*Interaction Between Phonological and Grammatical Processing in Single Word Production in Kiswahili**

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Key words

grammatical gender

grammatical processing

Kiswahili

modularity

phonological processing

Abstract

Grammatical priming of picture naming was investigated in Kiswahili, which has a complex grammatical noun class system (a system like grammatical gender), with up to 15 noun classes that have obligatory agreements on adjectives, verbs, pronouns and other parts of speech. Participants heard a grammatically agreeing (concordant), nonagreeing (discordant) or neutral prime before seeing a picture of a common object and being asked to name the object. Priming was found, with naming following concordant primes being faster than naming following the neutral prime ('say'). However, more interestingly, effects were found such that where two noun classes share a prefix, the grammatical prime from each of these two noun classes also primed words that have the same prefix but are not in the same noun class, and hence for which the prime was not grammatical. It is concluded that the prime appears to be facilitating the phonological form of the prefix rather than the syntacto-semantic group of words that are known as a noun class, and that the phonological form associated with a grammatical entity may be more significant in its processing than has previously been supposed.

* *Acknowledgments:* We would like to express our thanks primarily to the late Elizabeth Bates for initially suggesting and continuing to encourage this research, and to Maria Polinsky and Kathleen Hubbard for scientific advice, as well as to Fausta Ngowi and Charles Deus of the MAKWAMI project in Bagamoyo, Tanzania for their help in preparing the test materials and assisting in collection of the data reported in this paper. The study was carried out under the auspices of Partnership for Child Development (PCD, Wellcome Trust Center for the Epidemiology of Infectious Disease, Department of Zoology, Oxford University) and Ushirikiano wa Kumwendeleza Mtoto Tanzania (UKUMTA) — The Tanzania Partnership for Child Development. Support for this research was provided both by the James S. McDonnell Foundation, grant Reference 94-13, and by NIH/NIDCD R01 DC00216, to Elizabeth Bates.

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1 Introduction

1.1 *Influences on speech production*

In many languages, words that are produced as part of sentences must agree either in number or gender with other words or concepts. In producing a word, there is a variety of types of information available to a speaker as well as these grammatical constraints, including conceptual information about the referent of the word, such as its conceptual number, animacy, and biological gender, as well as phonological information.

There are debates about how much these types of information interact in the production of a word, in other words whether the conceptual and phonological information is available to a speaker when selecting the grammatical form of a word. These have been reviewed by Vigliocco & Hartsuiker (2002). There is much evidence, both from psycholinguistic experiments and from spontaneous speech errors, for the interplay of grammatical with conceptual information, including interactions between grammatical and conceptual number (Eberhard, 1997; Vigliocco, Butterworth, & Semenza, 1995), grammatical and conceptual/biological gender (Vigliocco & Franck, 1999; Vigliocco & Franck, 2001), and grammatical form and semantic properties (Ramscar, 2002).

However there is less evidence for interaction between grammatical form and phonological form. Bock & Eberhard (1993) carried out an experiment in which subjects heard phrases consisting of a singular head noun with a plural or singular noun in a following prepositional phrase, for example:

The player on the court

The player on the courts

Subjects were asked to complete the sentence in any way they wished, but a correct completion was scored if the sentence's verb immediately followed the second noun. As in previous experiments, an excess of agreement errors was found when the second noun—spoken just before the verb of the sentence—was plural. However no excess of agreement errors was found in a third condition where the second noun in the phrase that was heard ended in /s/, and was designed to mimic a plural (a pseudoplural), for example

The player on the course

However as Bock & Eberhard themselves note, these types of pseudoplurals are not true pseudoplurals as they do not conform to standard English morphophonemics, where plurals have final /s/ when preceded by unvoiced consonant, but final /z/ when as in this case it is preceded by /r/ or a vowel.

A second experiment used homophones (e.g., tax/tacks) presented visually, where one of the pair is a true plural and the other is a nonplural noun. Again agreement errors only occurred following true plural nouns. However it is possible that the visual presentation and/or the homophonic nature of the items may have affected this.

A similar experiment in Italian, in contrast (Vigliocco, Butterworth, & Semenza, 1995), using head nouns that have the same morphophonemics in singular and plural, did find an increase in verb errors following these nouns.

In addition, work with nonfluent aphasic subjects suggests that it is the phonology of regular past tenses that make them difficult to process by such subjects, again suggesting that grammatical information is reliant on phonological information (Bird, Ralph, Seidenberg, McClelland, & Patterson, 2003).

Hence evidence from the speech production system suggests that there is sufficient interaction between the various different types of information described above to cause serious trouble for a modular account of speech production, in which different systems do not interact. Further evidence for the interaction of phonological and grammatical information would add weight to the integrationist arguments.

Modularity of the grammatical system has also been argued for when examining the difference between regular and irregular grammatical agreements, such as the case of plurals in English (Pinker, 2000). It is argued that processing of regular plurals, for example, proceeds according to a set of rules learned by a child while acquiring their language, whereas irregular plurals are learnt on a word-by-word basis, and this different processing accounts for the different behavior of these types of plurals in some experimental situations. For example, children and adults will reject as ungrammatical compound phrases containing regular plurals such as *rats-eater* but will accept similar compound phrases containing irregular plurals such as *mice-eater*.

However if phonology and grammar do interact, then this data is explicable by reference to the phonology of the words. Seidenberg, Haskell, & MacDonald (1999) suggest that the difference between English regular and irregular plurals is not that irregular plurals are looked up in the lexicon while regular plurals are formed on a case-by-case basis using rules; rather the difference is that regular plurals have plural morphology while irregular plurals do not. There are some semiregularities in irregular plurals (e.g., ox — oxen; child — children; knife — knives; wife — wives) but only some of these semiregular plurals have plural morphology (knives, wives). Seidenberg et al. (1999) found that these semiregular plurals with plural morphology were, in common with regular plurals, less likely to be accepted as part of well-formed compounds, for example:

mouse-eater [1]
rat-eater
wolf-eater
mice-eater
*rats-eater
*wolves-eater

[1] Although both 'mouse' and 'rats' end in /s/ only 'rats' has plural phonology since plurals with a penultimate vowel must end in /z/. Final /s/ is not sufficient or necessary for a word to have plural phonology: 'rows' does not end in /s/ but has regular plural morphology.

— where those compounds marked * are less acceptable. This suggests that the plural morphology — not the regularity of the plural, and its possible formation using rules — is the crucial feature in determining whether it can form an acceptable compound noun, and similarly in whether it might behave like a "regular" plural.

It seems fruitful therefore to carry out further investigations into the interaction between phonology and grammatical agreement, especially in speech production. In English few words and constructions require morphophonemic marking of grammatical agreement, and in many other European languages there are few ambiguous situations where one phonological realization could potentially stand for more than one grammatical entity. However there are some non-European languages whose morphophonemic structure lends them more to this type of study, including the language used in this study, Kiswahili.

In English, marking of noun and verb agreement only occurs for number, and only the noun and the verb are marked. In other languages, however, marking can occur for number, grammatical gender, and grammatical case, and the verb, adjective, and various pronouns can be marked. The grammatical gender system has been investigated in several European languages (Akhutina, Kurgansky, Polinsky, & Bates, 1999; Bates, Devescovi, Hernandez, & Pizzamiglio, 1996; Bentrovato, Devescovi, D'Amico, & Bates, 1998).

1.2
Overview of grammatical gender

"Gender" is derived from a Latin word *genus* meaning 'type' and hence etymologically does not necessarily refer to whether a referent is masculine or feminine. It is therefore linguistically correct to refer to all such typological language systems as "gender," whether or not male and female humans and animals are referred to by particular genders. However, in the linguistics of Kiswahili, the language studied here, these differing groups of words which form grammatical agreements are not usually referred to as "genders" but rather as "noun classes," and this convention will be used here. In addition, as there is no male/female linguistic distinction in Kiswahili, the conventional use of "gender" to refer to male and female divisions might confuse the issue.

The noun class system found in Kiswahili and the gender systems found in many other languages share many features. By definition, a gender system is one in which one word (e.g., an adjective or pronoun) must agree in gender or class, and often number and case as well, with a referent (which can be, e.g., a noun explicitly present in the sentence, or a person or object mentioned previously or alluded to). Some languages have only number agreement. The simplest form of gender agreement is found in English and some other languages, where only anaphoric pronouns must agree with their referent. More complex systems involve adjective agreement, verb agreement, agreements of specialized adjectives such as possessives and numbers, and even adverbs and complementizers.

Although the principle of such systems — that some words in a sentence must agree with their referents in gender or noun class — is similar in all languages that have gender, the details, particularly of exactly how a word acquires gender, differ greatly

in different languages. Some languages appear to rely almost entirely on semantic or "natural" gender, including English and some languages of the Indian subcontinent. However, in other languages such as French and German the allocation of words to a particular gender can appear almost random to the casual observer.

This apparent randomness is deceptive, however, and on closer examination phonological and morphological regularities are found even in systems that appear relatively opaque. As described below, the noun class system that exists in Kiswahili is somewhat less opaque than many other languages but it is not always completely predictable. However, native speakers seem to be able to assign noun classes consistently and easily, as in other languages with gender.

How then do native speakers of such languages assign gender, and what might affect this? In many languages, regularities of the phonological and morphological features of a word can act as a guide to the gender of a word, but they are not always a perfect indication of gender. This makes the grammatical gender system appropriate for the study of the interaction of phonological and grammatical processing.

In some other languages, the semantics of a word is a very good guide to gender; in languages where both semantics and phonological form are important, there is some suggestion that semantics takes precedence in forming agreement (Corbett, 1991). This is also relevant to Kiswahili, as there are both morphological and semantic characteristics of a word that can determine its agreements. A short description of the grammatical structure of the language is in order.

1.3
Introduction to Kiswahili

Kiswahili is a language of the Bantu group which is spoken as a first or primary language in coastal and island areas of Tanzania and Kenya, and urban inland areas of Tanzania, and used as a trade language or a language of education throughout these countries, and in other areas of East Africa including Uganda, Rwanda, Burundi and areas of Zaire.

Historically, the status of Kiswahili as a coastal and trade language has meant that it incorporates a large number of borrowed words. Many of the loan words are derived from Arabic, and this was the original source of loan words. However, the grammatical characteristics of these words are strictly Bantu in character.

As with other Bantu languages, Kiswahili has a richly inflected grammatical noun class system. Noun classes are similar in structure and function to grammatical genders except that there are more of them and their semantic properties do not include biological gender. Noun classes are inflected by means of prefixes and, in the case of demonstratives and relative pronouns, infixes, though the latter were not used in this experiment.

Generally the singular and the plural of a noun class are counted as separate noun classes. This is partly for historical reasons, but also in an attempt to coordinate the labeling of noun classes across different languages, and a reflection of the fact that most, but by no means all, nouns in a particular noun class will form their plurals in the corresponding plural class.

This labeling system, a numeric system, is consistent across languages, and since some languages have either lost or never had some noun classes, this means that there are gaps in the numbering in many languages, including Kiswahili. The classes that are present in Kiswahili are shown in Table 1. For each noun the hyphen indicates the division between the prefix and the noun root, and is not present in normal Kiswahili spelling or pronunciation.

TABLE 1

Noun classes present in Kiswahili

Class	*Example*	*Meaning*
1	m-toto	child
2	wa-toto	children
3	m-lango	door
4	mi-lango	doors
5	embe	mango
6	ma-embe	mangoes
7	ki-tanda	bed
8	vi-tanda	beds
9	ny-umba	house
10	ny-umba	houses
11	u-zi	thread
14	u-zuri	beauty

Most nouns in Classes 11 and 14 are uncountable or abstract and hence do not regularly form plurals; however, where there are plurals, they are formed in Class 10. The prefixes of Class 11 and 14 have the same surface form, and are sometimes combined into Class 11/14; however, Class 14 contains mainly abstract nouns while Class 11 contains concrete but largely uncountable items. There are an additional four classes of derived nouns, three of which are locatives and one of which is a class of infinitive verbs.

There appear to be some semantic commonalties in words in each of the classes; some such generalizations are stronger than others (Contini-Morava, 1996; Zawawi, 1979). There is some evidence for the reality of semantic generalizations, including the fact that where a speaker desires to change the meaning of a word slightly, the word is often altered phonologically to place it in a different noun class. However, there is also some evidence against semantic generalizations for noun classes, including the fact that loan words are generally placed in the noun class that fits their phonological form, rather than the class that might fit their semantic characteristics. This has also been found in related Bantu languages (Demuth, 2000).

Agreements. In each noun class all of the following must agree with the noun: prefixes on adjectives, including some numbers; possessive pronouns, including the word 'of'; the subject prefix on verbs (including all verbs of action and the verb *kuwepo*, 'to be in a place or state', and the verb *kuwa* 'to be' in the past tense but not this one verb in the present tense); the prefixes and infixes on demonstratives; and the object pronoun and relative pronoun infixes on verbs. Examples of each type of agreement can be seen in the *Appendix*.

The noun obligatorily precedes adjectives, numbers and possessive pronouns. Verbs and demonstratives frequently precede the noun for topicalization or emphasis, although the basic word order in Kiswahili is SVO. Agreements on adjectives are the same as on nouns in all cases except Class 11/14. Agreements on other classes are semi-regular. The prefixes on nouns and agreements for all classes with the verb *kuwepo* ('to be in a place', the prime used in this experiment) are shown in Table 2.

TABLE 2

Noun class agreements with the primes used in the experiment

Noun class	*Prefix on noun*	*'To be in a place'*
1	*m-* (mw- before vowel) or Ø	yupo
2	*wa-*	wapo
3	*m-* (mw- before vowel)	upo
4	*mi-*	ipo
5	Ø or *j-*	lipo
6	*ma-*	yapo
7	*ki-* (*ch-* before vowel)	kipo
8	vi (*vy-* before vowel)	vipo
9	nasal consonant (notated N) or Ø	ipo
10	nasal consonant (N) or Ø	zipo
11/14	*u-*	upo

Atypical, flexible, irregular, and unprefixed nouns. The noun class system is not as rigid as has been implied. Some nouns regularly form agreements in one noun class although their prefixes imply they should be placed in another class. This is primarily true of animate nouns. In fact, the definition of gender (Corbett, 1991) is a group of nouns which all take the same agreements, rather than a group that share morphophonemic or semantic characteristics.

Most nouns referring to people and many referring to animals have the regular Class 1/2 *m-*/*wa-* prefix. However, many nouns referring to people and the majority referring to animals do not have these prefixes (such as *fundi*, 'craftsperson', or *simba*, 'lion'). Generally these nouns pluralize in either Class 5/6 (*mafundi*, 'craftspeople'), or Class 9/10 (*simba*, 'lions'). These nouns must still take all prefixes in Classes 1/2 as they are animate. Hence we have:

fundi yupo	the craftsperson is here	
fundi	*yu-*	*po*
craftsperson	Class 1 prefix	to be in a place
simba wapo	the lions are here	
simba	*wa-*	*po*
lions	Class 2 prefix	to be in a place

Neither of the above nouns have a Class 1/2 prefix but both take Class 1/2 agreements, and hence are grammatically placed in Class 1/2.

Note also that it is possible for the regular prefix for nouns in different classes to be phonologically the same. Classes 1 and 3 share a prefix, while some nouns in Class 1 and the majority of nouns in Class 9 share their lack of prefix. For Classes 1 and 3, the regular prefix is *m-*. Some agreements are the same for both classes, and some are not. For example:

mtoto mzuri 'good child'

m-	*toto*	*m-*	*zuri*
Class 1 noun prefix	child	Class 1 adjective prefix	good

mlango mzuri 'good door'

m-	*lango*	*m-*	*zuri*
Class 3 noun prefix	door	Class 3 adjective prefix	good

However:

mtoto analia 'the child cries'

m-		*toto*		*a-*		*na-*	*lia*
Class 1 prefix	noun	child		Class 1 prefix	verb	present tense marker	cry

mlango unalia 'the door squeaks'

m-		*lango*		*u-*		*na-*	*lia*
Class 3 prefix	noun	door		Class 3 prefix	verb	present tense marker	make noise

The above characteristics of the language — rigid and wide-ranging grammatical agreements, together with reasonably straightforward but less than 100% one-to-one correspondence between phonological form and grammatical noun class — mean that Kiswahili is ideally suited to the study of the interaction between phonological form and grammatical agreement in speech production. In particular, the sharing of phonological form between the prefixes of more than one grammatical noun class (Class 1 prefixed and Class 3; and also between Class 1 unprefixed and Class 5 [not used here] and Class 9), means that it is suitable for the investigation of pseudopriming, similar to the pseudoplural agreements investigated by Bock & Eberhard (1993).

1.4 *Experimental design and hypotheses*

This richly inflected noun class system provides a framework for a study of the

production of grammatical agreements. In particular, we can investigate gender agreements in a language that has a relatively transparent agreement system, and which has more than the two or three genders which are found in European languages. A simple and reliable method of doing this is grammatical priming of picture naming. This method also has the advantage of ecological validity when working with a fairly experimentally naïve population.

Historically in the study of speech production early studies of a particular phenomenon have examined spontaneous speech errors either qualitatively or quantitatively (Vigliocco & Hartsuiker, 2002). The experimental induction of speech errors is also a frequently used method. However grammatical priming is increasingly seen as a helpful means of studying the components of grammatical agreement.

Grammatical priming involves the presentation of a grammatically concordant or nonconcordant (either discordant, or neutral) stimulus prior to the presentation of the target. This can involve either visual presentation of a picture or a word, or auditory presentation of a word. It can be used to investigate number agreement (Gillon, Kehayia, & Taler, 1999; Liu, Chiarello, & Quan, 1999), grammatical case (Gurjanov, 1985), grammatical gender (Wicha, Bates, Hernandez, Reyes, & Galvadon de Barreto, 1997; Bates et al., 1996), or even the grammatical structure of the sentence (Bock, 1986).

We can thereby study the effects of agreement on speech processing; and in addition we can investigate the effects of the presence of a prime on single word production; we can vary the agreement of the primes, having nouns, adjectives and primes that either agree (are grammatically correct) or do not agree (are grammatically incorrect) with the noun to be processed. There are also possibilities for neutral primes, as some types of words, for example imperative verbs, are not marked for noun class.

Briefly, therefore, subjects hear a grammatically correct, grammatically incorrect, or neutral prime, followed by a picture. Subjects are required to say the name of the picture, and their naming is timed.

As well as examining the effects of straightforward noun class prefixes, the presence of unmarked or "irregular" nouns can be used to investigate the effects of noun classes with and without prefixes. As seen above, some nouns that take Class 1/2 agreements can be unmarked, as well as most nouns in Class 5 and many nouns in Class 9/10. There are a few nouns in Class 5 that are marked with a prefix (*ji*-) but as this is a rare prefix, Class 5/6 was excluded. Class 11/14 consists of abstract and uncountable nouns that are therefore not easily depictable, and this was also excluded; and plurals were excluded to simplify the study.

Hence the final design includes singular nouns from Class 1, Class 3, Class 7, and Class 9. Nouns from Class 1 and Class 9 included both those with a regular prefix and those without; and nouns from Class 3 and Class 7 all have a regular prefix. In Class 9 the regular prefix is a nasal consonant which varies depending on the following consonant or vowel. In some contexts the prefix can be /m/; as this is the same as the prefix in Class 1 (or nearly the same, as it is not syllabic whereas the Class 1 prefix is syllabic), such words were excluded, and the "regular" prefix for Class 9 was taken to be nasals (notated N) spelled as n—(these are /n/, /ŋ/ and /ɳ/).

It is hypothesized that if production of noun class agreement depends solely on grammatical processes, then production of nouns should only be primed by those primes that are grammatically concordant with the name of the picture. In other words, Class 1 nouns should be primed by the grammatically correct prime for that class, and Class 3, 7, and 9 words likewise.

Alternatively however it can be hypothesized that the phonological form of the prefix and/or its frequency play a role and hence there may be different priming effects for different classes. In particular, the common phonological form shared by the prefixes of some Class 1 nouns and all Class 3 nouns (the *m-* prefix) may cause some cross-priming between these two classes; and the common phonological form shared by other Class 1 nouns and most Class 9 nouns (a null prefix) may also lead to cross-priming. There are also different type frequencies for different noun classes and this may also be relevant. The experimental design can be illustrated in Table 3:

TABLE 3

Experimental design

		First subject hears one of:				*Then subject sees picture of:*	*Then subject says name of picture:*
Noun class	*Number of words*	*Correct (concordant) prime*	*Incorrect (discordant) prime e.g.*	*"Pseudoprime"*	*Neutral prime*		
1 (prefixed)	9	yupo	kipo	upo	sema ('say')	baby	mtoto
1 (unprefixed)	9	yupo	kipo	ipo	sema ('say')	lion	simba
3	18	upo	kipo	yupo	sema ('say')	belt	mkanda
7	18	kipo	yupo	–	sema ('say')	chair	kitanda
9 (prefixed)	9	ipo	upo	–	sema ('say')	hammer	nyundo
9 (unprefixed)	9	ipo	kipo	–	sema ('say')	phone	simu

There may be some confounding factors, which will be controlled for. As Kiswahili is not a very well-described language it can be difficult to determine the extent to which formal grammatical agreement corresponds to grammatical agreement as used in practice. Any interactions between grammatical processing and other processes in speech production might then be due to the mismatch between the "correct" agreement (derived from grammatical texts, e.g., Ashton, 1966, and used as part of school instruction) as assumed by the experimental design, and the actual grammatical agreement as used by native speakers.

This can be controlled for in two ways. The first is to obtain off-line grammat-

icality judgments from native speakers. The second is to vary the demographics of the subjects so that some subjects have current exposure to the maximum amount of grammatical instruction that is available in the society. Children in the later stages of primary schooling form this group in this society — their grammatical instruction is ongoing and they have had several years of this, and hence if their processing is closer to the "correct" processing than that of adults who have not recently been exposed to such instruction, this would suggest that any interactions found in the adult population are because of a mismatch between "correct" and actual grammatical agreement.

Hence in summary we have two alternative hypotheses as follows:

1. If there is no interaction between grammatical agreement processing and other forms of linguistic information, especially phonological information, then production of nouns should be primed by a verb that agrees grammatically with the noun, and not by any other verb.
2. If however there are "leaky joints" (Vigliocco & Hartsuiker, 2002) between phonological and grammatical agreement systems, then production of a noun in a class whose prefix shares a phonological form with another class could be primed by not only the verb that agrees with its own class but also by the verb that agrees with the other class.

2 Methods

2.1 *Participants*

Participants were 67 native speakers of Kiswahili, residents of Bagamoyo, Tanzania, of whom 29 were over 20 years of age (mean age 22.2 years, *SD* 3.65) and 38 were between the ages of 12 and 17 (mean age 14.3, *SD* 1.48); the latter were all students in the fifth through seventh grade in a primary school in the study area. This is a common age range for primary school students in the study area. Of the adults, 10 were female; of the primary school students, 19 were female. All participants spoke Kiswahili as their first and primary language. All of the children were learning English as a second language in school, and most of the adult participants had also attended primary school including some instruction in English. However, no participants spoke another Tanzanian language (many other Tanzanian languages have similar noun class systems) and no participant had attended (English medium) secondary school. Adult participants were given a small monetary compensation for their time, and students were given a small educational gift such as a pen or exercise book. All participants were tested by one of two members of the project whose primary language is Kiswahili and who are familiar with the testing setup.

2.2 *Materials—data on the nouns used*

Depictability and untimed grammaticality judgments. All of the nouns used were first pretested in untimed naming and grammaticality judgment tasks. Many of the pictures used are part of the battery used by the International Picture Norming Study (Bates et al., 2000). Suitable pictures were chosen and printed six to a page, and 10 local

participants (adults and children in the same age range as used in the study) were asked to name each picture. Pictures for which most participants provided the same name were retested with different participants. In the retest, participants were provided with the most common name if they did not state it themselves, and then asked to name the picture a second time following naming all the pictures once (50 to 60 pictures in a session). Pictures were rejected if 80% agreement on the second naming was not reached.

The nouns chosen to be sufficiently depictable were then presented to participants from the same locality in untimed grammaticality judgments. A total of 20 adults and 20 schoolchildren of the same age and educational level as the participants in the main study were asked to choose one possible agreement from two, or state that neither was appropriate (in which case they were asked to provide an alternative). The verb 'to be in a place' was used, as this was the prime chosen for the experiment. Originally two choices of verb were given for each noun, the verb agreeing with that noun (as determined by dictionary definition, Interterritorial Language (Swahili) Committee to the East African Dependencies, 1956), and an alternative from any of the other classes used in the experiment, or the verb agreeing with Class 5, which was not used in this experiment, but like Class 9 is unmarked in the singular for many nouns. Many nouns that the dictionary places in Class 9 were judged as not agreeing with the Class 9 verb, but with the Class 5 verb (or no verb given) by the participants.

All doubtful nouns and all nouns in Class 9 were then retested with another 20 participants, using both the correct verb according to the dictionary and another randomly chosen verb for non-Class-9 nouns, and both of the Class 9 and the Class 5 verb for Class 9 nouns, as many theoretical Class 9 nouns were judged previously to take agreements in Class 5. Some nouns were again chosen by a large minority of participants to be in Class 5, or at least to take Class 5 agreements, which is logically equivalent. Nouns that did not reach 90% agreement or higher were accepted. Nouns that form irregular plurals were also excluded.

Type frequency. All of the nouns in the Kiswahili language were extracted from an on-line dictionary, the Kamusi Project (Kamusi Project, 1999), and sorted by noun class, with duplicate meanings eliminated. Of a total of 6719 nouns, the totals in each class, with percentages of the total and of the class, are shown in Table 4. Bold figures indicate the total for each noun class.

TABLE 4

Type frequency of nouns in different noun classes

Class	*Frequency*	*Percentage of class*	*Percentage of total*
All animate nouns	973		14.48
1/2 regular	600	61.66	8.93
Animate with plurals as Class 9/10	252	25.90	3.75
Animate with other	121	12.44	1.80

plural formation			
3/4 inanimate	722		10.75
5/6 inanimate	1293		19.24
7/8 inanimate	826		12.29
9/10 inanimate total	1955		29.10
9/10 inanimate with nasal prefix	138	7.06	2.05
9/10 inanimate with nasal prefix	97	4.96	1.44
9/10 inanimate without nasal prefix	1817	92.94	27.04
11/14	950		14.14
Total	**6719**		

2.3 *Procedures*

The primes and pictures were all presented using the PsyScope stimulus presentation environment on a Macintosh Powerbook computer using a pair of headphones with attached microphone for stimulus presentation and voice recording, and a Carnegie Mellon button box for time recording (MacWhinney, Cohen, & Provost, 1997).

Participants were initially familiarized with the apparatus and then were presented with the entire set of pictures to be used for practice and experimental sessions, with the pictures shown on the screen and picture presentation time controlled by the experimenter, to ensure that the subject could become familiar with the pictures and apparatus without time pressure.

Participants were asked to name each picture and if the name given corresponded with the target name, they were told "yes, that's right." If the name given was not identical to the target name but was semantically plausible, was in the same noun class (took the same agreements) and had the same prefix, then the tester told the participant "Yes, or it could be [target name]." If the name given did not meet all of these criteria, the participant was told "No, it's [target name]."

Pictures used were 300 × 300 pixel black and white line drawings, taken from a number of corpora in use as part of the International Picture Norming Study (Bates et al., 2000). Pictures had previously been tested for agreement in naming (see above).

Following this, participants had a brief prepractice session where it was explained to them that they would hear a word before each picture was presented, and that they should try to say the name of the picture as quickly as possible. Only two pictures were used in the prepractice session and each was presented with three different primes. The first prime was *sema* ('say') and before this prime participants were told "Sometimes

you will just hear *sema* before you see the picture"; the next prime was a concordant prime (*yupo*, or other appropriate prime) and participants were told "Sometimes you will hear a word that goes well with the name of the picture"; and the last of the three primes was a discordant prime (*ipo*, or other discordant prime) and participants were told "And sometimes you will hear a word that does not go with the picture. Just try to say the name of the picture as quickly as you can." For this session each of the two pictures was presented three times in succession with the primes in the order described.

A practice session with 24 pictures, corresponding to six nouns in each class, followed this. This took the same form as the test session but no picture was repeated. Nouns were paired with either neutral (*sema*, 'say'), concordant (the agreeing form of *kuwepo*, 'to be in a place') or discordant (one of the other three, nonagreeing forms of *kuwepo*) primes. Note that further forms exist in the language but were not used here. The primes were heard first with a fixation point (a small cross) in the center of the screen, and then at the prime offset the picture appeared. Participants were encouraged to fixate the cross and then to name the picture as quickly as possible following its appearance.

The test session consisted of 72 nouns, each presented three times; all 72 pictures were presented in a random order, then again in a different random order, and then for a third time in a third random order. The nouns used consisted of 18 nouns each from Classes 1, 3, 7 and 9. To recapitulate, these classes have the following characteristics:

Class	Prefix	Example and gloss	Concordant form of *kuwepo*
1	*m-* or Ø	*mwalimu* teacher	*yupo*
3	*m-*	*mlango* door	*upo*
7	*ki-*	*kisu* knife	*kipo*
9	N- or Ø *	*nyumba* house	*ipo*

* where N indicates a nasal consonant

Hence some nouns in Class 1 or Class 9, that is to say forming agreements in Class 1 or Class 9, have prefixes, and some do not. Thus while all of the 18 nouns in Class 3 and all of the 18 nouns in Class 7 had prefixes, the nouns in Class 1 and Class 9 consisted of nine prefixed nouns in each class and nine unprefixed nouns in each class:

Class	No. of prefixed nouns	No. of unprefixed nouns
1	9	9
3	18	
7	18	
9	9	9

Each noun was randomly assigned to an order of prime presentation, with either neutral first, concordant first or discordant first; within each class and prefix group, a third were assigned to each condition. As for each noun there were three possible

discordant primes (being all the concordant primes from the other classes), each noun in each class and prefix group was assigned one discordant prime, so that different nouns in each class appeared with the different discordant primes.

Participants' voice reaction times (from the onset of the picture) were recorded using the internal clock of the button box; testers in addition recorded whether or not the target word was given, and any hesitations or self corrections, as well as any alternative words given.

Two possible scoring criteria were then used, strict and lenient. In the strict criteria only the target word given in the initial picture familiarization session was allowed as correct. In the more lenient criteria any word that was semantically plausible, in the same noun class and with the same prefix was taken as correct. Participants also had a tendency for within-word hesitations, for example when presented with a picture of a bed (*kitanda*) they might say *ki… tanda*. Under the lenient scoring criteria these were also deemed correct; as long as the final word produced was semantically plausible and the first sound produced was its initial sound, and there were no sidetracks to semantically implausible, grammatically incorrect, or differently prefixed words in between. Data based on these two sets of scoring criteria were both used for the final analyses (see below).

3 Results

3.1 *Adults*

Overall summary and numbers correct. Overall, participants named 195.34 (SD = 15.00) of the 216 pictures correctly under the strict scoring scheme and 201.76 (SD = 9.65) of the pictures correctly under the lenient scoring system.

There was a significant difference in the number correct under the two different scoring systems, $t(28) = 5.355$, $p < .001$. However, there were no effects of noun class or type of prime on number correct, no matter how number correct was scored. In the following analyses, number correct was therefore not analyzed; effects on reaction time did not differ between strict and lenient scoring methods, and hence it was decided to use the lenient scoring method in order to maximize the number of valid data points.

One effect on numbers correct was significant: there was a significant interaction between scoring method and class, $F(3, 26) = 5.53$, $p = .002$. This can be seen in Figure 1. It is possible that this is due to slightly more variable naming in Class 1 — names for occupations, especially, may have more options than other types of names. However neither planned comparisons, nor further analysis classifying words into people/nonpeople or animate (Class 1 nouns are all animate)/nonanimate revealed any significant results.

Figure 1

Interaction between noun class and scoring method (strict vs. lenient) – Adults. Error bars ± 1 *SE* in all charts

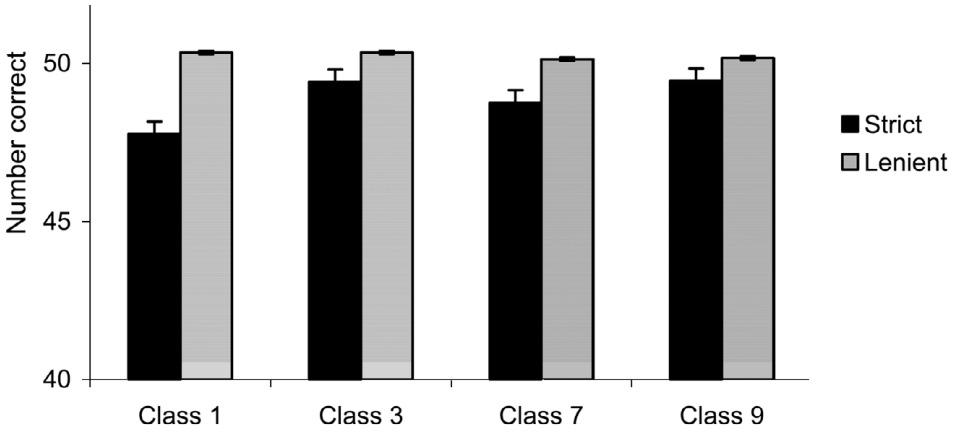
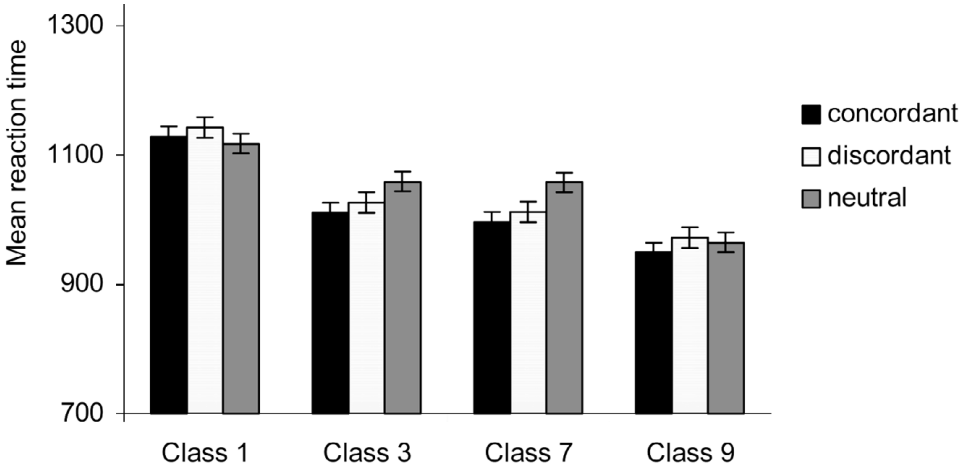


Figure 2

Analysis of noun class and prime effects – Adults



Effects of prime and noun classes. Figure 2 shows the comparisons between classes and primes.

An ANOVA revealed that there were significant main effects of type of prime word (concordant vs. discordant vs. neutral), $F(2, 27) = 3.628$, $p = .033$, and of noun class, $F(3, 26) = 40.168$, $p < .001$. Hence the type of word heard before naming the picture affected the speed of picture naming.

There was also a significant interaction between prime and noun class, $F(6, 23) = 2.714$, $p = .015$ — this effect of prime was not the same for all noun classes.

These effects were then investigated further, as follows.

Planned comparisons revealed that participants were significantly faster to name pictures when a concordant prime was presented than when a neutral prime was presented (mean difference = 28.442, $SE = 10.665$, $p = .031$). There was no difference between discordant primes and the two other types of prime. A concordant (grammatically agreeing) prime speeds picture naming up when compared to a neutral prime ('say'). A discordant (ungrammatical) prime does not slow picture naming down compared to the neutral prime.

When the different noun classes were compared, it was found that all pairs compared were significantly different with $p = .001$ or less, apart from the comparison between Classes 3 and 7, where there was no significant difference. Overall, pictures in Class 1 (nouns with prefix *m-* or no prefix, that are animate) were named the slowest, followed by Classes 3 (inanimate nouns with prefix *m-*) and 7 (prefix *ki-*), and Class 9 (nasal prefix or no prefix) was named the fastest.

One way ANOVA of each noun class revealed that in Classes 1 and 9 there was no effect of type of prime, the significant effect of prime occurring in Classes 3 (prefix *m-*) and 7 (prefix *ki-*), $F(2, 27) = 3.365$, $p = .042$ for Class 3 and $F(2, 27) = 6.334$, $p = .003$ for Class 7. Hence there was no difference between hearing different types of words before naming the picture in Classes 1 and 9, but only in Classes 3 and 7.

Planned comparisons were carried out and revealed the following (throughout, where no results are reported, the comparisons were not significant): in Class 7 there was also a significant difference found in planned comparisons between concordant primes and both neutral primes (mean difference = 61.771, $SE = 14.779$, $p = .001$) and discordant primes (mean difference = 45.940, $SE = 17.671$, $p = .044$). Hence in Class 7 (prefix *ki-*) picture naming following a grammatical prime word (*kipo*) was faster than following an ungrammatical prime word or a neutral prime word ('*sema*'); in Class 3 though there was a significant effect of the type of prime word, it was less easily broken down than in Class 7.

Effects of the presence of a prefix. In Classes 1 and 9 some words carry a prefix and some words do not. The interaction between prefix and class can be seen in Figure 3.

It seemed possible that this confound might be responsible for the absence of the predicted priming effect for some Class 1 and 9 nouns. This possibility was examined in an ANOVA looking at prime, presence of a prefix, and at noun class. The analysis revealed that there was a significant main effect of noun class, $F(1, 28) = 107.474$, $p < .001$, such that Class 9 words were faster. There was a significant main effect of prefix, $F(1, 28) = 97.412$, $p < .001$, such that unprefixed words were named faster, but no significant effect of prime. Finally, there was a significant interaction between class and prefix, $F(1, 28) = 6.106$, $p = .020$.

Hence words in Class 9 (unprefixed or with a nasal prefix) were named faster than those in Class 1 (with *m-* prefix or unprefixed, and animate). In both noun classes unprefixed words were named faster, and the difference was greater for Class 1.

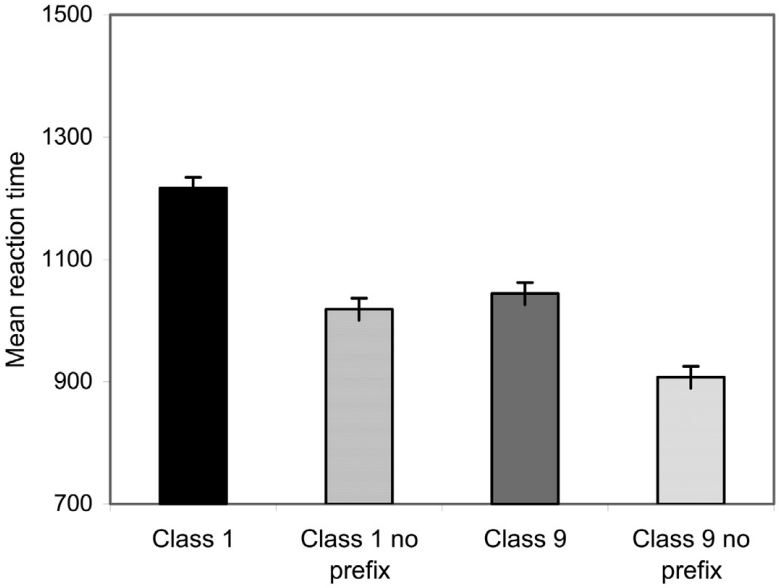


Figure 3
Analysis of noun class and prefix interactions – Adults

However there was no significant effect overall on these words of hearing a grammatical prime rather than an ungrammatical or neutral prime ('say'), nor was there any interaction between prefix and prime or noun class and prime.

Since reaction time is measured using a voice key, it is possible that low-salience nasal-prefixed words are picked up more slowly on the whole than nonprefixed words, which can begin with any consonant — including some higher salience consonants such as stop consonants. However, the comparison above between Class 3 words (always with an *m-* prefix) and Class 7 words (always with a *ki-* prefix) shows there is no significant difference in RT between these two classes, suggesting that the voice key is equally efficient at picking up both types of consonant.

Interaction of phonology and grammatical agreement. Nouns in Class 1 that have a prefix, and nouns in Class 3 (where all nouns are prefixed) share the same prefix (*m-*), even though the grammatical prime for these classes is different. Nouns in Class 1 that have no prefix and nouns in Class 9 (where the majority of nouns are unprefixed) again have in common that they have no prefix, and again have different grammatical primes.

This effect — of common prefix but different grammatical prime — was investigated. Items were divided into three types: Primes that are grammatical with a particular noun class, primes that can plausibly be followed by a particular prefix but are not grammatical (i.e., they "sound right" even though they are not), and primes that cannot plausibly precede a particular prefix were compared, across noun classes, for Classes 1 (prefixed), 1 (unprefixed) and 3. For simplicity, we will refer to items in the "plausible sounding" conditions as "pseudoprimes." These separate conditions can be summarized as follows:

Class	Prefix	Grammatical prime	Pseudoprime	Ungrammatical-implausible primes
1	*m*-	yupo	upo [grammatical prime for Class 3]	kipo, ipo
1	Ø	yupo	ipo [grammatical prime for Class 9]	upo, kipo
3	*m*-	upo	yupo [grammatical prime for Class 1]	ipo, kipo

All of these comparisons can be seen in Figure 4.

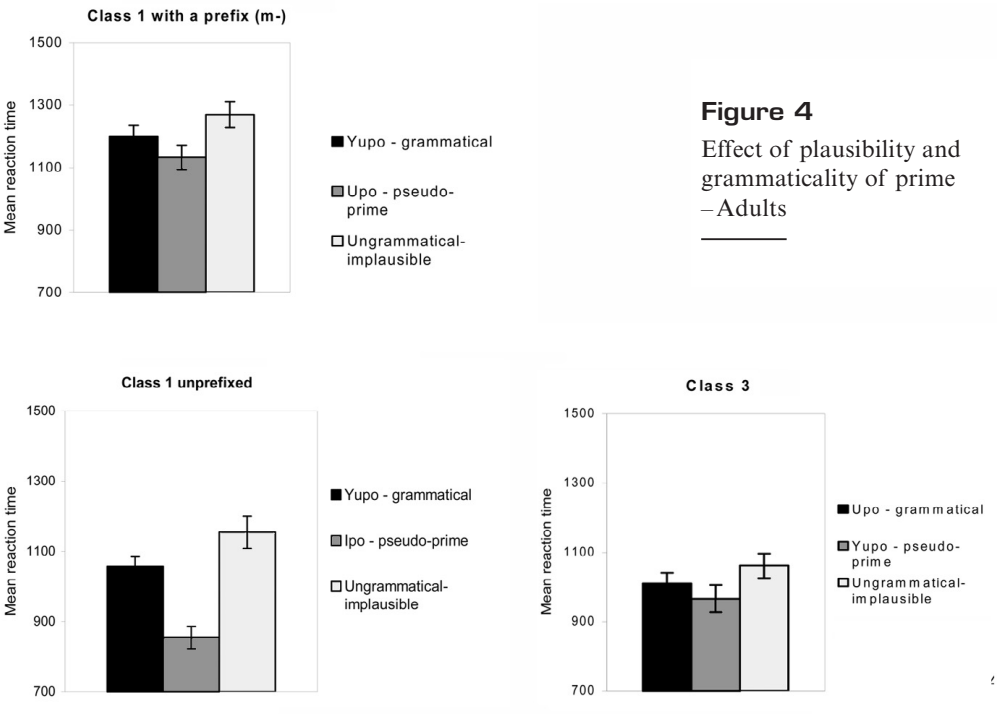


Figure 4
Effect of plausibility and grammaticality of prime – Adults

An ANOVA examining all of these classes comparing grammatical primes, pseudoprimes, and ungrammatical primes, revealed main effects of plausibility, $F(2, 27) = 10.342$, $p < .001$, and, as before, noun class, $F(1, 28) = 75.946$, $p < .001$. Hence the difference in naming times between the classes held up, with Class 1 being named slower than Class 3, and the primes that were more plausible (and not necessarily more grammatical) caused pictures to be named faster.

Planned comparisons are necessary to untangle the effect of specific phonological plausible pseudoprimes on specific classes. These revealed that for Classes 1 (prefixed words, *m-* prefix) and 3 (also *m-* prefix), reaction time after a grammatical prime is no faster than reaction time after an ungrammatical pseudoprime, suggesting that the critical factor lies in the fact that nouns in these classes have the same prefix—production of nouns in both of these classes was primed equally by primes from the other noun class, which shares a prefix.

However, for both noun classes, reaction times for both grammatical and pseudoprimes were faster than reaction times with a prime that is ungrammatical-implausible (grammatical prime vs. ungrammatical-implausible prime, mean difference = 60.565, SE = 18.978, p = .010; pseudoprime vs. ungrammatical-implausible prime, mean difference = 115.806, SE = 30.981, p = .003).

Hence the naming of pictures in Classes 1 (prefixed) and 3 is primed equally by grammatical primes from their own and the other, phonologically similar, class, even though the primes from the other class are not grammatical. Naming is not primed by ungrammatical-implausible primes, which come from other classes.

For Class 1 (unprefixed), there was an effect of plausibility, $F(2, 27) = 42.313$, $p < .001$, and it was found that reaction times after pseudoprimes were faster than both those for grammatical primes and those for ungrammatical-implausible primes (mean difference = 202.360, SE = 22.177, $p < .001$ for comparison to grammatical primes, mean difference = 299.805, SE = 36.349, $p < .001$ for comparison to ungrammatical-implausible primes), while the difference between grammatical primes and ungrammatical-implausible primes approached significance. Hence unprefixed nouns in Class 1 are primed more by grammatical primes from another class (Class 9, which is generally unprefixed) than by primes from their own class, and are not primed by ungrammatical-implausible primes from other classes.

3.2 *Children*

Overall summary and numbers correct. The mean number correct out of 216 pictures using the lenient scoring method for the children was 199.39 with a standard deviation of 8.20; mean number correct by the strict scoring method was 192.87 with a standard deviation of 10.68.

For the children as with the adults an overall effect of the scoring method (strict method vs. lenient method) was found, $F(1, 37) = 133.830$, $p < .001$. There was also an interaction between scoring method and noun class, $F(3, 35) = 5.892$, $p = .001$, but there was no effect of class. As with the adults, it seems as if the scoring method makes a bigger difference in Class 1. This can be seen in Figure 5.

Effects of prime and noun class on number correct. Using the lenient scoring method (which is used hereafter), the effect of prime and noun class on number correct was examined and it was found that there was a significant effect of prime (concordant vs. neutral vs. discordant) on the number correct, $F(2, 36) = 5.317$, $p = .007$. Hence the word heard before naming a picture affected the accuracy of naming the picture.

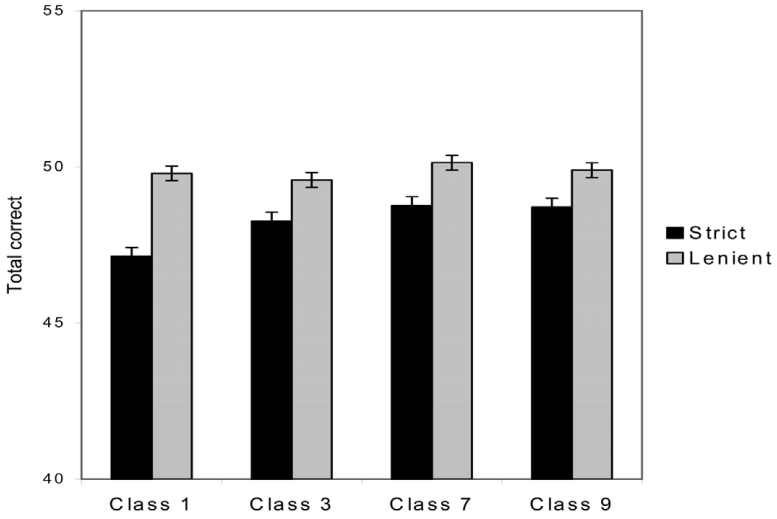


Figure 5
Interaction between noun class and scoring method (strict vs. lenient) – Children

There was also a significant effect of class on the number named correctly, $F(3, 35) = 2.814$, $p = .043$. Planned comparison revealed that the difference in prime conditions was such that more pictures were named correctly in the concordant condition than the neutral condition (mean difference = 0.329, $SE = .093$, $p = .003$). For the effect of class, more pictures were named correctly in Class 7 than in Class 9 (mean difference = 0.474, $SE = .166$, $p = .042$).

The effect of the presence or absence of a prefix on the number correct was also examined for Classes 1 and 9 and a significant effect of the presence of a prefix was found, $F(1, 37) = 48.636$, $p < .001$. It was found that words without a prefix were named correctly more often.

Effects of prime and noun classes on reaction time. The interaction between prime and noun class can be seen in Figure 6.

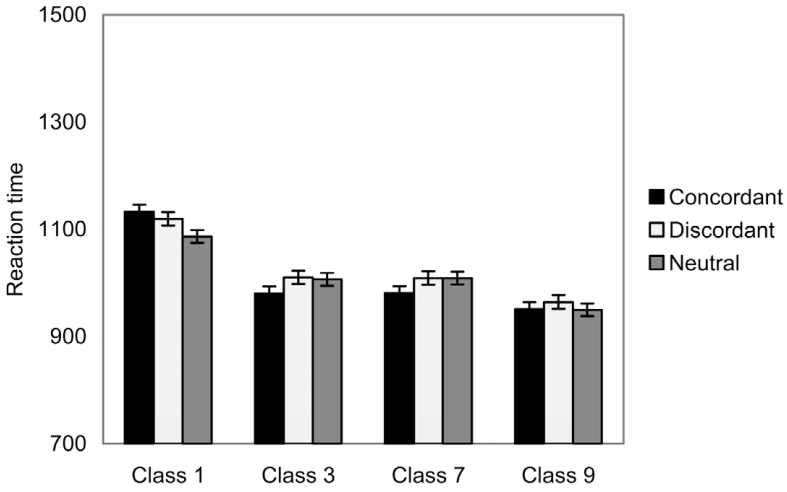


Figure 6
Effect of prime and noun class – Children

The mean reaction time for picture naming was 1008.83, with a standard deviation of 117.57.

Examining the effects of type of prime (concordant, neutral or discordant) and the noun class on reaction time, an effect of noun class, $F(3, 35) = 32.705$, $p < .001$, was seen, together with an interaction between prime and noun class, $F(6, 32) = 2.312$, $p = .035$. The effect of prime approached significance, $F(2, 36) = 2.525$, $p = .087$. Hence words in some noun classes were named faster than others; and the type of prime word heard before naming a picture affected speed of naming in some classes.

Planned comparisons revealed that naming of items in Class 1 was slower than in all other classes (comparison to Class 3 mean difference = 113.689, $SE = 15.992$, $p < .001$, comparison to Class 7 mean difference = 113.200, $SE = 17.275$, $p < .001$, comparison to Class 9 mean difference = 157.801, $SE = 20.046$, $p < .001$). In addition, items in Class 9 were named faster than items in Class 7 (mean difference = 44.601, $SE = 14.624$, $p = .025$). Hence words in noun Class 1 (*m-* or no prefix, animate nouns) were named more slowly than other nouns; and words in Class 9 (nasal prefix or no prefix, inanimate nouns) were named faster than other nouns.

There was also a significant difference between words named after a concordant prime and words named after a discordant prime (mean difference = 20.080, $SE = 7.172$, $p = .024$). Hence hearing a grammatical prime before a word meant that the word was named faster than if an ungrammatical prime was heard, regardless of class.

Effects of the presence of a prefix. The effect of the presence or absence of a prefix was examined for nouns in Class 1 and Class 9. Significant effects of both prefix, $F(1, 37) = 164.699$, $p < .001$, and class, $F(1, 37) = 42.470$, $p < .001$, were found, but there was no interaction. Class 1 nouns (*m-* prefix or no prefix) were named more slowly than Class 9 nouns (nasal prefix or no prefix), and nouns with a prefix (in either class) were named more slowly than nouns without a prefix. This can be seen in Figure 7.

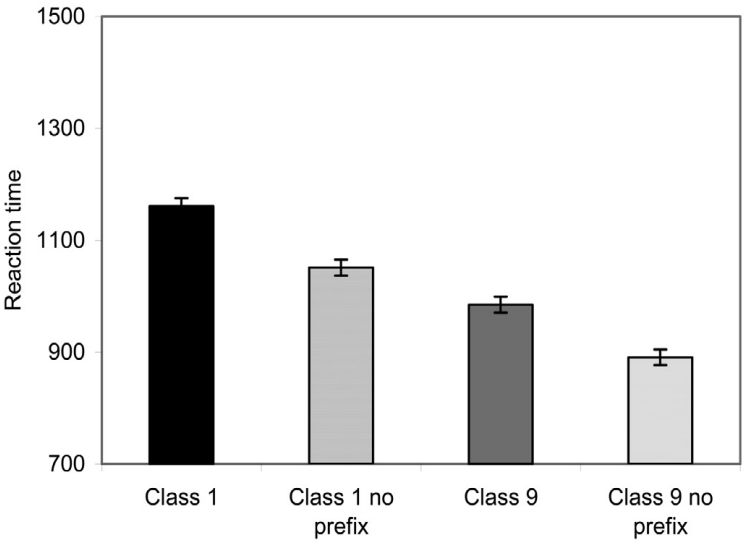


Figure 7
Analysis of noun class and prefix interactions – Children

Effect of individual prefixes. As with the adult participants, the effect on picture naming of phonologically plausible but ungrammatical primes (pseudoprimes) was examined for Classes 1 (with prefix, which is *m*-) and 3 (which always has the prefix *m*-). These comparisons can be seen in Figure 8.

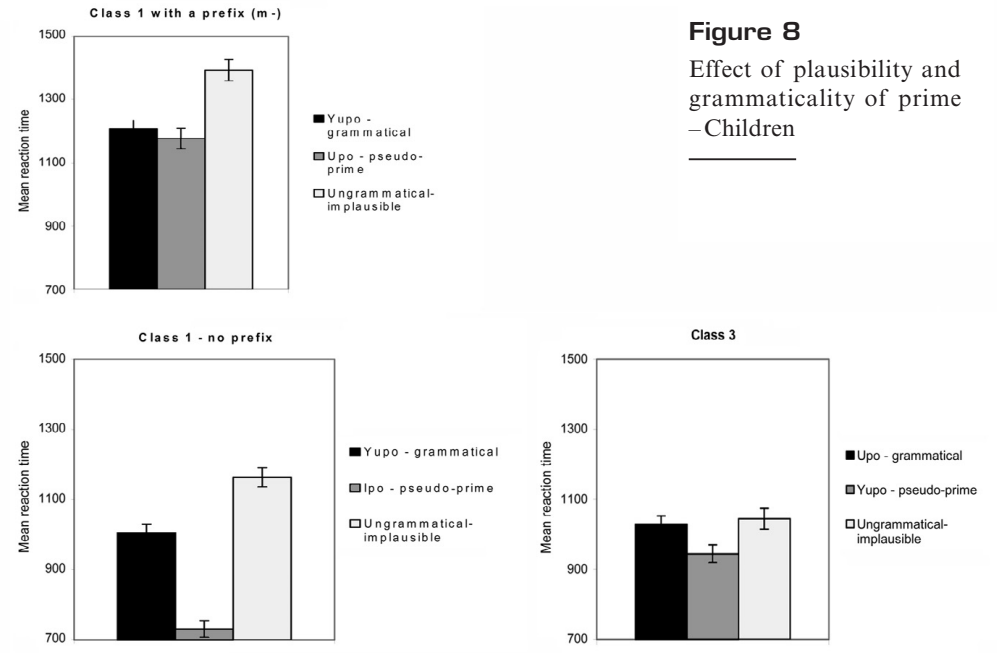


Figure 8
Effect of plausibility and grammaticality of prime – Children

A main effect of plausibility was found, $F(2, 36) = 21.094$, $p < .001$, as well as one of class, $F(1, 37) = 131.086$, $p < .001$. Hence naming was not equally fast following all types of primes (grammatical primes, phonologically plausible pseudoprimes, and ungrammatical-implausible primes), and as before naming of words in Class 1 was slower than words in Class 3.

Planned comparisons revealed that both the grammatical primes and pseudoprimes were followed by faster naming than the primes that were ungrammatical-implausible (mean difference for grammatical primes = 77.498, $SE = 13.755$, $p < .001$, mean difference for plausible primes = 116.271, $SE = 20.501$, $p < .001$). Hence for Class 1 nouns with a prefix (*m*-) and Class 3 nouns which have the same prefix (*m*-), naming was primed to an equal extent by the prime that was grammatical for the other class (*upo* and *yupo* respectively), and therefore phonologically plausible, and to the grammatical prime (*yupo*, *upo*), but not by the primes that were grammatical for other classes (*kipo, ipo*).

This comparison was also carried out on Class 1 unprefixed nouns, comparing the grammatical prime (*yupo*), the pseudoprime (*ipo*, which is grammatical for other unprefixed words, those in Class 9) and the other, ungrammatical-implausible primes. Again there was an effect of plausibility, $F(2, 36) = 45.436$, $p < .001$, and planned comparisons revealed that the pseudoprime, *ipo*, primed naming more than either the grammatical prime, *yupo* (mean difference = 177.349, $SE = 21.087$, $p < 001$) or than

the items that were ungrammatical-implausible (mean difference = 233.789, SE = 30.779, $p < .001$).

Hence for unprefixed words in Class 1, priming was greater by the phonologically plausible pseudoprime (*ipo*) from Class 9 (which is mostly unprefixed) than by the grammatical prime for this class (*yupo*).

4 Discussion

In this experiment we have demonstrated facilitatory grammatical priming for words in different noun classes in Kiswahili, a language with a relatively large number of gender-like noun classes. For the adult group, priming was seen with respect to neutral conditions and for the children, with respect to discordant conditions. These priming effects were not equivalent in all conditions. Two of the noun classes, Classes 3 and 7, have obligatory prefixes, and these classes demonstrated more priming than the other two classes, 1 and 9, which do not always have a prefix. However, it does not seem to be true that prefixed words are primed while unprefixed words are not. When words in these two classes with and without prefixes were compared, there was no extra priming for words with prefixes.

The solution to this conundrum seems to be found when comparisons were made between words that come from grammatically different noun classes but that share a prefix. In these cases, the words in each class should, based on classical grammar, have distinct grammatical primes. However, on purely phonological grounds, the prefix for one category sounds identical to the prefix for another, which leads to the possibility of phonologically based pseudopriming. That is, an ungrammatical prime could have a facilitatory effect if it "sounds right."

In the case of words in Class 1, this is precisely what happens — words are primed by modifiers intended for another noun class that shares the same prefix. These pseudoprimes are different for words that have or do not have a prefix, and this may go some way towards explaining why the grammatical prime for Class 1 did not seem to cause priming overall in Class 1. Some words in Class 1 are primed by the grammatical prime for that class (*yupo*) and are also primed by one other prime (*upo*, which is the grammatical prime for Class 3); some words in Class 1 are only primed by the grammatical prime for Class 9 (*ipo*) and are not primed by the grammatical prime for Class 1.

It is interesting that this pseudopriming effect — priming by modifiers that are grammatical for other classes — also happens in Class 3. In Class 3, priming is observed but there were fewer distinct differences found in planned comparisons tests between prime types than were found in Class 7, where no such effect of plausible but ungrammatical prime could be found — the prefix for Class 7, *ki-*, is distinct to this class.

There remains the anomaly that no priming at all is found in Class 9. This is the class with the largest number of words, and while in Class 1 words with prefixes are much more common than those without, the opposite is true in Class 9. Of all the words in the language, 27% are unprefixed words in Class 9. If normally a prime prepares the listener for a particular prefix, and most of the words in this class have no prefix, this may be why they are primed less than other words. It is also possible that there

is no further leeway for priming to occur in words in this class (i.e., a floor effect for the unmarked or standard form). In fact, evidence that gender priming may not occur for the unmarked (masculine) gender has been reported for Russian (Akhutina et al., 2000).

4.1 *Conclusions*

In summary, we have shown here that in Kiswahili, a highly inflected language with multiple noun classes, grammatical noun class priming can be demonstrated for picture naming in the same way that it has been shown in languages with simpler gender systems (Wicha et al., 1997).

More interestingly, however, we have shown convincingly that this priming is dependent on the phonological form of the noun class prefix, apparently so much so that where there is a conflict between phonological form and classical grammatical noun class, the phonological form can take precedence. Phonological processing and grammatical processing do not just interact, they appear to be equivalent (Bentrovato et al., 1998).

It is possible that what is being primed is the noun class prefix rather than words in a particular noun class. There is evidence from this experiment for either side of this argument. In favor is the point that when a subject hears a pseudoprime they produce a word in the noun class that has pseudoagreement with the prime faster (e.g., when hearing *yupo*, which agrees grammatically with words in Class 1, whether they have an *m-* prefix or not, *mti*, a Class 3 word with an *m-* prefix, is primed); but they are no more likely to incorrectly produce a whole word from the noun class which agrees grammatically with the prime. This suggests that the prefix is primed, rather than the whole word; whole word errors are equally likely in all prime/class combinations.

However in opposition to this suggestion it is possible to argue that a whole word could still be primed, but the semantic properties of the picture prevent whole word errors. In addition, it is hard to see how priming of only the prefix of a word could explain priming of whole, unprefixed words in Class 1 by primes that are grammatically correct for Class 9, which is largely unprefixed.

In any case, whether the prefix or the whole word is primed by pseudoprimes that agree with a noun class that shares a prefix with the word that is primed, it cannot be the case that the pseudoprimes are priming solely morphologically. Primes that are in two different noun classes are grammatically separate — they have different agreements with other constituents of the sentence, and untimed grammatical judgments confirm the theoretical grammatical separateness, in the face of on-line cross-priming.

In this study it has been possible to investigate this phenomenon in a population that is computer-naïve and has a generally low level of education, using a task that appears natural to participants — naming a picture — with a similarly natural prime presented auditorily. This technique does not rely on participants' metalinguistic skills and judgments, or overt knowledge of grammatical noun classes. Many previous experiments have relied on having relatively literate participants, or have used overt grammaticality judgments, and hence may not reflect the on-line grammatical processing that takes place in real language use. Where a more naturalistic type

of task, more similar to our experiment, has been used with highly literate and grammatically educated participants, it is possible that some feature of their education has led them to perform in a certain way. These very similar results with participants with a much lower level of education also add interpretative power to other similar studies. In addition, our similar results in our two subject groups — older children in education and adults who had very few years of education and whose education had finished a few years previously — add weight to the suggestion that these effects are not due, for example, to instruction in formal grammar.

The mean level of facilitatory priming found the mean difference in latency between a word named after a neutral prime ('say') and a concordant prime (the agreeing form of 'to be here'), was approximately 30 ms for adults, with a similar difference being seen between concordant and discordant primes for children. This seems a small effect but it is significant, and there are a number of features which mean that this effect size is still interesting. Firstly, all the pictures were practiced twice before the experiment started. Hence, even on the first experimental trial with each picture, it had been named twice. Secondly, upon closer analysis, while it was found that the average amount of priming was 30 ms, this concealed great variability. In Class 3 and Class 7, whose nouns consistently carry a prefix, the mean amount of facilitation was approximately 70 ms. In Class 1 and Class 9, where some nouns carry a prefix and some do not, this facilitation did not appear to be present.

Within Class 9 there are other possibilities, however. Words with the N- prefix (nasal consonant), which is the regular prefix for Class 9, have a very low type frequency, comprising only 2% of words in the language. Words with no prefix that take Class 9 agreements are probably the most frequent type in the language. It is possible that the prime *ipo* which is grammatical for Class 9 does not facilitate naming of words with an N- prefix (nasal consonant) because these words are so unlikely to occur. There is also another similar word which can prime these words, *zipo*, which would be the grammatical prime for the plural of this class. Since the words in Class 9 remain unchanged in the plural, but additional words take the N- prefix in the plural (words in Class 11/14 also take this prefix in the plural), more words have N- prefix and agree with *zipo* than have N- prefix and agree with *ipo*. Further investigation might determine the cause of this particular effect. It is interesting, however, to note the results of Akhutina et al. (2000). In the Russian three gender system, as in Kiswahili, the most common gender (masculine, in the case of Russian) is also unmarked, and no priming effect was found in this gender. This combination of more than two genders, one of which is unmarked and very frequent, is not found in previously investigated Western European languages.

When looking more closely at the nouns in Class 1, it was found that naming of these nouns was not only being facilitated by the prime that was grammatical for this class. In Class 1, most nouns have a prefix (*m-*) but a substantial minority do not. In the language as a whole, the majority of nouns that do not have a prefix are in other classes than Class 1, and therefore do not take Class 1 agreements. In fact the majority of unprefixed nouns are in Class 9 and take Class 9 agreements. Class 1 is not the only class to have *m-* prefixes; it shares these prefixes with Class 3, and the type frequency of nouns in Class 1 and Class 3 is roughly equal.

If speakers are only dependent on the grammaticality of a prime when their naming of a picture is facilitated by that prime, then these shared prefixes and the probability of a word with a particular prefix being in a certain noun class should be of no importance. If, however, speakers rely on the likelihood of the next word having a particular prefix, based on what they have heard, then the fact that more than one noun class can have a particular prefix should be very revealing.

Since some words in Class 1 and all words in Class 3 can have an *m-* prefix, but their grammatical primes are different (*yupo* and *upo* respectively) then if speakers are relying only on grammaticality, then *yupo* should not prime Class 3 and neither should *upo* prime Class 1 words with *m-* prefixes. If speakers rely on the probability of an upcoming prefix, an upcoming word form, then *yupo* should prime Class 3 words, and *upo* should prime Class 1 words that have an *m-* prefix. The latter was indeed found to be the case. It was not the case, however, that all of the non-neutral primes primed these classes equally. These two primes were equivalent to each other but faster than the two primes that can be neither grammatical nor associated with the *m-* prefix, *ipo* and *kipo*.

A similar pattern was found with words in Class 1 that do not have a prefix. Here if speakers depend entirely on grammaticality then *yupo* should be the only prime to cause facilitation. If, however, speakers are relying on the probability of a particular prefix following a prime, then there should also be priming by *ipo*, which can be followed by an unprefixed word. In fact, not only was there facilitation of naming by *ipo* but unprefixed words in Class 1 were named 200 ms faster after *ipo* than after the grammatical prime *yupo*. In fact, words were not named any faster after *yupo*, which is grammatical, than after the two primes that cannot be grammatical or associated with unprefixed words, *upo* and *kipo*.

Hence it appears that speakers use the primes to determine what type of prefix might be coming up in a following word. It is particularly interesting that words with the *m-* prefix are equally likely to be in Class 1 or Class 3, and the grammatical primes for each of these classes primes words from the other class by the same amount. However, the prime *yupo* is only rarely associated with unprefixed words — as the majority of words in Class 1 do have a prefix — while the prime *ipo* is mostly associated with unprefixed words, as the majority of words in Class 9 have no prefix; with regards to priming, *yupo* does not appear to prime these unprefixed words at all, and they are unlikely to appear in everyday speech after this word. It appears that a prime word may lead to the activation of all possible words that can follow that prime, based on their prefixes, but preferentially of words that are more probable following the prime word, based on the frequency of each type of word in each class.

This pattern of priming — equivalent priming for *m-* prefixed words by any prime that can go with an *m-* prefixed word, and good priming of nonprefixed words only by the prime that goes with the most frequent type of word that is nonprefixed — suggests that grammatical priming cannot be described as dependent on grammatical noun class but influenced by phonological form; it appears to be largely determined by the most likely phonological form.

A further possibility however might be that speakers were unsure about which primes were correct, grammatically, when associated with the words in different classes,

leading to these slightly paradoxical patterns of priming and grammaticality effects. As mentioned above, however, all of the words used in the experiment — as well as those used in the practice trials — were selected based on untimed grammaticality judgments by speakers from the same population as the participants. Previous research has suggested that, in the final analysis, when semantics and morphophonemics conflict, speakers rely on the semantics of a noun to determine which agreements it takes (Corbett, 1991), and this has been analyzed extensively for Kiswahili (Contini-Morava, 1996). If the data from untimed grammaticality judgments alone were used, this would seem to hold up. Animate nouns, which are in Class 1, are generally judged under such circumstances to agree with *yupo*, regardless of their prefix. Inanimate nouns with an *m-* prefix are judged to be in Class 3 and to agree with *upo*. However, the data we have presented here suggest that the effects of the prefix and of the probability of a noun agreeing with a particular prime are both very strong, and may be even stronger than the semantic effect. In fact, the traditional definition of a grammatical gender or noun class as the set of words that take a particular agreement may itself need rethinking.

There was no difference between the group of adults — who have some education but some years previously — and the group of school students, who have at least four years of immediately recent grammatical instruction and who are currently in education. Hence it does not seem to be the case that being in an educational situation where the "correct" grammatical agreements might be emphasized affects subjects' processing of grammatical agreement and phonological form.

This study makes an important contribution to the literature on grammatical processing in speech production. In Vigliocco & Hartsuiker's (2002) terms, the "joints" between grammatical agreement processing and phonological processing appear to be leaky to the point where selection of the next — grammatically agreeing — word in the sentence does not just seem to be influenced by phonological processing but to be largely dependent on such processing. This study has wider implications for data from other languages, such as that pertaining to the classic problem of the English regular and irregular past tense (Bird et al., 2003).

Received: December 11, 2000; first revision received: July 16, 2002; second revision received: July 16, 2003; accepted: September 26, 2003

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