WORDS OR RULES: PHONOLOGICAL MUTATIONS IN WUBUY

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ABSTRACT

The present study addresses the question of whether complex morphological sequences are the result of rule application or relational or associative morphological processes/schemas and extensive listings in the lexicon. It does so by testing the effect of phonological hardening (a phonological mutation of syllable initial sonorants, turning them into stops) on word-recognition in the highly polysynthetic Australian Indigenous language Wubuy, in a Two-Alternate Forced Choice paradigm. The results indicate that it is harder to recognise the correct word-form when mutation applies, than when it does not, and that recognising the correctly mutated form may not happen under all conditions. These results are consistent with rule-application approaches to language processing rather than associative/relational models, relying on more listings in the lexicon.

Keywords: Polysynthesis, phonological alternations, word-recognition, word processing.

1. INTRODUCTION

The present study addresses the question of whether complex morphological sequences are generated as the result of rule application (syntactic, morphological, and/or phonological) as is assumed under generativist/Chomskyan models of language processing [1], [2] or whether they can be accounted for by relational or associative morphological processes/schemas and extensive listings in the lexicon (e.g., [3] as well as for instance in [4]'s Short-List B.

The present study addresses this question by testing the effect of the application of morpho-phonological alternations on the process of word-recognition in the highly polysynthetic Australian Indigenous language Wubuy [5]. Wubuy implements two complex, parallel morpho-phonologically processes, *phonological hardening* (the focus here) and /ŋu/-insertion, which offer an ideal testing ground for the very fundamental question of words versus rules. Wubuy Hardening, just like the perhaps more well-known Welsh mutations [6] results in significant phonological changes to initial segments of surface forms of morphemes under certain conditions.

Phonological hardening in Wubuy is a process of consonant alternation which affects morpheme initial approximants when the previous morpheme ends in a non-continuant, by realising the approximant as a stop consonant at the same place of articulation. Hardening operates in parallel with a second process—*/ŋu/ insertion*—in which the meaningless string /ŋu/ is inserted before underlyingly (not derived) stop-initial morphemes, when these occur in similar environments: /*nuŋu-ak-walaŋi*/ (we/her-BEN-paint.PAST) → /*nuŋaapalaŋi*/ (/*walaŋi*/ hardened to /*palaŋi*/) versus /*nuŋu-ak-paḻuŋ*/ (we/her-BEN-cut.past) → /*nuŋaaŋupaḻuŋ*/ (with insertion of /*ŋu*/).

Under parallel-associative (PA) and relational models like *Construction Grammar* (CxG; e.g. [7]) and *Relational Morphology* (RM; [3]), language acquisition is "item based" and lexico-grammatical choices are explained primarily by complex patterns of parallel associations between (adjacent) elements. These elements are organised into "independent systems for phonology, syntax, and semantics", connected by linkages which create "correspondences between components rather than *derivations from one component to another"* [3].

Under parallel-associative and similar full-listing models, phonological mutations such as those in Wubuy and Welsh must thus be accounted for as non-derivational and parallel, and the involved morphemes/words must be selected in a one-step process from multiple equivalent forms in the lexicon, on the basis of their co-occurrence patterns in the input. These models generate the prediction that we would observe no difference in processing cost (measured in for instance response time, event related potentials, or response accuracy in

experimental paradigms like the one implemented here) for selection of particular forms, including those forms that have traditionally been referred to as hardened over those that are not hardened: "Hence, the composition of a word or sentence involves clipping together stored pieces in such a way that every element of the composed structure is accounted for in terms of one stored piece or another" [3]. Note that, despite talking of 'words' here, Wubuy verbs are complete propositions, and thus their processing is more akin to the processing of sentences in some respects [13].

Under a rule-based (Chomskyan) analysis [1], individual morphemes have one canonical phonological shape in the lexicon, which must be selected prior to the application of any morphophonological rules that are triggered by the phonological shape of the selected morphemes. This is logically a sequential process (even if constraints on surface forms are computed in parallel, as in Optimality Theory [8]), and the identification and implementation of necessary phonological mutations presumably increase the processing demands of spoken word recognition and comprehension when a mutation must be applied, although we are aware of no work on this specific issue. In the case of the Wubuy hardening phenomenon, we would expect application of a hardening rule to induce greater processing cost than non-application of a rule (no change as the trigger for change is absent), and likely higher error rates and greater time cost associated with rule application. Such asymmetrical performance is at odds with the predictions from parallel-associative models.

2. METHOD

2.1. Participants

14 speakers of Wubuy participated in the experiment. The participants (11 women) ranged in age from approximately 40-70 years. All participants were native speakers of Wubuy, and resident in Numbulwar at the time of testing. The participants were recruited by word of mouth in the community of NumbulwarThe participants constitute app. 25% of the speaking population (see discussion in [9]). This population is predominantly older, as the community is and has been undergoing language-shift to the English-lexified contact variety Kriol [10], [11].

2.2. Materials

The materials consisted of a Two-Alternate Forced Choice experiment in two parts (Exp. 1; Exp. 2). In each part of the experiment, participants were presented with pairs of one of four complex Wubuy words, half of which differed in whether the Wubuy hardening rule had been applied in an obligatory hardening context, or whether hardening had been incorrectly applied in a non-hardening context. Exp. 2 differed from Exp. 1 only in that a 500 ms period of silence was inserted before the target verb in each of the words.

The four complex words consisted of the prefix */nuŋaak/* (we/her-BEN), which induces hardening of following sonorants, even though it is realised as [*nuŋaa*] due to a rule deleting final /k/, followed by one of four incorporated sonorant-initial nouns, which had been correctly hardened, and by one of four verb stems, each in a Non-Hardened (sonorant-initial; S) form and a Hardened (stop-initial; H) form. Two of the nouns (*/ʈarpic/*, 'thigh'*; /ʈaŋak/,* 'branch') are stop-final and thus induce hardening of the initial segment of the following verb stem, while two of the nouns (*/paɲca/*, 'arm'*; /ʈukanta/*, 'leg') do not (See Table 1).

Pref.	Noun	Verb
nuŋaa	ʈarpic	ʟiɲ/ʈiɲ (chop.PAST)
	ʈaŋak	aajuu//kaajuu (cut.PAST)
	paɲca	waɭaŋi/paɭaŋi (paint.PAST)
	ʈukanta	waɭpumana/paɭpumana (paint.PRES)

Table 1: Prefix (Pref.), Nouns and Verbs in Non-Hardened (first) and Hardened (second) forms.

The complex word stimuli for the 2AFC experiments were produced by a literate Wubuy speaker (female, in her 50s), using a PMD660 Marantz flash-RAM digital recorder with a DPA d:fine headset microphone. All recordings had a 16-bit sampling depth with a sampling rate of 44.1 kHz. During the recording session, the speaker was asked to produce [*nuŋaa*] + each of the four nouns followed by pause in which she *imagined* producing a verb stem. This approach ensured that the intonation contour for the

incorporated noun did not bear unusual phrase-final intonation, and that coarticulatory information from a transition into a following verb stem would not influence the participants preference judgements. The speaker produced several utterances of each [*nuŋaa*]+*NOUN* frame, and one token of each frame type was selected on the basis of clarity, pitch, and naturalness in the matchup between the frames.

The four [*nuŋaa*]+*NOUN* frames were cross-spliced with naturally produced recordings of the four non-hardened and the four hardened verb stems elicited by the same speaker with phrase final intonation, in *Praat* [12]. This procedure created 16 word-pairs in which hardening was correctly applied in half and over-applied (i.e., without a preceding non-continuant segment) in the other half. Each pair was presented twice (order counterbalanced) producing 32 pseudo-randomised trials (See Examples 1 and 2):

Non-hardening example, correct form second:

1) [*nuŋaa-panca-ʈiɲ*] *vs* [*nuŋaa-panca-ɭiɲ*]

Hardening example, correct form first:

2) [*nuŋaa-ʈarpic-ʈiɲ*] vs [*nuŋaa-ʈarpic-ɭiɲ*]

2.3. Procedure

Participants completed Exp. 1 and Exp. 2 in a quiet home in Numbulwar, in the presence of the authors and a Wubuy speaker well-known to the participants. All testing instructions were provided in English, but the Wubuy speaker provided instructions also in Wubuy when necessary or requested.

Presentation order of Exps. 1 and 2 was counter balanced so that seven participants completed Exp. 1 (No Pause) first, and seven participants completed Exp. 2 (Pause inserted) first. The participants were presented with the word pairs over headphones from a MacBook computer which displayed two line-drawings of faces, to indicate that two speakers would be heard. The participants were instructed to indicate which of the utterances they preferred (the first or the second), and they could do so by pointing to the first or second line-drawn face on the screen, by saying 'number one' or 'number two' (in English or in Wubuy), or by raising one or two fingers. This approach deviates from the approach typically taken, due to the test-taking profile and preferences of the participants. The participants were free to listen to each word pair as many times as they liked, before recording their response. All participants were given an open-ended rest break between the two parts of the experiment. All testing instructions were provided in English, but a familiar L1 Wubuy speaker was also present before and during testing to provide instructions also in Wubuy when necessary or requested.

2.4. Predictions

If Wubuy word recognition relies on complex patterns of parallel associations between adjacent morphemes in morphological schema which are fully listed, we predict that the participants will show similar levels of accuracy for words with hardened and non-hardened verb stems. We do not expect to see improved performance as a function of artificial pause insertion, given that pausing interrupts the sequence of morphemes and that no processing cost is incurred at the juncture by the application of a morphophonological rule. If on the other hand, Wubuy word recognition relies on sequential application of a morphophonological rule triggered only in half of the experimental trials, we might expect poorer performance on Hardening trials than Non-Hardening trials, and improved performance with increased processing time in the form of pause insertion.

3. RESULTS

The mean percent correct performance in Exp. 1 and Exp. 2 is presented in Figure 1. The average accuracy ranged from 58% (*SD* = .194) and 62% (*SD* = .146) for the Hardened (H) verbs in the two Pause Conditions (A, B) respectively, to 69% (*SD* = .192) to 71% (*SD* = .213) for the Non-Hardened (S) verbs in the two Pause Conditions (A, B). The low averages indicate that the task was challenging, likely due to the two levels of hardening (nouns *and* verbs), and the additional rule deleting final /k/ from the prefix. It may however, also in part be due to the artificiality of tasks of this kind.

To test the competing predictions from models like CxG/RM and more traditional Chomskyan rule-based approaches, we first compared the participants performance on hardening and non-hardening trials with and without pause insertion to chance performance

(50%). This analysis showed that participant accuracy did *not* differ from chance in the *hardened no-pause condition* (p = .0658), but that participants performed above chance on the non-hardened no-pause condition (p = .0002), and on both hardened and non-hardened trials in the pause insertion condition (p = .0128, and p = .0001, respectively).

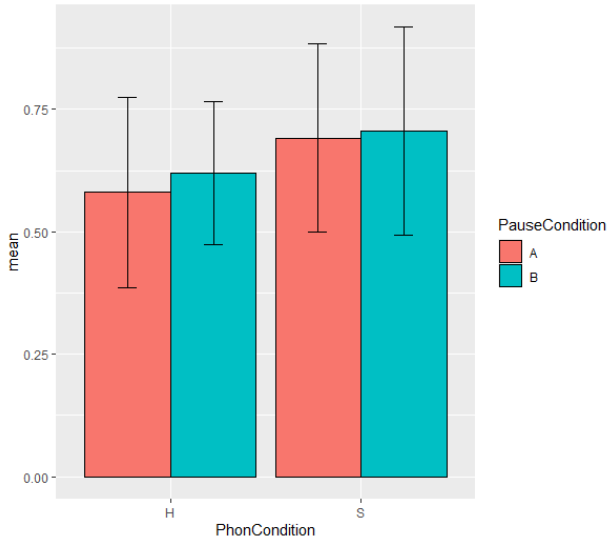

Figure 1: Average accuracy in %. H indicates correct application of hardening rule, S indicates no hardening. A indicates no pause inserted, B indicates 500ms of pause inserted before the verb stem. Error bars indicate SE.

In order to test whether the Wubuy participants' performance is affected by the phonological condition (hardened or non-hardened verb stem) and by pause condition (no pause inserted and 500 ms of silence inserted prior to the verb stem), we built a linear mixed-effects model (LMM, fixed effects: Phonological Condition [Hardened vs Non-Hardened] and Pause Condition [No Pause vs Pause Insertion]; random effects: Participant and Word). We checked the model using a Wald Chi-squared test, which revealed a significant main effect of Phonological Condition (Wald $\chi2$ = 10.6285, p = .0011), but no main effect of Pause Condition (Wald $\chi2$ = 1.6333, p = .2013). There was no interaction (*Wald $\chi2$ = 0.3126, p = .5761*).

Given that we did not find a significant effect of Pause Condition, nor an interaction between Phonological and Pause Conditions, we conducted only *post hoc* comparison for the two Phonological Conditions (Hardened onset vs Non-Hardened onset). This comparison indicated that it was significantly more difficult for the participants to select the correct verb form in the Hardened condition than in the Non-Hardened Condition (estimated means = 64.3% (Hardened) and 80.4% (Non-Hardened), z = 3.281, p = .0010).

4. DISCUSSION

The results of the present experiments clearly indicate that Wubuy speakers find it much harder to recognise the correct Hardened verb forms than correct Non-Hardened verb-forms in a 2AFC paradigm. While we found no main effect of Pause Condition (No-Pause vs Pause Insertion), and therefore cannot conclude that Pause Insertion, as a proxy for extra processing time, improves performance accuracy, we note that performance on Hardened forms with No-Pause was the only condition that did not differ from chance.

The results are consistent with a rule-based account of Wubuy phonological mutations, in that it would appear that application of the Hardening rule decreases accuracy (presumably due to increased cognitive demand, c.f. [14]), and further, that, to some extent, correct rule application appears to benefit from additional processing time (above-chance performance on Hardened forms only in the Pause Condition).

The results cannot be readily accounted for from within a RM (or similar) account of word-formation, where words are "clipped together" from already-stored forms, unless there are highly asymmetrical frequencies in the input (for which we have no clear evidence: all eight verbforms appear with low frequency in the available Wubuy text corpus). A third potential explanation, one in which morpheme-initial stop-sonorant pairs following morpheme-final stops are treated as context-dependent neutralisations, fails to account for the accuracy asymmetry between Hardened and Non-Hardened forms, and we thus also discount this explanation of the phenomenon.

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