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Meaning or morphology: Individual differences in the categorization of Kinyarwanda nouns

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Unlike the gender-based systems of noun categorization in many European languages, numerous semantic categories contribute to Bantu noun class systems. Kinyarwanda, the focus of our study, has a rich inventory of noun class prefixes, but it is unknown the degree to which the semantic and morphological systems underlying these noun classes influence how speakers mentally categorize nominals in their language. To investigate this, speakers of Kinyarwanda (n = 46) were recruited to take part in an online triadic comparison experiment. Across 144 trials, participants were asked to identify the item most different from a written list of three nouns. These lists were constructed based on morphological similarity (from noun classes 3, 5, 7 or 9), semantic overlap (from the domains of 'mammals' and 'tools'), or both. Results show an overall preference for semantic grouping in the triads, although the strength of these preferences differed across individuals. This variation turned out to be systematic and predictable: speakers of Kinyarwanda who spoke Kiswahili as an additional language generally preferred categorizing on the basis of noun class, while those who did not speak Kiswahili as an additional language were more likely to base their decisions on the shared semantic domains of the nouns. These data suggest that noun categorization choices in Kinyarwanda can be influenced by knowledge of other linguistic systems, highlighting the impact that learning additional languages may have on first-language lexical knowledge.

1. Introduction

A core function of human language is to categorize the world around us, and one way that languages achieve this is by arranging nouns into various classes based on meaning and/or form. Many Bantu languages of Africa make use of a system of noun classes, and unlike the gender-based systems of European languages, noun classes are sensitive to a range of semantic categories. To explore the origins of such a system, considerable work has been done to recreate the semantic system in the ancestor of modern Bantu languages, called Proto-Bantu (de Wolf, 1971; Givón, 1970; Guthrie, 1967; Meeussen, 1967; Welmers, 1973; *inter alia*). However, comparatively less is known about the categorization of noun classes in synchronic Bantu languages, and there are contrasting views on the nature of these systems.[1] Some have argued that language change has resulted in a heterogeneous mix of semantic meanings within a particular noun class, but that there are some general tendencies, such as noun classes for humans, animals, non-living things, and locations (Burton & Kirk, 1976; Creider, 1975; Katamba, 2003). Others claim that noun classes are still semantically cohesive, with words linked by abstract cultural metaphors (Leakey, 1959; Palmer & Woodman, 2000; Selvik, 2001). A third view suggests that the morphophonological structure of the prefixes are the primary driving force in categorizing classes, and that the meaning of the noun is secondary (Demuth, 2000; Demuth & Ellis, 2009). However, a paucity of research in this area has left few convincing answers to the nature of noun classes, and very few psycholinguistic studies have investigated Bantu languages (cf. Burton & Kirk, 1976; Ciaccio et al., 2020; Creider, 1975; Kgolo & Eisenbeiss, 2015; Selvik, 2001), although such an approach is crucial to understanding the psychological composition of noun class systems in users of these languages.

In this study, we explore these questions in Kinyarwanda (a language of Rwanda), a Bantu language which, despite having one of the largest numbers of native speakers, has received relatively little focus with respect to its noun class system. Specifically, we address whether Kinyarwanda speakers use semantic or morphophonological criteria to group written sets of nouns together, and the degree to which individual speakers adhere to these tendencies, by exploring sources of individual variation. In this exploratory analysis, we find that additional knowledge of Kiswahili, another Bantu language, plays an important role in how our participants classify nouns in Kinyarwanda.

1.1 Noun classes in Bantu

The Bantu languages are a subfamily of between 500–600 languages spoken throughout the South-Saharan region of Africa. A large number of these languages make use of between 15–25

[1] Furthermore, the nature of the Proto-Bantu noun class system is not agreed upon, and specific noun classes were likely heterogeneous; see Creider (1975) and Dingemanse (2006) for discussion.

prefixes which categorize nouns (Katamba, 2003; Maho, 1999), with many similarities and differences observed across the family (de Wolf, 1971; Givón, 1970; Guthrie, 1967; Meeussen, 1967; Welmers, 1973). One commonality is that most languages in the family have a class dedicated to nouns which denote human entities. For example, in Kiswahili (Kenya, Tanzania), the noun *m-toto* 'child' is part of this 'human' class, categorized by the presence of the prefix *m–*. The majority of languages in the family preserve a cognate class dedicated to nouns which denote human entities, referred to as Class 1 in the Bantuist literature.

The majority of classes are less uniform in their semantic membership; for example, in Lubukusu (Kenya), Class 9 (marked with the prefix *é–*) is dedicated mostly to nouns referring to animals, such as *é-esoko* 'weaver bird' and *é-engoxo* 'chicken', but also includes words like *é-emoni* 'eye' and *é-barwá* 'letter' (Mutonyi, 2000, pp. 19ff). Broadly speaking, it appears that language change has resulted in a heterogenous mix of semantic meanings within a particular noun class, but that there are some general tendencies, such as noun classes for humans, animals, non-living things, and locations (Burton & Kirk, 1976; Creider, 1975; Katamba, 2003).[2] Some research on language acquisition in Sesotho (Lesotho) has argued that the meaning of the noun is secondary to the morphological categorization afforded (Demuth, 2000; Demuth & Ellis, 2009). For other languages, it has been argued that noun classes are indeed semantically cohesive, and that in situations for which nouns denote unrelated concepts, the words are linked by abstract cultural metaphors (Leakey, 1959; Palmer & Woodman, 2000; Selvik, 2001).

1.2 Kinyarwanda nouns

The Kinyarwanda noun class system includes 16 'core' classes (Kimenyi, 1980; Ngoboka, 2016; Seymour, 2016). Following the Bantuist convention, singular nouns are labeled with odd numbers, and their corresponding plural is N + 1 (with the exception of Class 12/13, where 12 is the singular and 13 is its corresponding plural, and Class 11, which contains a number of uncountable nouns with no plural forms, and otherwise has Class 10 for its corresponding plurals). For example, *umu-ntu* 'person' is a Class 1 noun marked with the prefix *umu–*, and its corresponding plural is the Class 2 noun *aba-ntu* 'people', marked with the prefix *aba–*. **Table 1** lays out the noun class prefixes in Kinyarwanda. Kinyarwanda also has three locative prefixes

[2] In addition to the question of what determines the categorization of nouns within particular classes in these languages, other research has been done on related topics, such as the syntactic structure of nouns and noun phrases in Bantu languages (Carstens, 1991, 1993, 2008; Ferrari, 2005; Ferrari-Bridgers, 2008; S. S. Mufwene, 1980), markedness relationships between classes (S. Mufwene, 1980), the morphosyntactic status of locative classes (Bresnan, 1994; Bresnan & Kanerva, 1989; Guérois, 2016; Marten, 2010; Marten et al., 2007; Ngoboka, 2016; Riedel & Marten, 2012; Rugemalira, 2004; Zeller & Ngoboka, 2014), and the morphological processing of nouns (Kgolo & Eisenbeiss, 2015). We restrict our current discussion to the the topic of how noun classes are categorized, leaving many of the interesting related questions regarding the Kinyarwanda noun class system to future work.

that are added before the noun class prefix: *ku–*, *mu–*, and *i–* (Jerro, 2016; Ngoboka, 2016; Zeller & Ngoboka, 2014), but we leave the investigation of how these are categorized to future research.

Table 1: Noun classes in Kinyarwanda (adapted from Seymour, 2016).

Class		Noun Prefix		Allomorphs	
SG	PL	SG	PL	SG	PL
1	2	umu–	aba–	umw–	ab–
3	4	umu–	imi–	umu–	imy–
5	6	iri–	ama–	i–	am–
7	8	iki–	ibi–	igi–, icy–	
9	10	in–	in–	i–	i–
11	10	uru–	in–	urw–	i–
12	13	aka–	utu–	aga–, ak–	udu–, utw–
14		ubu–		ubw–	
15		uku–		ugu–, ukw–	
16		aha–			

Note that many of the above noun classes have phonologically conditioned allomorphs, driven by productive systems of voicing dissimilation and palatalization, among other processes. To limit the degree of variation in the stimuli used in the following study, we focus on only a subset of noun class prefixes in the singular form, and present them in the standard orthography. More details on our selection of materials are discussed below in 2.2.1.

1.3 Previous work in noun classification

One of the few studies to address noun classification in Bantu languages with experimental data is an investigation of Gĩkũyũ (Kenya) by Burton & Kirk (1976). They looked at speaker classifications in nine target words in the semantic domain of 'flying animals' – five in Class 11, three in Class 9, and one in Class 5. Thirty-three monolingual participants were presented sets of three words at a time, and were asked to select the most different item from the other two. Consider the triad in (1), in which nouns denoting three flying creatures were presented to the participant.[3]

(1) *rulgi* 'hawk' *ndahi* 'grasshopper' *ruruto* 'preying mantis'

[3] English glosses are included in (1) for the sake of exposition, but were not included in the original study.

In this example, *ru-lgi* ‘hawk’ and *ru-ruto* ‘preying mantis’ belong to the same noun class, evident in their both having the prefix *ru–*. On the other hand, *n-dahi* ‘grasshopper’ and *ru-ruto* ‘preying mantis’, share biological taxonomy; they are both insects and in turn differ from *ru-lgi* ‘hawk’, which is a type of bird. Thus, participants had the option to pair words based on meaning (i.e., *n-dahi* ‘grasshopper’ and *ru-ruto* ‘preying mantis’) or noun class (i.e., *ru-lgi* ‘hawk’ and *ru-ruto* ‘preying mantis’). Participants in this study were presented with 46 total triads parallel to those in (1).

Across triads, participants in this study showed an overall preference to use semantic criteria to group nouns in terms of size (large/small) and phylogeny (insect/bird), categories which were determined based on a separate hierarchical clustering analysis. Burton & Kirk (1976) also observed that noun class had a statistically significant effect on triad choices, although the effect of noun class was subsidiary to semantic distinctions. Specifically, among triads where one item was semantically dissimilar from the other two (by both phylogeny and size), participants were able to pick this item out as the most dissimilar 50% of the time on average, with participants making determinations based on noun class only 27% of the time. However, when triads contained items that were more semantically similar (differing only by size *or* phylogeny), participants focused more on the morphophonological aspects of the word, and selected the item which did not match noun class 37% and 38% of the time, respectively.

For the present study of Kinyarwanda noun classes, we adopt a similar triadic paradigm to that of Burton & Kirk (1976). Our approach, however, differs from Burton and Kirk’s in several ways. First, all our participants were university-level educated and multilingual, the latter of which is the norm for speakers of Kinyarwanda (Rosendal & Amini Ngabonziza, 2023), whereas Burton & Kirk (1976) excluded participants with more than three years of any formal education, to avoid what they deemed as potential “contamination” of English-language bilingualism on the results. Second, our participants were all literate; as such, the experimental stimuli were presented as written items in the standard orthography of the language.[4] While not specified in their paper, the triadic method implemented by Burton & Kirk (1976) was likely done verbally, given the inclusion of non-literate participants in their sample, with instructions given to them to use “images which the words brought to mind” (Burton & Kirk, 1976, p. 163). Finally, while Burton and Kirk’s (1976) design used an imbalanced set of nouns from Classes 11, 9 and 5 (five, three and one noun, respectively), we utilized an equal proportion of nouns from four of the sixteen noun classes in Kinyarwanda, in an effort to improve confidence and reliability in our subsequent analysis. We believe these amendments will provide a more ecologically valid

[4] Literacy levels among people in Rwanda is around 73% (Mtika & Abbott, 2023), with Kinyarwanda spoken by 99.4% of the population (Rosendal & Amini Ngabonziza, 2023).

representation of the linguistic reality of Kinyarwanda speakers than a full replication of the aforementioned Gĩkũyũ study would afford.

2. Methods

2.1 Participants

46 native Kinyarwanda-speaking participants took part in this study, recruited from the University of Rwanda College of Education. Ethical approval was granted by University of Essex Ethics Sub-Committee, and informed consent was gathered from each participant before data collection began. Information about participants' age, self-reported gender, region of residence, and linguistic and educational backgrounds was also collected prior to the beginning of the experiment. All information in the study (including consent forms, the background questionnaire, and all of the experimental instructions) was translated from English by a native Kinyarwanda speaker, and presented only in Kinyarwanda.

Participants were all native Kinyarwanda speakers, aged 20 to 63 (mean = 31.3). All reported having been born in Rwanda, with one exception (who was born in the Democratic Republic of Congo), and all were currently residing in Rwanda, suggesting they were likely to be using Kinyarwanda in their daily life. Rwandans are typically multilingual; as such, participants also reported knowledge of several additional languages. Details of the reported languages and averages of self-reported age of first study and proficiency levels are listed in **Table 2**.

Table 2: Additional languages spoken by participants, with mean self-reported proficiency levels on a 5-point Likert scale (from 1: *I don't know well* to 5: *I know very well*), with standard deviation in parentheses. Average age of first study is listed in years with range in parentheses. One participant did not provide language data and has been omitted. Four of the original 46 participants were excluded from analysis for poor performance (see 2.4.2) and are also omitted from the table. These participants also reported speaking English (N = 4), French (N = 2) and Kiswahili (N = 3).

Language	*N*	*Proficiency*	*Age of First Study*
English	41	3.88 (0.75)	10.15 [4–18]
French	36	2.63 (1.19)	10.31 [3–19]
Kiswahili	24	3.17 (1.43)	15.12 [9–29]
German	1	3	14
Chinese	1	4	22

2.2 Materials

Similar to the design of Burton & Kirk (1976) discussed above, participants were presented with a triad of nouns from Kinyarwanda and tasked with identifying which of the three in the set is

least like the others. For example *iki-bwana* ‘puppy’, *in-gurube* ‘pig’, and *umu-kindo* ‘palm tree’ differ in many respects, but a similarity exists between *iki-bwana* ‘puppy’ and *in-gurube* ‘pig’ in that they are both animals (and, more specifically, mammals), whereas *umu-kindo* ‘palm tree’ is a plant. In such a triad, participants would be expected to identify *umu-kindo* ‘palm tree’ as least like the others.

On the other hand, nouns could also be grouped purely in terms of the prefix of the noun. For example, *umu-kubuzo* ‘broom’, *umu-shushwe* ‘rat’, and *in-dimu* ‘lemon’ all bear different semantic properties, but the former two share morphology and are part of the same noun class (3). Triads in this experiment were designed such that they contained pairs of semantically similar words, morphologically similar words, or both (detailed in 2.2.2).

2.2.1 Noun selection

The nouns selected for this experiment come from kinyarwanda.net, an online dictionary of Kinyarwanda lemmas containing 5800 items. Nouns belonging to Classes 3, 5, 7 and 9 were extracted and coded according to the semantic domain of the lexical item (e.g., bird, insect, food, mammal, plant, and tool). These specific classes were selected due to a combination of their high frequency and the heterogeneity of semantic groups within the classes. The dictionary employs the following semantic domains as heuristic categories for the kinds of entities present within certain noun classes: trees, shrubs and things that extend (Class 3), things in quantities, body parts and liquids (Class 5), generic, large or abnormal things (Class 7), and some plants, animals, and household implements (Class 9). In order to compare more reliably among noun classes, we restricted our word set to include only nouns from two of the larger semantic domains which were well represented across these classes: mammals and tools.

From the available items, we used a pre-determined set of criteria for inclusion of the nouns in our study. First, we chose to eliminate any ambiguity in terms of class membership based on prefix allomorph. This is relevant specifically for *i–*, which occurs in both Class 5 and Class 9, but is much more frequent in Class 5. We therefore excluded all Class 9 nouns with the *i–* prefix, such that in our data it occurred only in Class 5. We also chose to reduce the overall variability in forms by limiting the allomorphy of the remaining prefixes to a smaller set than would otherwise be available. Thus, items from Class 3 all begin with *umu–*, Class 5 begins only with *i–*, Class 7 with *igi–* or *iki–* (determined by the voicing of the first stem consonant), and Class 9 with *in–* or *im–* (determined by the place of articulation of the first stem consonant). Finally, we restricted our set to relatively short items, comprising noun stems between 2–3 syllables in length (resulting in items 3–5 syllables total, depending on the attached prefix).

From the remaining items available, we selected two items per semantic domain per class which were judged by the research team as items likely to be familiar to the participants. While this determination would ideally be made based on a corpus with frequency or familiarity

judgements, no such corpus exists for Kinyarwanda.[5] Similarly, given the small number of available items, we were unable to control other variables, such as the number of letters in each item, which would have been taken account of in an ideal scenario where a larger number of lemmas might be available. Thus, we arrived at a final list of sixteen nouns, given in **Table 3**: eight in each semantic domain, with two per class per domain.

Table 3: List of Critical Lemmas used in the experiment.

Class	*Domain*	*Lemma*	*Translation*
3	Tools	umu-kubuzo	broom
3	Tools	umu-horo	machete
5	Tools	i-panu	frying pan
5	Tools	i-piki	pick axe
7	Tools	igi-koresho	tool
7	Tools	igi-sokozo	comb, hairbrush
9	Tools	im-akasi	scissors
9	Tools	in-koni	stick, cane
3	Mammals	umu-hari	fox, wild animal
3	Mammals	umu-shushwe	rat
5	Mammals	i-tungo	livestock, domesticated animal
5	Mammals	i-shyo	herd of cows
7	Mammals	iki-bwana	puppy
7	Mammals	iki-nyogote	porcupine
9	Mammals	in-kura	rhinoceros
9	Mammals	im-parage	zebra

In order to allow us to perform additional semantic and morphophonological comparisons, we selected a further set of eight nouns from the same noun classes, but from a different semantic domain (namely foods and plants).[6] These filler nouns were selected using the same

[5] The semantics of the classes was based on the researchers' intuitions about reliably distinct categories, and our central aim in this study was to be able to control for numbers of types of nouns. Ideally, we would want to base these categories on independent evidence of how Kinyarwanda speakers categorize the world, such as through a Feature Production Norms study, where participants provide lists of related words in response to stimuli. We leave such a study for future work.

[6] As pointed out by an anonymous reviewer, some of these terms are loan words, e.g., *i-panu* 'frying pan'. The categorization of loan words in Kinyarwanda is outside of the scope of this article, though see Rose (1995) and Rose & Demuth (2006) for discussion of the phonological processes that underpin the incorporation of (French) loans into Kinyarwanda.

criteria used for the critical nouns, namely being of relatively high familiarity as judged by the research team, containing one of the subset of available prefix allomorphs, and being of the appropriate semantic domain and morphological class. These nouns play a critical role in allowing us to assess whether our participants use the strategies we expect (grouping items by either semantic domain or by prefix), discussed at more length below. The selected items are in **Table 4**.

Table 4: List of Filler Lemmas used in the experiment.

Class	*Domain*	*Lemma*	*Translation*
3	Food	umu-neke	banana (ripe)
3	Plants	umu-kindo	palm tree
5	Food	i-shaza	pea
5	Plants	i-shami	branch
7	Food	igi-tunguru	onion
7	Plants	igi-huru	thick bush, shrub
9	Food	in-dimu	lemon
9	Plants	in-tusi	eucalyptus tree

2.2.2 Triad structure

Each triad contains two critical lemmas and one filler lemma, the combinations of which lead to 144 different triads. These were arranged into three groups: semantic baseline trials (N = 48), morphological baseline trials (N = 48), and critical trials (N = 48), discussed separately below. The order of lemmas in each triad, and the presentation of the triads themselves, were randomized for every participant.

Baseline trials were used to estimate how readily participants grouped nouns by semantic domain or morphological class, when there was no competition between these elements. The semantic baseline trials included triads such as [*igi-koresho* ('tool', Class 3) — *umu-horo* ('machete', Class 5) — *i-shaza* ('pea', Class 9)], where we have three distinct classes and overlap in the tool domain between *igi-koresho* 'tool' and *umu-horo* 'machete'. An example of a morphological baseline trial would be [*umu-kubuzo* ('broom', Class 3) — *umu-kindo* ('palm tree', Class 3) — *i-tungo* ('domesticated animal', Class 5)], where two items share the Class 3 *umu–* prefix, but all three are from different semantic domains. These baseline trials were included to assess whether or not speakers chose to attend to differences between noun classes and semantic domains generally. Performance on these trials was used as exclusion criteria, explained in more detail in 2.4.

Critical trials gave participants an opportunity to match an item either based on its morphological structure, or on its semantic domain, by having pairs of nouns within the triad which satisfy each criteria. For instance: [*umu-kindo* (‘palm tree’, Class 3) — *in-kura* (‘rhinoceros’, Class 9) — *umu-hari* (‘fox, wild animal’, Class 3)]. In this set, *umu-hari* ‘fox, wild animal’ and *in-kura* ‘rhinoceros’ are both members of the mammal domain, while one is Class 3 and the other is Class 9. On the other hand, *umu-kindo* ‘palm tree’, and *umu-hari* ‘fox, wild animal’ share the noun class prefix, but differ with respect to their semantic domains. If participants select *in-kura* ‘rhinoceros’ to be most different here, this would suggest that morphology plays a larger role in categorization than semantic similarity, whereas the opposite conclusion may be drawn if participants select *umu-kindo* ‘palm tree’.

2.3 Procedure

The experiment was administered online using Qualtrics (2020), and comprised two blocks of 72 triads. Triads were presented as a written list of lemmas on the left side of the screen. Participants were instructed in Kinyarwanda to “identify the word out of the three that is different from the others,”[7] which they accomplished by dragging one of the lemmas into a box labelled “ATANDUKANYE N’ANDI” (Kinyarwanda for ‘most different,’ as recommended by the translator) on the right side of the screen. This wording was chosen to leave open how participants understood that word to be different from the others.

The experimental blocks were preceded by a practice block of 6 trials, with items drawn from an additional set of nouns from semantic domains such as birds and bugs, not included in the main experiment. As in the main experiment, participants were only asked to drag the ‘most different’ item into the box in order to ensure they understood the mechanics of the task on Qualtrics. If participants failed to pick any item and drag it into the box, they were not allowed to move on further in the experiment. The six practice trials were structured with the same proportion of trial types as the main experiment, with two being analogous to morphological baselines, two semantic baselines, and two critical trials. Because we did not want to bias participants toward paying attention to any specific aspect of the items when making their determinations, we did not provide feedback on their classifications in the practice block. The full experimental sequence lasted approximately 25 minutes.

2.4 Analysis

2.4.1 Triad accuracy

Initial analysis of responses to baseline and critical trials revealed a number of triads in which performance was significantly below what we had anticipated. To determine significantly above-chance performance, we calculated the binomial probability of choosing a specific item given

[7] The original text in Kinyarwanda: “Urasabwa kugaragaza ijambo muri ayo atatu ritandukanye n’andi.”

three choices, with observations from 46 participants. For baseline trials, this calculation gives a cut-off value of 20/46 (43.48%), meaning that only for trials where 20 or more participants provided the expected answer can be we confident that they were collectively performing above chance. For critical trials, where two of the three choices were considered correct answers, the cut-off value was calculated as 35/46 (76.09%). Although both of these calculations provide more stringent cut-off values than the single-trial probability of 33% for baseline trials and 66% for critical trials, this is a more robust method of calculating above-chance performance across repeated trials. There were 5 semantic baseline trials, 3 morphological baseline trials, and 1 critical trial which did not meet the cut-off criteria. Closer analysis of these trials revealed relationships between the three items in the triads which made identifying the 'odd one out' more difficult than intended in our original design.

For the semantic baseline trials, this included triads such as [*i-shami* ('branch', Class 5) — *umu-kubuzo* ('broom', Class 3) — *in-koni* ('stick, cane', Class 9)], where despite the latter two nouns belonging to the Tools domain, there is obvious semantic overlap between all three items in terms of physical and material characteristics. Similarly, the triad [*umu-kubuzo* ('broom', Class 3) — *i-panu* ('frying pan', Class 5) — *igi-tunguru* ('onion', Class 7)] resulted in many participants identifying *umu-kubuzo* 'broom' as the odd one out, presumably finding commonalities between items one might use for cooking, whereas we had predicted participants would select *igi-tunguru* 'onion' as the only non-Tool. We therefore determined to exclude all 5 of these low-scoring trials from further analysis. A programming error affected two additional semantic baseline trials, such that no responses were recorded; these were also excluded.

Among the morphological baseline trials, the three items which scored lower than chance shared a highly similar morphophonological profile. An example of this is the triad [*in-tusi* ('eucalyptus', Class 9) — *i-tungo* ('livestock', Class 5) — *im-akasi* ('scissors', Class 9)], where the two Class 9 prefixes utilize different allomorphs (*in–* and *im–*) and the Class 5 prefix *i–* is, as noted above, an available allomorph for Class 9 nouns (although Class 9 nouns with this prefix allomorph were not included in our stimulus set). In fact, all of the lowest-scoring morphological trials are of this construction, with Class 5 *i–* prefixes in triads with two Class 9 nouns using at least one of the *in–* or *im–* allomorphs. These low-scoring trials raise interesting questions about whether the participants are indeed decomposing these items morphologically, or whether the orthographic surface similarities are creating interference, a point which we return to in Section 4. For analysis, we elected to keep the same exclusion criteria in place across all trials; thus, the three morphological baseline trials falling below the 43% accuracy threshold were excluded.

In the critical trials, there was a single item in which participants picked neither the semantic nor the morphological odd one out at a greater than chance rate. This triad was [*i-piki* ('pick axe', Class 5) — *i-shami* ('branch', Class 5) — *in-koni* ('stick, cane', Class 9)]. In comparison to the issues discussed above, this trial appears to have commonalities with both the low-scoring semantic baseline trials (having highly semantically similar nouns across domains) and the low-scoring morphological

baseline trials (with direct comparisons between the *i–* and *in–* prefixes). In this case, the largest proportion of responses was for *i-piki* 'pick axe' (46%) rather than either of the other items, which would have suggested participants either grouping based on semantic criteria (had they picked *i-shami* 'branch', the only non-Tool), or morphological criteria (had they picked *in-koni* 'stick, cane', the only non-Class 5 noun). As in the baseline trials, this trial was excluded from further analysis.

Having taken out the trials which failed to meet the inclusion criteria, and those for which responses were missing, the final data set comprised 133 triads: 41 semantic baseline triads, 45 morphological baseline triads, and 47 critical triads.

2.4.2 Participant accuracy

In line with the previous analysis, participant scores were analysed to identify individuals who were below chance in selecting the anticipated items in baseline trials. Given that different participants may use different strategies across trials, we opted to exclude only those participants who scored below chance on *both* of the baseline trials. As above, we used the binomial probability distribution to calculate the cut-off value for each baseline condition. This value was 18/41 (43.90%) for the semantic baseline trials, and 20/45 (44.44%) for the morphological baseline trials. Only subjects who provided a higher number of expected answers in these baseline conditions were considered to be performing above chance and, therefore, treated as sensitive to the semantic and/or morphological similarities across triad items. There were four subjects who scored below both of these cut-off values in the two baseline conditions, and were subsequently excluded from further analysis. This resulted in a final set of 42 subjects, the characteristics of which are listed in **Table 2**.

3. Results

In the present study, we sought to address two sets of questions about the classification of nouns by Kinyarwanda speakers: (1) to assess whether Kinyarwanda speakers have a preference for grouping nouns in a triad by either morphological structure or by semantic similarity, and (2) to explore whether there are individual differences in participant characteristics or stimulus items that influence noun choice in critical trials. To answer these questions, we analysed response data from the remaining 42 participants using R (R Core Team, 2013). We begin by discussing performance in the baseline trials as a check on whether participants were sensitive to the morphological and semantic structure of the triads in general, before discussing performance in the critical trials, and finally present the exploratory analysis of individual difference measures.

3.1 Baseline trials

In analysing overall preferences in baseline trials, we utilize chi-square goodness-of-fit tests to determine whether the observed distribution of responses differs from the distribution

predicted under the null hypothesis, namely, that all three items have an equal chance of being selected. If the chi-square goodness-of-fit test is significant, this indicates a significant deviation from the null distribution, indicating that participants were choosing the semantic or morphological responses in each baseline condition with significantly higher frequency than would be predicted by chance. When comparing the proportions of expected responses across baseline conditions (where an expected response is the semantically 'most different' item in the semantic baselines, and the morphologically 'most different' item in the morphological baselines), we use a two-proportion z-test, which compares whether the two proportions are equivalent.

In semantic baseline trials, 66.38% of the items identified as 'most different' were those that did not share a semantic domain with the other items. A chi-square goodness-of-fit test showed this was significantly above chance ($\chi^2(1) = 846.07, p < .0001$), suggesting that as a group, our participants were sensitive to semantic similarities among triads.

In morphological baseline trials, 64.34% of the items identified as 'most different' were those that had morphological structure that differed from the remaining items. This was, again, found to be above chance using a chi-square goodness-of-fit test ($\chi^2(1) = 817.61, p < .0001$), suggesting that our group of participants were also sensitive to morphological similarities across nouns in the baseline triads. Both of these results are illustrated in **Figure 1**.

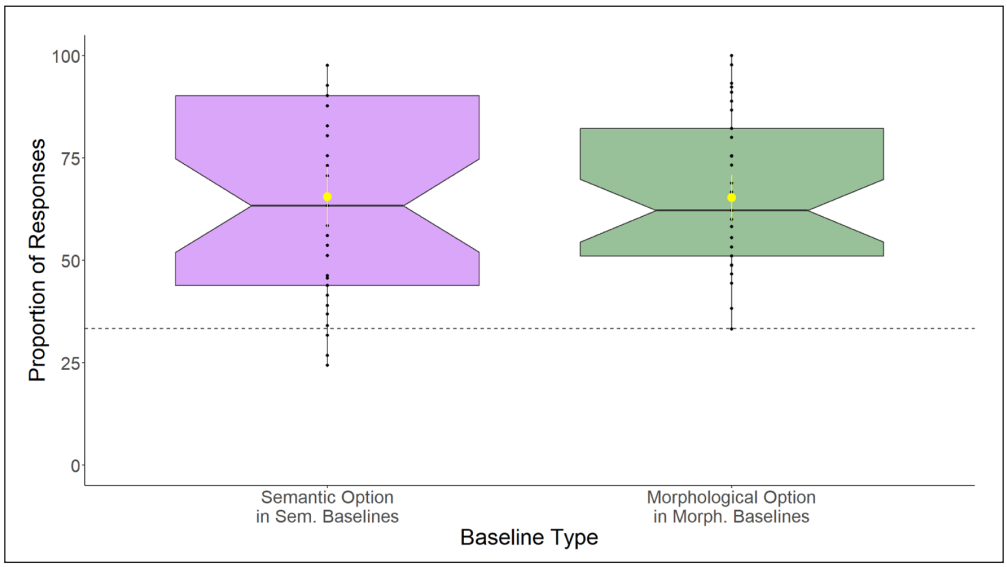

Figure 1: Proportion of responses in semantic and morphological baseline trials that correctly pick out the 'most different' item as that which does not share semantic domain (left) or morphological structure (right). Each dot represents participant mean proportions of responses. Group average proportion of responses is illustrated as a yellow square, with the line indicating one standard deviation from the mean. Chance-levels are indicated by a dashed horizontal line.

Analysis of responses by participant showed variation within participants in the relative preferences for semantic and morphological categorization. When comparing performance across morphological and semantic baseline trials, a two-proportion z-test shows 17 participants had larger proportions of expected responses in semantic baselines, 15 participants had larger proportions of expected responses in morphological baselines, and 10 had no significant difference in response proportions across the two baseline categories. Individual subject averages and test statistics are available in the OSF repository for this study (see below for link).

3.2 Critical trials

In critical trials, where participants could choose either a semantically-dissimilar item or a morphologically-dissimilar item, we find a great deal of variation in response types. A total of 50.16% of responses selected the item that did not share semantic domain with the other items. On the other hand, 43.43% of responses selected the item that did not share morphological class. The remaining 6.42% of trials selected the third item, grouping together items which were neither morphologically nor semantically cohesive. These findings are illustrated in **Figure 2**.[8]

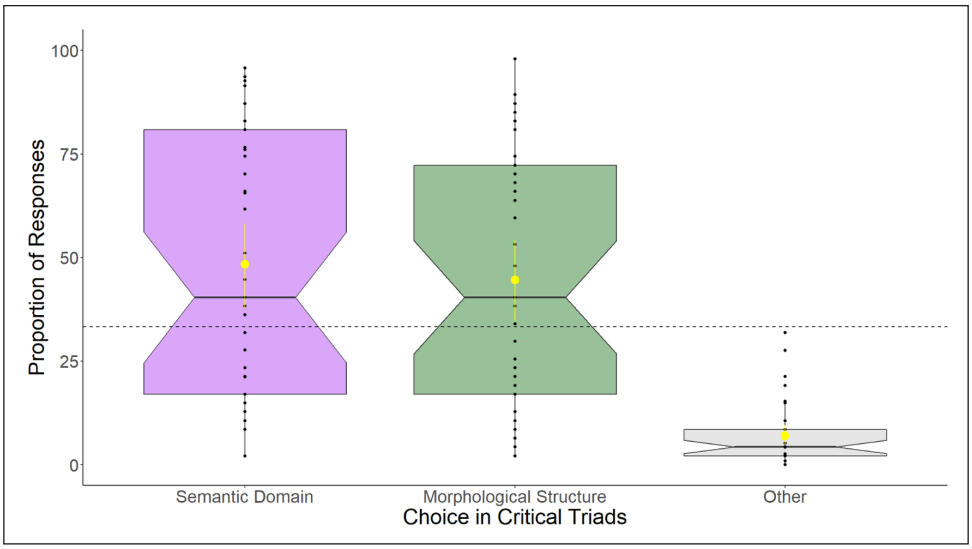

Figure 2: Proportion of responses in critical trials which pick out the 'most different' item as the one that differs by semantic domain (left), morphological structure (middle), or by the 'other' third option (right). Each dot represents participant mean proportions of responses. Group average proportion of responses is illustrated as a yellow square, with the line indicating one standard deviation from the mean. Chance-levels are indicated by a dashed horizontal line.

[8] While responses to all three options in the critical triads have been represented in Figure 2 for transparency (and similarly in Figure 4 below), our statistical analysis ultimately removed responses to the 'other' option from our models in favour of a binomial analysis, as discussed in the main body of the text.

A two-proportion z-test comparing the proportions of responses that chose the semantically-dissimilar item compared to the morphologically-dissimilar item shows a significant difference ($\chi^2(1) = 17.30$, $p < .001$). This indicates that as a group, participants were more likely to choose the semantically-dissimilar item over the morphologically-dissimilar ones. Using the same comparison within individual subjects, we find 19 participants were significantly more sensitive to semantic similarity than morphological similarity, 17 were significantly more sensitive to morphological similarity than semantic similarity, and 6 showed equivalent sensitivity in semantic and morphological categorization. Individual subject proportions and test statistics are available in the OSF repository for this study (see below for link).

3.3 Individual variation

For our exploratory analysis of sources of variation in response selection in critical trials, a logistic mixed effects model was fit. Responses were coded as 1 for selecting the semantic item and 0 for selecting the morphological item; all 'other' responses were removed prior to analysis. The model included stimulus variables of ResponseDomain (Tools/Mammals) and ResponseClass (3/5/7/9) and participant variables of Age, YearsInEducation, and Kiswahili (Y/N; whether a participant listed Kiswahili as an additional language) as fixed effects. As Age and YearsInEducation were highly correlated, we residualized YearsInEducation against Age, and centered both variables prior to inclusion in the model. Knowledge of other languages was excluded from analysis due to lack of variation, as all participants reported speaking English, a large majority reported speaking French, and only a single participant listed speaking Chinese and German each (see **Table 2**). Participant and Trial were included as random effects, and their inclusion was justified by means of likelihood ratio testing. The models were fit using the lmer package (Bates et al., 2015), and p-values estimated from lmerTest (Kuznetsova et al., 2017).

The logistic mixed effects model analysis of participant responses in critical trials showed that response type was not predicted by participant Age ($\chi^2(1) = 0.001, p > .05$) or YearsInEducation ($\chi^2(1) = 0.53, p > .05$). Similarly, the stimulus characteristics of ResponseDomain ($\chi^2(1) = 0.61$, $p > .05$) and ResponseClass ($\chi^2(3) = 3.17$, $p > .05$) were also found not to be significant. However, our model did show a significant effect of Kiswahili (Y/N) on response choice, such that participants who listed Kiswahili as an additional language were more likely to choose the morphological odd one out as the 'most different' ($\chi^2(1) = 4.92, p < .05$).

As this outcome was not predicted by any previous work, we sought to better understand the contributions of the Kiswahili speakers to our data, and whether this seeming distinction by language background might, in fact, be driven by the contribution of other covariates. Compared to the other participants in our data, the Kiswahili participants were younger (mean age = 29.2 (8.83)) than non-Kiswahili speakers (mean = 34.6 (12.1)). This relationship was significant in a simple linear model predicting Age from Kiswahili status ($\beta = –5.54$, $z = –11.12$, $p < .001$).

The same was true for YearsInEducation, where Kiswahili speakers had spent less overall time in education (mean years = 17.1 (2.58)), compared to non-Kiswahili speakers (mean = 17.4 (3.48)). This relationship was likewise statistically significant in a simple linear model predicting residualized YearsInEducation from Kiswahili status (β = –0.58, z = –4.98, $p < .001$).

We ran two additional models to address these confounded sources of variation separately. We first opted to run a smaller exploratory model without the Kiswahili variable, to see if its inclusion in the original model was masking potentially significant contributions from Age and YearsInEducation. This model with Age, YearsInEducation, ResponseDomain, and ResponseClass as fixed effects showed none of the predictor variables were significant (all $ps > .05$). Taking the opposite strategy, we fit a final model including Kiswaili but without Age or YearsInEducation. In this model, Kiswahili indeed maintained significance at a slightly higher level than in the original exploratory model (β = 1.41, OR = 4.10, z = 2.22, $p < .05$), showing that speaking Kiswahili had a strong influence on the likelihood that a participant would choose the morphological odd one out in the critical trials.

We followed up on this finding by running two further exploratory logistic mixed effects models on the semantic and morphological baseline trials, respectively. These models were structured identically to the model used for the critical trials, but excluded Age and YearsInEducation. In the semantic baseline trials and the morphological baseline trials, we find a similar pattern of results as in the critical trials, with no significant difference in response choice by ResponseDomain or ResponseClass, but an influence of Kiswahili status in both. In the semantic baseline trials, Kiswahili speakers are shown to be less likely to select the semantic odd one out than non-Kiswahili speakers (β = –0.99, OR = 0.37, z = –2.28, $p < .05$). In the morphological baselines, Kiswahili speakers are also somewhat more likely to select the morphological odd one out (β = 0.74, OR = 2.10, $z = 1.98, p < .05$). Baseline triad observations comparing Kiswahili and non-Kiswahili L2 speakers are illustrated in **Figure 3**, while critical triads are illustrated in **Figure 4**.

4. Discussion

Taken together, the findings of our study show that most Kinyarwanda speakers are sensitive to semantic and morphological similarity within groups of nouns, and when forced to choose between these two methods for classification, there is a preference for using semantic information. However, a more detailed analysis of the results showed that people differ quite widely in their preferences, with some preferring to group nouns based on meaning and others preferring morphological categorization. In exploring why such variation might exist, we found that responses in Kinyarwanda appear to be affected by whether the individual also speaks Kiswahili, with non-Kiswahili speakers preferring to group nouns semantically, and Kiswahili speakers choosing more often to group nouns by morphology. We discuss these points in more detail below.

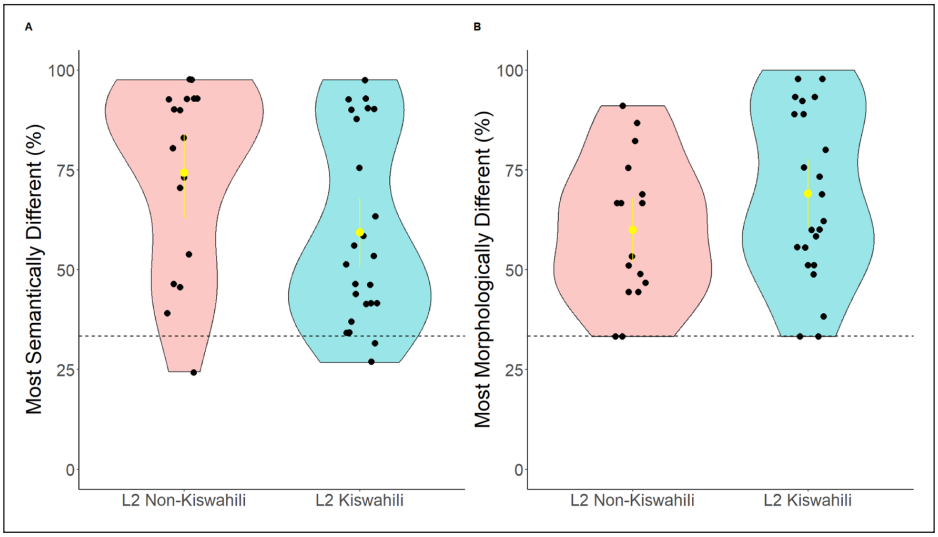

Figure 3: (A) L2 Non-Kiswahili vs. L2 Kiswahili baseline triad responses identifying most semantically different as preferred option. (B) L2 Non-Kiswahili vs. L2 Kiswahili baseline triad responses identifying most morphologically different as preferred option. Each dot represents participant mean proportions of responses. Group average proportion of responses is illustrated as a yellow square, with the line indicating one standard deviation from the mean. Chance-levels are indicated by a dashed horizontal line.

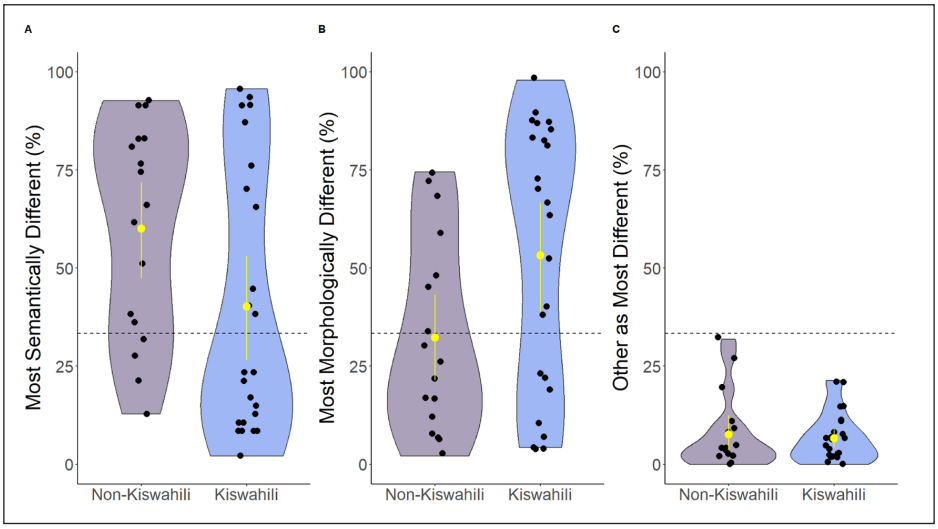

Figure 4: (A) L2 Non-Kiswahili vs. L2 Kiswahili critical triad responses identifying most semantically different as preferred option. (B) L2 Non-Kiswahili vs. L2 Kiswahili critical triad responses identifying most morphologically different as preferred option. (C) L2 Non-Kiswahili vs. L2 Kiswahili critical triad responses identifying the 'other' option as most different. Each dot represents participant mean proportions of responses. Group average proportion of responses is illustrated as a yellow square, with the line indicating one standard deviation from the mean. Chance-levels are indicated by a dashed horizontal line.

4.1 The classification of nominals by Kinyarwanda speakers

The findings of the present study provide support for Burton & Kirk's general observation that noun class morphology has a statistically significant effect on triad choices, over and above semantic considerations. Their work showed that while classification of nominals in Gĩkũyũ is largely driven by semantic characteristics, noun class membership is used secondarily when semantic similarity across nominals is high. Although the setup of our triads differs somewhat from theirs (without gradations in semantic similarity), we find a very similar pattern: semantic classification is generally preferred, but when semantic similarity across nouns is quite low, as in our morphological baselines, nominals are grouped by noun class instead. In addition, as with our own findings in Kinyarwanda, their data displays a large degree of variability, with noun class membership being used to classify nouns by some participants in all of their triads, regardless of the degree of semantic similarity.

Although the broad findings are similar at a group level, we implemented several changes to the design and analysis of the data, in comparison to Burton & Kirk's original study, that are worth commenting on. First, we note that we took a more hands-off approach to categorization, giving minimal instruction to our participants. In contrast, Burton & Kirk suggested that participants use "images which the words brought to mind" (Burton & Kirk, 1976, p. 163) as the basis for determining their similarity. Given this, we might have predicted a greater proportion of semantically-based responses in their data compared to ours, but we note that the overall proportions remain roughly the same. In their triads which contained one item which was semantically different from the others, by either size or phylogeny, they report 44–54% of their responses choose the semantically odd item. This range is similar to ours in critical trials, where participants chose the semantically odd item 50.16% of the time, and much smaller than in our own semantic baseline trials, where participants chose the semantically odd item 66.38% of the time. Thus, it appears that participants naturally attend to semantic characteristics even without explicit instruction to move their focus away from word form.

In terms of word forms, we presented our stimuli in standard written orthography rather than verbally (although Burton & Kirk do not explicitly state what modality their experiment took place in, we can assume it was done verbally, given their inclusion of non-literate participants). In doing so, our data does introduce additional complications, owing to written stimulus characteristics. In particular, we note that participants were more able to identify the morphologically odd item in the baseline trials when there was a large phonological and orthographic difference in prefix compositions: accuracy was higher when participants needed to discriminate Class 3 *umu–* prefixes and Class 7 *igi–/iki–* prefixes from other items. As discussed in 2.4.1, accuracy was much lower when triads contained nominals which had only Class 5 *i–* and Class 9 *im–/in–* prefixes. The additional complication of Kinyarwanda nominals in Class 9 having phonologically conditioned *i–* prefix allomorphs (not included in our stimuli) makes the

contribution of orthography and phonology difficult to untangle in the present study. Future work could explore the degree to which allomorphs within noun classes are consciously grouped together when reading written forms, which would expand on existing work in morphological decomposition in reading (Baayen & Schreuder, 2003; Libben, 1994; Rastle & Davis, 2008; Stockall & Marantz, 2006), where comparatively little focus has been put on the processing of inflectional prefixes.

4.2 The possible influence of multilingualism

A key point of divergence from Burton & Kirk's original work is our choice of which participants to include. In their study, they included only participants with less than three years of formal schooling, explicitly to avoid participants who had knowledge of additional languages (Burton & Kirk, 1976, p. 164). While this does, in some ways, lead to a more homogeneous pool of participants, it is far from ecologically valid in the present educational situation in Rwanda. In Rwanda, schooling is free and compulsory up through Grade 12, with English as the language of instruction from Year 4 onward, including at university (Nzabalirwa, 2014). As our participants were primarily students from the University of Rwanda, avoiding bilingual participants was a practical impossibility. We note that even with highly multilingual participants, the results we find are largely in line with Burton & Kirk's original study.

Where we find greater discrepancies is in looking more closely at individual participant characteristics. Here we found that individual variation in triad choice was significantly influenced by Kinyarwanda speakers who had also learned a particular additional language: Kiswahili. The decision by Burton & Kirk to look solely at monolingual speakers of Gĩkũyũ is then in some ways justified, but while their initial concern was the possible influence of learning English, our data suggests that it is the influence of having learned Kiswahili specifically that may alter the way native speakers of Kinyarwanda treat nominals.

That Kiswahili knowledge played a large role in classification preferences in Kinyarwanda was an unexpected finding. Given that Kinyarwanda, Kiswahili, and Gĩkũyũ are *all* Bantu languages with similar noun class systems, it is not immediately obvious why speaking two Bantu languages would lead a speaker to a greater propensity for attending to noun classes. One linguistically-grounded explanation of this would be to point out that some individual nouns used in this study will belong to different noun classes in Kiswahili. For instance, while *in-kura* 'rhinoceros' and *im-parage* 'zebra' are both Class 9 nouns in Kinyarwanda, their equivalents in Kiswahili are in separate classes: *ki-faru* 'rhinoceros' is in Class 7, and ∅*-punda milia* 'zebra' is in Class 9. This kind of cross-linguistic discrepancy in grammatical category membership has been thoroughly investigated in terms of grammatical gender systems in primarily Indo-European languages (see Sá-Leite et al. (2019, 2020) for review). This large body of work has provided evidence that in both perception (Morales et al., 2011; Paolieri et al., 2010) and production

(Wang & Schiller, 2019), words belonging to conflicting gender categories across languages can cause processing difficulties. What has not been addressed is whether there is any fundamental change to the speaker's degree of awareness of the gender systems in their native language, and whether this would be relevant for the case of multilingual speakers of Bantu languages, where as we have seen, the noun classes have a strong semantic component in addition to an abstract grammatical form. Of what studies there are on Bantu multilingualism, the findings suggest that learning noun class systems generally is aided by speaking a language that already has noun classes (cf. Orr (1987) cited in Spinner (2011)), but as far as we are aware there is no further work on the underlying nature of this knowledge. The field of multilingual language processing is clearly in need of more research on within-Bantu multilingualism (see Spinner (2011) for further discussion).

Another possibility which may explain the influence of Kiswahili learning concerns the impact of the learning environment itself. In our data, Kiswahili experience differs from our participants' reported background and proficiency with English and French. Both English and French were reported as having been learned on average around the age of 10, corresponding to current Rwandan educational policy which relies on Kinyarwanda as the language of instruction in pre-primary and early primary school, but switches to English in Year 4, and introduces French as a foreign language at the same point (Nzabalirwa, 2014). In contrast, our Kiswahili speakers reported learning this additional language later in life (around age 15 on average), following from Kiswahili education not being generally available to younger children (Rosendal, 2010). Given this scenario, it is fair to say that learning Kiswahili will be fundamentally different from learning English or French in Rwanda. This difference may itself have an impact on the kinds of linguistic knowledge that our Kiswahili speakers have acquired. Indeed, research into additional language instruction in primary and secondary school settings has suggested that metalinguistic skills are slow to develop, and that these abilities may not be fully available to younger learners (cf. DeKeyser, 2003; Ellis, 2009). Thus, if learning a language later in life improves grammatical awareness more generally, this may be more likely to be observed in our Kiswahili speaking group.

Beyond general grammatical awareness, a more specifically relevant aspect of learning Kiswahili in a formal setting would be a likely focus on noun classes as a grammatical feature. If noun class structure is taught explicitly in Kiswahili classrooms, this may help explain why Kiswahili speakers appear to be more sensitive to the similar grammatical structures in Kinyarwanda. While this explanation is enticing, we note that little has been published on the specifics of language instruction in Rwandan educational settings, and we cannot speak with confidence about the methods with which the Kiswahili grammatical system would have been taught to our participants. We also note that while there is a rich literature surrounding the role of metalinguistic awareness in second or additional language acquisition (see Roehr-Brackin

(2018) for review), there are relatively few studies which address whether explicit grammatical instruction in an L2 impacts L1 grammatical knowledge directly (although see, for instance, Martínez et al., 2024; van Rijt et al., 2022). What our results do indicate is that this is an area which is in need of much more research, both in terms of the specific educational situation in Rwanda, and the larger question of the impact of L2 instruction on typologically-similar L1 grammatical knowledge.

4.3 Individual variation in classification

We chose to look closely at individual data as well as group data to assess how uniform individual participant preferences may be in the use of semantic and morphological criteria to classify nominals. Our data shows clearly that speakers of Kinyarwanda do not have uniform judgements about noun categorization and display a great deal of individual variability in their triad responses across both baseline and critical trials. For some, the morphological similarity inherent in the class of the noun is a major contributing factor in how they categorize nominals in the language; for others, it is shared semantic properties that have a larger influence on how they categorize nouns in Kinyarwanda; others yet show a flexible use of both strategies. This individual variability suggests that a single, uniform analysis of noun categorization in Kinyarwanda is unlikely to capture the behavior of individual speakers.

This variation has an impact on the way we might conceptualize lexical organization in complex morphological systems, such as this one. Although there are several theoretical suggestions for how noun class systems in Bantu languages are structured (ranging from more semantically-based (Creider, 1975) to more morphophonologically-determined (Demuth, 2000; Demuth & Ellis, 2009), our data suggests these choices are on an individual level perhaps non-deterministic, and that speakers may arrive at different solutions when presented with the same linguistic data. Thus, for complex systems such as these, which have historically-derived semantic and morphophonological regularities, but are no longer synchronically fully cohesive, the true composition of the noun classes may be both emergent and dynamic. The emergent nature of grammatical categories has a long history in language acquisition theory, where emergent systems have been proposed as an alternative approach to learnability outside of a nativist framework (e.g., Ibbotson et al., 2019; Tomasello, 2005). For our study, the data suggests that individual speakers may treat the systems as varyingly semantically- or morphologically-based, and that the nature of this conceptualization may be impacted by specific lived experiences, including learning additional languages that share typological similarities.

5. Conclusion

Our research adopted the triadic comparison method implemented by Burton & Kirk (1976) in order to examine how speakers of Kinyarwanda categorize nouns, with the aim of improving

our understanding of the semantic reality of noun classes among speakers of the language. Our results show a mixed picture: although there is an overall preference for semantic categorization across the group, individual participants vary in the degree to which they attend to semantic and morphological properties in groups of nouns. An exploratory analysis to determine sources of this variation led to the unexpected finding that knowledge of Kiswahili may change the way Kinyarwanda speakers perform this kind of task in their native language.

However, determining how or why Kiswahili knowledge would affect categorization data in Kinyarwanda requires further research. We suggest that there may be changes to the grammatical system that come about by having learned two similar but non-identical noun class systems. Testing this hypothesis would require conducting a comparable triads study in Kiswahili, and doing comparative work between Kinyarwanda and Kiswahili noun classes to better understand where differences in noun class membership within our group of nouns would arise.

In addition, it is possible that metalinguistic awareness of noun class systems (acquired through learning an additional language which has this kind of system) makes Kinyarwanda speakers more aware of noun classes as a grammatical phenomenon in general, which, therefore, makes speakers more likely to attend to that information. Future work could compare Kinyarwanda speakers of Kiswahili versus Kinyarwanda speakers of other Bantu languages; this would permit generalizations as to whether there is an effect of metalinguistic awareness or whether there is transfer of specific knowledge from Kiswahili. An exploration of teaching practices would also better explicate the degree to which explicit teaching of noun classes is required for this kind of increase in metalinguistic awareness, over and above the learning of two languages with similar noun class systems. While the current study provides an empirical and conceptual starting point for understanding the nature of transfer between and among multiple Bantu languages in the mind of a speaker, there are a number of open questions for future research.

Data accessibility statement

A full list of triads used in this study and other supplementary materials are available at https://osf.io/3bh9q/.

Ethics and consent

This study was conducted with the approval of the University of Essex's Ethics Sub-Committee 3, approval numbers ETH2223-1076, ETH2021-0978 and ETH1920-0975.

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Competing interests

The authors declare no competing interests.

Authors' contributions

The authors contributions are as follows: conceptualization (LL, KJ, FO, WvB), data curation (FO, WvB), formal analysis (LL, FO), funding acquisition (KJ, LL, FO, WvB), data collection (KJ, JPN), investigation (LL, KJ, FO, WvB), methodology (LL, KJ, FO, WvB), project administration (LL, KJ), resources (JPN), supervision (LL, KJ), visualization (LL, FO), writing – original draft (LL, FO, KJ, WvB), writing – review & editing (LL, KJ,JPN, FO and WvB).

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