The application of morpho-phonological rules comes with a processing cost
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Background: Many Indigenous Australian languages allow highly complex single words, such as *ŋanijinaŋukucukucaani* in Wubuy (a.k.a. 'Nunggubuyu': [2]) which is best translated into English as *I was tickling him on the head*. It is not clear to what extent these words are generated procedurally, like phrases in English, or whether they are stored as chunks in a speaker's mental lexicon (and serially/linearly linked to preceding and following elements). One morpho-phonological rule, called 'hardening', in Wubuy provides a typologically rare opportunity to examine this question: In Wubuy, all stems beginning in a continuant (vowel, liquid or glide—Wubuy has no contrastive fricatives or stop voicing contrast) alternate with stop-initial forms when the stem follows a nasal or stop across a morpheme boundary. If Wubuy words are indeed word-like and do not involve operations on constituent morphemes, these forms would presumably be stored whole and retrieved as individual lexical entries, as needed. If, on the other hand, these words are like phrases, we would expect a morpho-phonological alternation rule to be applied to the un-hardened (underlying) lexeme as needed, with a processing cost. **The study:** 14 speakers of Wubuy (aged 40-70; approx. 25% of the speaking population; 1 participant excluded) participated in a self-timed two-alternate forced choice preference task in two parts. In Part 1 (No Pause Condition), participants were presented with four pairs of Wubuy words that differed only in whether or not the hardening rule had applied to the stem: Wubuy verbs *ḻiɲ* (to chop), *aajuu* (to cut), *walaŋi* (to paint), and *walpumana* (also 'to paint') and their hardened forms *ṯiɲ*, *kaajuu*, *palaŋi*, and *palpumana*. These verbs were cross-spliced into two complex word frames which induce hardening (1a, 1b) and two which do not (2a, 2b), generating 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. Part 2 (Pause Condition) was identical to Part 1, except that a 500 ms period of silence was inserted before the target verb. **Predictions:** If Wubuy word comprehension does not require morpho-phonological decomposition, we would expect no difference in accuracy for verbs in frames requiring hardening versus frames that do not, and we might also expect decreased accuracy for hardened and non-hardened forms in the Pause Condition due to unexpected word-internal pausing. If on the other hand, Wubuy word comprehension requires complex morpho-phonological decomposition, we would expect hardened forms to be more demanding to process than non-hardened forms, resulting in lower task accuracy. It is also plausible that pause insertion provides listeners with extra processing time, increasing task accuracy, in particular for the more complex hardened forms, in the Pause Condition. **Results and Discussion:** A mixed-effects logistic regression model was fit to the results; estimated group means are represented in Figure 1. We included 'Hardening Condition' (hardening [H] vs no hardening [NH] required) and 'Pause Condition' (Part 1 vs Part 2) as fixed effects, while participant and item were included as crossed random effects. Participants preferred words with correct verb forms in both conditions—hardening and non-hardening—in Part 2 (H: 95% CI = 52%-73%, *p* = 0.0252; NH: 95% CI = 64%-84%, *p* <.001), and in trials which required no hardening in Part 1 (95% CI = 62%-82%, *p* < .001). In Part 1, preference for hardened over non-hardened verbs in frames that require hardening did not differ from chance (95% CI = 46%-70%; *p* = 0.1884). Further, participants more accurately selected the correct verb form in non-hardening than in hardening conditions in both Part 1 (*p* = 0.0091) and Part 2 (*p* = 0.0497). The fact that hardening environments are more difficult to process than non-hardening environments suggests that the two forms are not stored as equally accessible separate lexical

entries, but rather that the hardened form is generated by the application of a rule to the underlying non-hardened form. This interpretation is supported by the observation that it is easier to correctly select a hardened form when participants have more time to process the word in question (in Part 2).

1a)   nuŋaa-panca (*we for her + arm*) + TARGET
1b)   nuŋaa-ṯukanta (*we for her + leg*) + TARGET
2a)   nuŋaa-ṯarpic (*we for her + thigh*) + TARGET
2b)   nuŋaa-ṯaŋak (*we for her + branch*) + TARGET

Note that all incorporated nouns ('arm', etc) are hardened forms, following the benefactive prefix form *nuŋaa-* (underlyingly *nuŋa-ak-*).
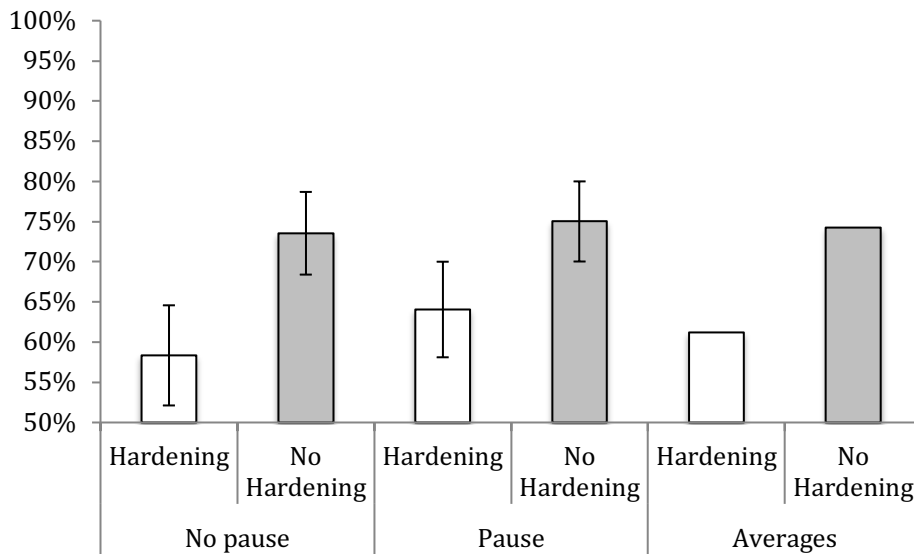
Stimulus example (non-hardening), correct form presented second:
3)   nuŋaa-panca-ṯiɲ... nuŋaa-panca-l̪iɲ
        (*we for her + arm*) + TARGETa ... (*we for her + arm*) + TARGETb

Stimulus example (hardening), correct form presented first:
4)   nuŋaa-ṯarpic-ṯiɲ... nuŋaa-ṯarpic-l̪iɲ
        (*we for her + arm*) + TARGETa ... (*we for her + arm*) + TARGETb

Figure 1. Average accuracy in %. Error bars indicate SE.

Reference.
[1] Baker, B. & Bundgaard-Nielsen, R. (2016). Pause acceptability is predicted by morphological transparency in Wubuy. In C. Carignan, M.D. Tyler (Eds.), Proceedings of the Sixteenth Australasian International Conference on Speech Science and Technology, Sydney, Australia, 07 Dec 2016 - 09 Dec 2016, (pp. 197-200). Australasian Speech Science and Technology Australia (ASSTA), Sydney.
[2] Heath, J. 1984. Functional grammar of Nunggubuyu. Canberra: AIAS.
[3] Baker, B. (2018). Super-Complexity and the Status of 'Word' in Gunwinyguan Languages of Australia. In G. Booij (ed.) *The Construction of Words* (pp. 255-286). Springer: Cham.