parts of the UK, with some migration to the Southern United States, it has in recent years been observed amongst younger speakers in Southern England (Cheshire, 2005). Participants in Experiment 2 were not exclusively Northern British English speakers, but included a significant proportion of Southern British English speakers as well as some non-British English speakers. However, all participants in Experiment 2 were young. It is possible that this phenomenon is due to a very recent geographical spread of a formerly localised dialect phenomenon, so that older participants who are speakers of a variety of dialects of British English may not show this pattern of results. With this in mind, Experiment 3, attempts to replicate these findings with older participants.

Experiment 3 - Methods

Materials

The materials used in Experiment 3 were the same as those used in Experiment 2.

Participants

Participants were recruited from articles in the local press and from local senior and adult education classes, and were given a small payment for their

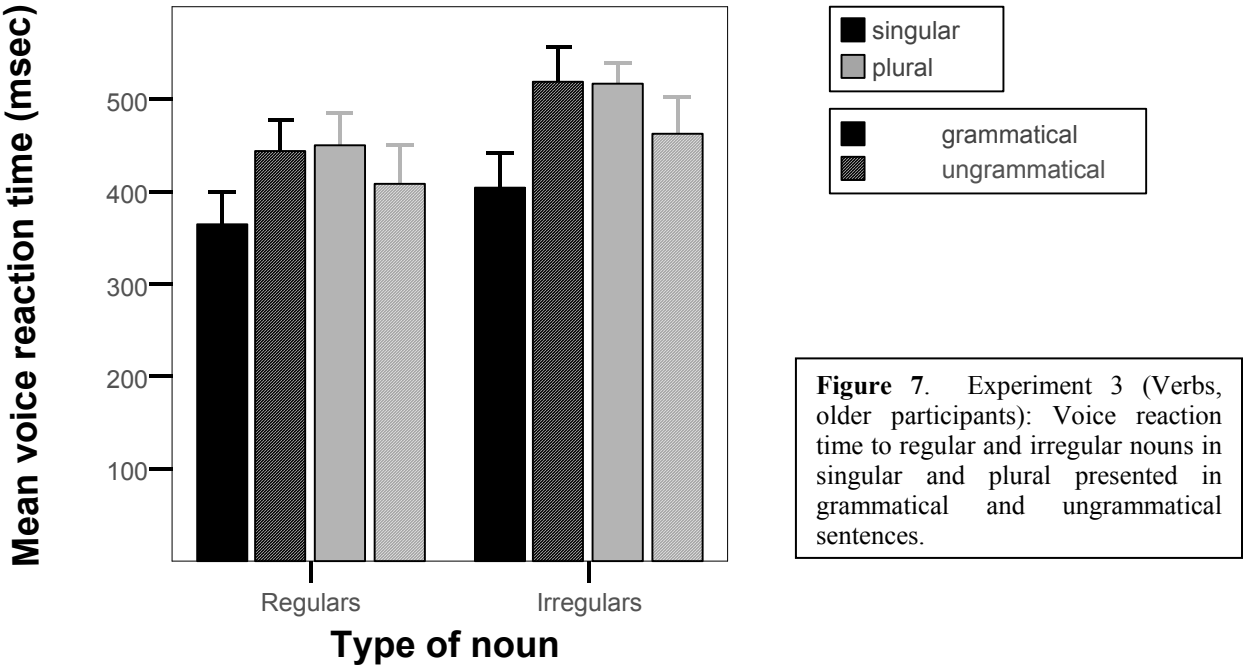

Figure 7. Experiment 3 (Verbs, older participants): Voice reaction time to regular and irregular nouns in singular and plural presented in grammatical and ungrammatical sentences.

time. All participants in Experiment 3 were between the ages of 50 and 80, and had equivalent education to the students participating in Experiments 1 and 2, to at least the age of 18. A total of 38 participants completed testing and the data of eight had errors on more than 10% of trials, and were excluded. Hence data was analysed from 30 participants (20 female), mean age 62.7 years, s.d. 6.80. Participants were not selected for dialect but were native speakers of a variety of dialects of British English. Although more participants failed to meet error criteria in Experiment 3, a non-parametric comparison between participant exclusion rates in the three experiments showed this difference was not significant.

Procedure and Analysis

These were identical to those used in Experiment 2.

Results

Comparison of the processing of irregulars to the processing of regulars

Again a 2x2x2 ANOVA compared reaction time to sentences with regular/irregular nouns, singulars/plurals and grammatical/ungrammatical final verbs. In this experiment a main effect of type of noun was seen ($F1_{1, 29} = 5.87$, $p = .022$, $\eta^2 = .17$, $F2_{1,136} = 5.46$, $p = .021$, $\eta^2 = .04$), but no main effects of grammaticality or number. An interaction between number and grammaticality was also seen ($F1_{1,29} = 10.14$, $p = .003$, $\eta^2 = .26$, $F2_{1, 136} = 8.08$, $p = .005$, $\eta^2 = .06$).

Regulars were again processed faster than irregulars, and again for singulars ungrammatical sentences were processed more slowly while for grammatical sentences the pattern was reversed; there was no overall significant difference between grammatical and ungrammatical sentences. In this experiment two sub-ANOVAS were carried out examining regulars and irregulars separately.

Grammaticality effects within regulars and irregulars

For regular nouns, no main effects were found nor any interaction. Grammatical sentences were not processed faster than ungrammatical sentences overall. For irregular nouns there were also no main effects but an interaction between grammaticality and number was found ($F1_{1,29} = 8.32$, $p = .049$, $\eta^2 = .22$, F2 n.s.). Here, grammatical sentences were processed faster with singular nouns and slower with plural nouns. The data from all of the above comparisons can be seen in Figure 7 (above).

Do irregular plurals behave as if they were regular/according to their morphology?

If irregular plurals behave as if they were regular (are processed according to their morphology), then Table 1 predicts:

> 1) *a grammaticality effect should be seen whereby grammatical sentences should be processed faster than ungrammatical sentences*. However, when grammaticality in plurals is

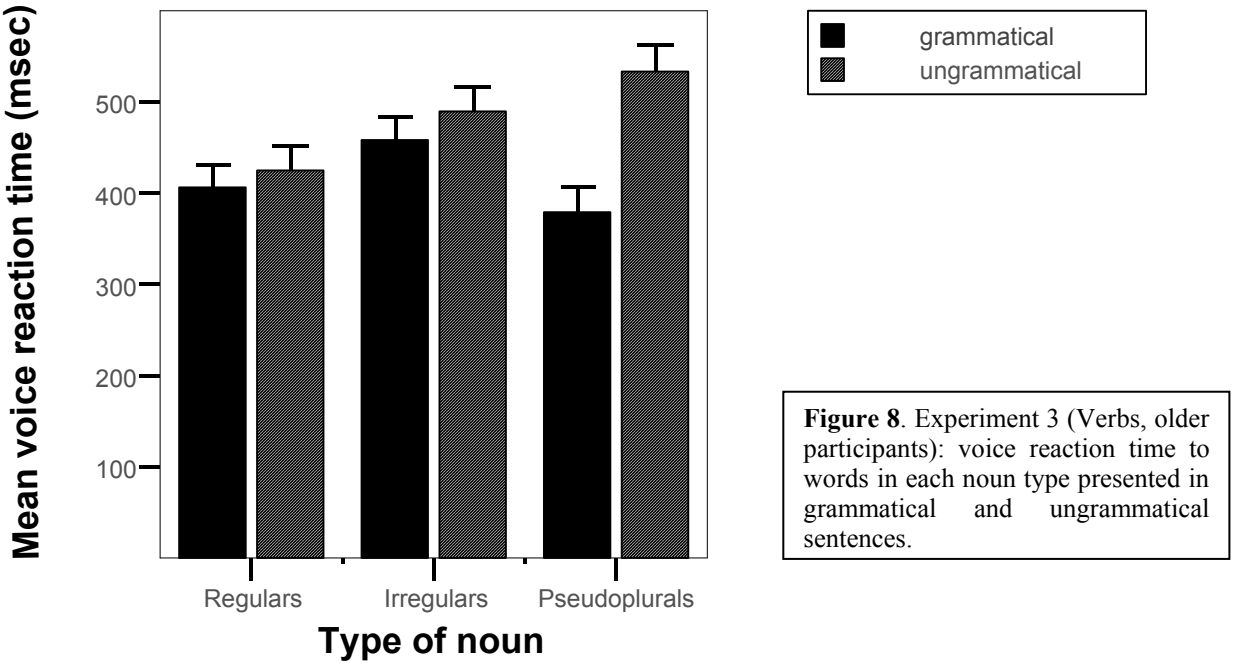

Figure 8. Experiment 3 (Verbs, older participants): voice reaction time to words in each noun type presented in grammatical and ungrammatical sentences.

examined, for both irregular and regular plurals *ungrammatical* nouns are processed faster than *grammatical* nouns. This difference was not significant, but neither do irregular plurals show a significant grammaticality effect in the direction predicted by their morphology.

However, if irregular plurals behave as if they were singulars, then Table 1 predicts:

1) *processing of irregular plurals in ungrammatical sentences (which are morphologically plausible) will be* faster *than processing in grammatical (but morphologically plausible) sentences.* There was no significant difference however between processing of grammatical and ungrammatical irregular plurals.

2) *processing of irregular plurals in ungrammatical sentences should mirror that of regular singulars in grammatical sentences, and vice versa*. Ungrammatical irregular plurals were in this experiment processed significantly more slowly than grammatical regular singulars ($t1_{29}$ = 3.13, p = .032, d = 0.58, t2 n.s.) and there was a trend in the same direction which did not reach significance for grammatical irregular plurals and ungrammatical regular singulars.

Recall that no overall grammaticality effect was found for regular nouns, and from inspection of Figure 7 it can be seen that as in Experiment 2 regular singulars were processed faster in grammatical than ungrammatical sentences while for regular plurals the opposite is true. The same question asked in Experiment 2 must now be reconsidered:

Do regular plurals behave like regular singulars?

Table 1 predicts again that:

For regular plural nouns, grammatical sentences will be processed significantly faster *than ungrammatical sentences*. In fact, as in Experiment 2, the opposite was found: ungrammatical sentences were processed slightly faster than grammatical sentences; again however, this difference was not significant.

Comparison of the processing of pseudoplurals to the processing of regulars and irregulars

Irregular, regular and pseudoplural singular nouns, in grammatical and ungrammatical sentences, were again compared in a 3x2 ANOVA. A main effect of grammaticality was found ($F1_{1,29}$ = 19.83, p < .001, η^2 = .41, $F2_{1,102}$ = 18.23, p < .001, η^2 = .152) but the effect of type of noun only approached significance ($F1_{2,58}$ = 2.57, p = .086, η^2 = .081, F2 n.s.) and there was no interaction between type of noun and grammaticality. Reaction times were slower for ungrammatical than grammatical sentences and

slower for irregulars and pseudoplurals than for regulars. Post-hoc t-tests examining grammaticality for each type of noun showed as above that for regulars grammatical sentences were processed faster than ungrammatical sentences ($t1_{29} = 1.98$, $p = .057$, $d = 0.36$, t2 n.s.), and the same was true for pseudoplurals ($t1_{29} = 3.55$, $p = .001$, $d = 0.67$, $t2_{34} = 4.01$, $p < .001$, $d = 1.33$), and for irregulars ($t1_{29} = 2.90$, $p = .007$, $d = 0.56$, $t2_{34} = 2.19$, $p = .036$, $d = 0.73$). Data from these comparisons can be seen in Figure 8 (previous page).

Do pseudoplurals behave like regular singulars?

It appears from the above data that, like in Experiment 2 but in contrast to Experiment 1, pseudoplurals behave somewhat like regular singulars. As predicted in Table 1:

> *Processing of ungrammatical sentences will be* slower *than processing of grammatical sentences, similarly to regular singulars.* As in Experiment 2, an ANOVA examined regular singulars and pseudoplurals alone. A main effect of grammaticality was seen ($F1_{1,29} = 19.32$, $p < .001$, $\eta^2 = .40$, $F2_{1,68} = 14.00$, $p < .001$, $\eta^2 = .17$) and the effect of type of noun approached significance ($F1_{1,29} = 3.53$, $p = .070$, $\eta^2 = .11$, $F2_{1,68} = 2.91$, $p = .093$, $\eta^2 = .041$), but there was no interaction. Grammatical sentences were processed faster than ungrammatical sentences, and sentences containing regular singulars were processed somewhat faster than sentences containing pseudoplurals.

As in Experiment 2, however, given that grammatical sentences with regular plurals were not processed significantly faster than ungrammatical sentences with regular plurals, the comparison between regular plurals and pseudoplurals should be examined, as in Experiment 2. In this instance, Table 1 again predicts that if pseudoplurals are being processed in accordance with their phonology:

> *Pseudoplurals will behave like regular plurals and that for both of these types of nouns sentences with plural verbs will be processed* faster *than sentences with singular nouns.* A 2x2 ANOVA as in Experiment 2 comparing regular plurals with pseudoplurals in grammatical and ungrammatical sentences again found a significant interaction between noun type and grammaticality ($F1_{1,29} = 14.87$, $p = .001$, $\eta^2 = .34$, $F2_{1,68} = 8.28$, $p = .005$, $\eta^2 = .101$) but no main effects. Again the speed of processing of pseudoplurals is more similar to that of regular plurals, and ungrammatical regular plural sentences, along with grammatical pseudoplural sentences, are processed faster than grammatical regular plural sentences and ungrammatical pseudoplurals: again the two pairs of sentences share phonology, but not morphology.

Experiment 3: Discussion

In Experiment 3 there was some evidence for a replication of Experiment 2, but the effect was not as strong. Irregular plurals were processed as if they were regular singulars, showing no overall grammaticality effect, but an interaction in irregulars between grammaticality and number: in Experiment 1 likewise there was also no overall grammaticality effect in irregulars, and these findings confirm the hypothesis that the phonology of these nouns would influence processing as much as morphology.

As in Experiment 2, regular plurals in grammatical sentences were not processed significantly faster than the same plurals in ungrammatical contexts – in fact the difference was in the opposite direction in both experiments, though did not reach significance in Experiment 3.

Although these older participants do not seem to be influenced as strongly by errors in subject-verb agreement, there is still some influence seen. As in Experiment 2, pseudoplurals are processed in a similar manner to regular singulars – but as regular plurals are also processed in a similar way, with slower processing when paired with *plural* verbs, and pseudoplurals are in fact processed in a way that is more similar to regular plurals, it is again hard to determine whether pseudoplurals are being processed according to their phonology or according to their morphology, in this experiment.

General Discussion

In summary, it has been shown in these three experiments that both plural morphology and plural phonology are necessary, but seemingly not sufficient, conditions for nouns to be processed as if they were plural nouns in this type of priming task. In Experiment 1 regular singulars and plurals were processed more slowly in ungrammatical than grammatical sentences; irregular plural nouns have plural morphology but not plural phonology, and in this experiment the irregular singulars were processed like regular singulars, but irregular plurals were not processed like regular plurals. Neither, however, was a reverse grammaticality effect seen: irregular plurals were not processed like their phonological matches, singular nouns. Parallel findings were seen in Experiment 1 with

pseudoplurals: no straightforward grammaticality effect was seen with these nouns, which are not processed like regular singulars, but no reverse grammaticality effect is seen; neither are these nouns processed like their phonological matches, plural regulars.

Processing of regulars

A somewhat more complex and surprising picture is seen in Experiment 2 and 3. Here plural nouns adjacent to plural verbs appear to have been processed as "ungrammatical" by participants, both older and younger. No significant processing advantage for grammatical sentences with regular plurals was seen, with differences between means in the opposite direction to that expected. Interactions between number and grammaticality were found for regulars in both experiments (although post hoc comparisons for regular plurals were non-significant).

It is well known that intervening material between the head noun of a sentence and its verb agreement can cause breakdown in noun-verb number agreement (Bock, Eberhard, Cutting, Meyer, & Schriefers, 2001), and Francis (1986) suggests that English noun-verb number agreement is changing from one based on head-noun-verb agreement to one based on proximal-noun-verb agreement, but suggests that this is happening with both singular and plural nouns. Comparisons of regional English to standard English may give a better clue to our findings. The Northern Subject Rule (NSR – see, for example, McCafferty, 2003) describes the use of verbs with –s endings with all persons except for adjacent personal pronouns. Under this rule,

1) *When you drop them on the floor, the jars breaks*

is acceptable, as is

2) *When you drop the jars on the floor, they break*

and

3) *When you drop the jars on the floor, they obviously breaks.*

may also be acceptable, but not

4) *When you drop the jars on the floor, they breaks.*

Many, but not all, participants in Experiments 2 and 3 were originally from the North of England, although as Cheshire (2005) has found, this pattern can now be seen in the speech of young people in British Midlands dialects as far south as Reading. Our motivation for carrying out Experiment 3 with a similar, but older, population to the participants in Experiment 3 was to determine whether this effect was due to a generational difference in the spread of this feature in British English. No major generational differences were however found.

However, given that both the Standard English pattern:

5) *When you drop them on the floor, the jar breaks*

and the NSR rule as in 1) are heard in spoken British English, including in the daily spoken and written language input to these participants, it is surprising that in Experiments 2 and 3 we found a significant interaction between number and grammaticality for regulars, with faster processing for ungrammatical sentences with plurals. For pseudoplurals and irregular plurals, a parallel pattern was found: sentences with singular verbs were processed faster than those with plural verbs.

A final possibility which may explain this difference is that Experiments 2 and 3 involve repeating a verb, unlike Experiment 1, which involves repeating a noun. The contexts where the verb was repeated faster in these experiments were those with grammatical singular nouns, and ungrammatical plural nouns – in other words, those with third person singular verbs. If singular verbs are, overall, repeated more quickly, this could also explain the findings. However, this would be slightly surprising, as third person singular verbs are, marked (i.e. non-default), are less frequent than unmarked verbs, and are acoustically longer than unmarked verbs.

Processing of irregulars

For irregular plurals, which have singular phonology, the pattern in Experiments 2 and 3 partially replicates that in Experiment 1: processing of irregular plurals may be in line with their phonology alone or these verbs may be processed in the same way as regular plurals when they are adjacent to verbs. In Experiment 1 there was no significant interaction between grammaticality and number with irregulars, while such an interaction was found in Experiment 2, suggesting that in Experiment 2 processing of these nouns differs from processing in Experiment 1: since the agreement required with these nouns' phonology no longer clashes with the agreement required for their morphology, we can now see what amounts to a reverse grammaticality effect with irregular plurals.

Processing of pseudoplurals

In Experiment 1, no significant grammaticality effect was found for pseudoplurals. The significant effect found in Experiments 2 and 3 may therefore be due to the same effect described above for irregular plurals: once the verb form that agrees with these nouns' morphology is no longer different to the form that appears to agree with their (plural) phonology, a grammaticality effect can be seen. The different findings for pseudoplurals in these three experiments, and the contrast with the findings of Bock and Eberhard (1993) with similar pseudoplural-like nouns, highlight the effects of choice of stimuli and of tasks on results of studies examining interactions between syntactic processing and other features of English words. Although Bock and Eberhard's pseudoplurals were not as close to true plural phonology as our pseudoplurals, it can be seen from these data that task choice is at least as important as stimulus choice in uncovering phonology/morphology interactions.

Conclusion

In summary we have seen in Experiment 1 that for both irregulars and pseudoplurals, processing effects are better explained by an interaction between phonology and morphology than by nouns' morphology alone. It is also possible that the phonology of pseudoplurals is contributing to the effects seen with these nouns in Experiments 2 and 3. However, the surprising finding in the latter two experiments of a significant interaction between number and grammaticality for regulars, which cannot be explained either by the phonology or by the morphology of regular plurals, suggests that further investigation of this type of stimulus in a variety of experimental paradigms is necessary.

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