Non-word repetition in Yélî Dnye: A small-scale study

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Abstract

ADD

Keywords: phonology, non-word repetition

Word count: xxx

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TODO

- create stimuli table that has complexity & length
- integrate demo data & stim table in final data
- add analysis on the basis of complexity & length
- add analysis on the basis of demo chars
- fix the back-transformation
- add summary of types of error: %semantic, %deletion (which sounds?) %subst (which are the most common sounds)
- maybe add to the last ana the prevalence (ie out of all the gh which proportion get transformed)
- discussion

Introduction

Although infants begin to learn about their native language's phonology within the first year, many studies suggest that in perception and production, in phonetics and phonology, their knowledge continues to develop throughout childhood (e.g., Hazan & Barrett, 2000). One common task in this line of research is nonword repetition (NWR). In NWR studies, participants are presented auditorily with an item that is phonologically legal but lexically meaningless in the language children are learning. The child should immediately try to say it back without changing anything. Accuracy is thought to reflect long-term phonological knowledge (which allows the child to perceive the item accurately even though it is not a real word they have encountered before) as well as online working memory (to encode the item in the interval between hearing it and saying it back).

NWR has been used to seek answers to theoretical questions, including what are the links between phonology, working memory, and the lexicon (Bowey, 2001), as well as for applications, notably using nwr as a diagnostic for language delays and disorders (Estes, Evans, & Else-Quest, 2007). Since non-words can be generated in many languages, it has been used acros a wide array of languages, particularly in Europe (Meir, Walters, & Armon-Lotem, 2016,@is08042009language).

In this study, we use NWR to measure perception-production in children learning Yêly Dnyé, an isolate spoken in Rossel Island, PNG, with an unusually dense phonological inventory. In our implementation of NWR, we made sure that some of the items contained typologically rare and/or challenging sounds.

Intro to the language ((???)) - please feel free to throw away anything that is not useful!

- complexity in the vowel system
- complexity in the consonant system
- word shapes
- typical word length
- although not the focus of this paper, high use of suppletion in verbal paradigms, other features of language, see Levinson XXX for details

Intro to the people ((???)) - please feel free to throw away anything that is not useful! Little is known about language development in children growing up in Rossel Island, a community of primarily subsistence farmers who tend to reside in close-knitted villages where child care is distributed across many individuals, and who typically speak Yélî Dnyé, a phonologically and lexically complex language.

- usually monolingual at home
- schooling in English but it starts at age XX, so not relevant here

- however, some use of English due to immigrants & children of immigrants
- children spend a lot of time with other children
- most parents are subsistence farmers
- parental education generally varies between XX and YY

Brief review of NWR for our purposes. Although the procedure tends to be quite stable, there is some variation in the presentation and structure of items found in previous NWR work. For example, items are often presented orally by the experimenter (Torrington Eaton, Newman, Ratner, & Rowe, 2015), although an increasing number of studies have turned to playing back the stimuli in order to have greater control of the stability of the presentation (Brandeker & Thordardottir, 2015). Additionally, while some studies have used 10-15 non-words, others have employed up to 46 unique items (Piazzalunga, Previtali, Pozzoli, Scarponi, & Schindler, 2019). Often, authors modulate structural complexity, typically measured in terms of item length (measured in number of syllables) and/or syllable structure (open as opposed to closed syllables, Gallon, Harris, & Van der Lely, 2007).

Previous work seems to avoid difficult sounds, but we felt this was important to represent the language, so we also varied this factor. We designed a relatively large number of items but, aware that this may render the task longer and more tiresome, we split some of the items across children. This allowed us to get information about repetition accuracy of more items.

Naturally, designing the task in this way may render the study of individual variaiton within the population more difficult because different children are exposed to different items. However, a review of previous work on individual variation suggested to us that many individual differences effects are relatively small, and would not be detectable with the sample size that we could collect in a given visit. That said, we contribute to the literature by also reporting descriptive analyses that could potentially be integrated in meta-analytic

efforts. Based on previous work, we looked at potential improvements with age (Farmani et al., 2018; Kalnak, Peyrard-Janvid, Forssberg, & Sahlén, 2014; Vance, Stackhouse, & Wells, 2005), and potential negative effects of bilingual exposure (Brandeker & Thordardottir, 2015; Meir & Armon-Lotem, 2017; Meir et al., 2016). Previous work typically finds no significant differences as a function of maternal education (e.g., Farmani et al., 2018; Kalnak et al., 2014; Meir & Armon-Lotem, 2017) or child gender (Chiat & Roy, 2007). Although previous research has not often investigated potential effects of birth order on NWR, there is a sizable literature on these effects in other language tasks (Havron et al., 2019), and therefore we report on those too.

Research questions. We sought to address the following questions:

- What is the overall repetition accuracy (whole word, phoneme based, distance)?
- How does this change as a function of item complexity (number of syllables, sound complexity)?
- How frequent are errors that result in real words? Is that a function of item complexity? What are some common patterns of phonological errors?
- Is individual variation explainable by child age, sex, birth order, monolingual status, and/or parental education?

In view of the hypothesis-driven nature of this work, we consider boosting the interpretational value of these data by announcing our analysis plans prior to conducting them. However, we realized that even pre-registering an analysis would be equivocal because we do not have enough power to look at all relationships of interest, and often to detect any of the known effects. For instance, an effect of stimulus length and age has been reported as significant sometimes, but Tables XX and XX show that even these effects can be quite small. **add table with r/ds from previous work**) Moreover, by virtue of this being a language-specific study, it is unclear that our method (including saliently the items we used) is comparable in precision to previous NWR studies. Therefore, all analyses here are

descriptive and should be considered exploratory.

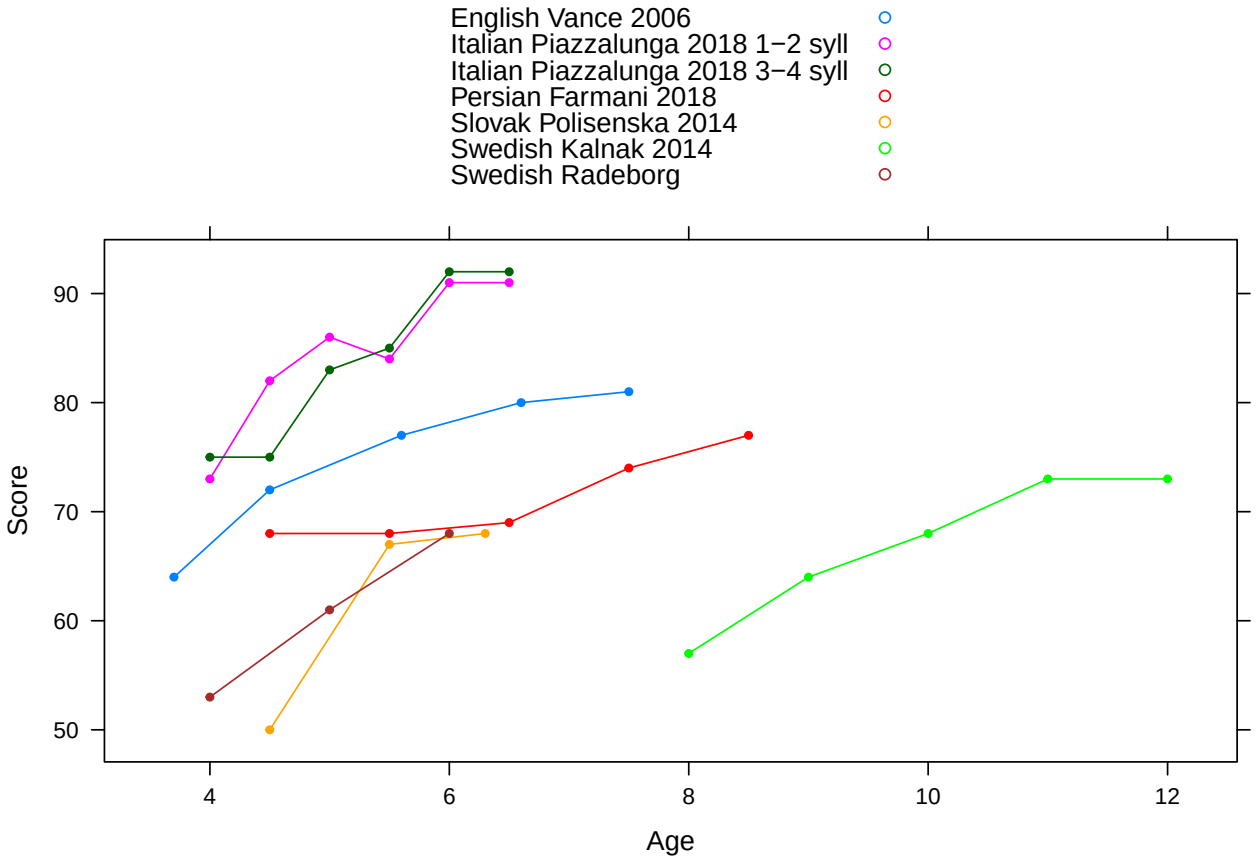


Figure 1. Proportion of non-words correctly repeated as a function of age (in years), study (first author and year regardless of the number of authors), and, when available, shorter versus longer non-words.

Methods

Stimuli. Many NWR studies are based on a fixed list of 12-16 items that vary in length between 1 and 4 syllables, often additionally varying syllable complexity and/or cluster presence and complexity, always meeting the condition that they do not mean anything in the target language. We kept the same variation in item length and the non-meaningfulness requirement, but we did not vary syllable complexity and clusters because these are vanishingly rare in the language. We also increased the number of items

and individual child would be tested on, so that a child would get up to 23 items to repeat, and we created more items and distributed them across children, so as to increase the coverage, and be able to study more items.

A first list of candidate items was generated in 2018 by selecting simple consonants ("p", "t", "d", "k", "m", "n", "w", "y") and vowels ("i", "o","u", "a","e") that were combined into consonant-vowel syllables, further sampling the space of 1- to 4-syllable sequences. These candidates were automatically checked against Levinson's 2015 dictionary and removed from consideration if they appeared in the dictionary. MC presented them orally to three local research assistants, who were asked to repeat them and further say whether they were real words. Any item for which two or more of the assistants reported them having a meaning or some form of association was excluded.

A second list of candidate items was generated in 2019 by selecting complex consonants and systematically crossing them with all the vowels in the Yelî inventory to produce consonant-vowel monosyllables. As before, items were automatically excluded if they appeared in the dictionary. Additionally, since hearing vowel length in monosyllables in isolation is challenging, any item that had a short/long real word neighbor was filtered out. Since the phonology and phonetics of Yélî is still in the process of being described (CITE **???** please fill in), there could have been undocumented constraints that rendered items illegal. Therefore, we made sure that the precise consonant-vowel sequence occurred in some real word in the dictionary (i.e., that there was a longer word included the monosyllable as a subsequence). These candidates were presented to one informant, for a final check that they did not mean anything. Together with the 2018 selection, they were recorded using a headset XXX and an olympus XXX from the written form presented together with the same item orally. The complete recorded list was finally presented to two more informants, who could repeat all the items and who confirmed there were no real words. Even so, there was one monosyllable that was often identified as a real word (intended "yî" /yXX/; identified as "yi"

/yi/, *tree*). This item is removed from analyses.

(**???**) can you please add the IPA in // for all of the items below? The final list is composed of three practice items (wî, poni, nopimade); 20 monoysllables containing sounds that are less frequent in the world's languages than singleton plosives (dpa dp:a dpâ dpéé dpê dpi dpu kp:ââ kpu tp:a tpâ tpê gh:ââ ghuu lva lv:ê lvi t:êê); 8 bisyllables (kamo kipo kani tupa noki piwa towi nomi); 12 trisyllables (nademo meyadi diyeto widone nuyedi tumowe pedumi dimope tiwune wumipo nayeki mituye); and 4 quadrisyllables (todiwuma wadikeno nomiwake diponate).

A Praat script was written to randomize this list 20 times, and split it into two sublists, to generate 40 different elicitation sets. The 40 elicitation sets are available online from https://osf.io/5qspb. The split had the following constraints:

- the same three items were selected as practice items and used in all 40 elicitation sets
- splits were done within each length group from the 2018 items (i.e., separately for 2, 3, and 4-syllable items); and among onset groups for the difficult monosyllables generated in 2019 (i.e., all the monosyllables starting with tp were split into 2 sublists). Since some of these groups had an odd number of items, one of the sublists was slightly longer than the other (20 versus 23).
- once the sublist split had been done, items were randomized such that all children heard first the 3 practice items in a fixed order (1, 2, and 4 syllables), a randomized version of their sublist selection of difficult onset items, and randomized versions of their 2_syllables, then 3-syllables, and finally 4-syllable items.

Procedure. We tried to balance three desiderata: That children would not be unduly exposed to the items before they themselves had to repeat them; that children would feel comfortable doing this task with us; and that the community would feel safe with us doing this task with their children. Moreover, there were also some logistic constraints in

terms of the space availability. As a result, the places where elicitation took place varied across the hamlets.

Indeed, we visited four different hamlets once, and attempted to test all eligible childr en present at that time, to prevent the items "spreading" through hearsay. In the first village, we tested children in five different places, with some children being tested inside their house and others tested on the veranda of a house even if it was not their own. The complete list of places and the ways in which they met the desiderata mentioned above can be found in the raw data, available from online supplementary materials.

The child was donned a headset (xx (**???**) please fill in for most of the children, SHURE WH20 XLR headset with a dynamic microphone for the rest), recorded into the left channel into a Tascam DR40x digital recorder. For most children, the headset could not stay comfortably on the child's head, and thus it was placed on the child's shoulders, with the microphone carefully placed close to the child's mouth. A local informant sat next to the child, to would provide the instructions and, if needed, coach the child to make sure, using the three practice items as well as real words, that they understood that the task was to repeat the items precisely without changing anything. An experimenter delivered the elicitation stimuli to the local informant and the child over headphones.

The first phase was making sure the child understood the task. This was explained orally and the first training item was presented. Often, children froze and did not say anything. If this happened, then we followed this procedure. First, the informant insisted. If the child still did not say anything, the informant asked the child to repeat a real word, and another, and another. If the child could repeat these correctly, then we provided the recorded training item over headphones again. Most children successfully started repeating the items presented over headphones at this point; a few further needed the local informant to model the behavior (i.e., they would hear the item again, and she would say it; then we would play it again, and ask the child to say it). A small minority still failed to repeat the item after

hearing it over headphones. If that occurred, we tried with the second training item, at which point some children got it and could continue. A small minority, however, failed to repeat this one, as well as the third training item, in which case we stopped the test altogether.

NWR studies vary in whether children are provided with several opportunities to hear and say the item. To have a fixed and clear procedure, we decided that items other than the inital three training ones would not be repeated unless the child made an attempt to produce them. If this attempt was judged correct by the local informant, then the experimenter would move on to the next item (whispering this over a separate headset that was recording onto the right track of the same Tascam). If the local informant heard a deviation, she indicated to the experimenter that the item needed to be repeated, and up to 5 attempts were allowed.

Whenever siblings from the same family were tested, an attempt was made to test first the older and then the younger child, and always on different elicitaiton sets.

Coding. There is an implicit accuracy coding occuring online as a function of whether the local informant asked for the item to be repeated or not. We will call this "online accuracy", and it reflects a wholesale impression of whether the item was correctly or incorrectly repeated.

We sought additional information by asking a local informant to listen through each child production, paired with the auditory target the child had been provided with, and make a judgment of whether the item was correctly or incorrectly repeated. We additionally asked her to transcribe exactly what the child said, providing some examples of the types of errors children in general make (without making specific reference to Yélî sounds or the items in the elicitation sets). This "native coding" provides both accuracy and qualitative desciptions of what the child said that are likely more reliable than those of the non-native coder.

Analyses. For NWR accuracy, we considered separately the child's first and subsequent attempts. These were scored as correct or incorrect on the fly depending on whether the native experimenter asked for the item to be repeated; as well as offline. Some NWR studies employ phoneme-based accuracy in addition to or instead of word-level accuracy [CITE]. We calculated accuracy as the number of phonemes that could be aligned across the target and attempt, divided by the number of phonemes of whichever item was longer (the target or the attempt). Although previous work does not use distance metrics, we additionally report those.

Finally, for describing children's patterns of errors, all repetitions of a given target were taken into account. We describe the proportion of items where the change resulted in a real word (semantic errors); and classify the most common phonological errors.

Participants. A total 55 children were tested, from 34 of families, in five hamlets. Some children could not be included for the following reasons: refused participation or failed to repeat items presented over headphones even after coaching (N=8), spoke too softly to allow offline coding (N=5). In addition, 2 teenagers were tested to put younger children at ease; their data is not included in analyses below. The remaining 40 children (14 girls) were aged 6.96 years (range 3.92-11.03 years). There were 32 children exposed only to Yélî in the home, 6 children who were also exposed to another language in the home, and , 2 for whom this information was missing. Maternal years of education averaged 8.24 years (range 6-12 years; 2 children had this information missing). In terms of birth order, 0 were first borns, 5 second, 4 third, 2 forth, 6 fifth, 5 sixth, and 1 did not have this information.

(**???**) why is maternal education always in even years? Can you add a footnote to explain?

Results

Taking into account only the first attempts, the overall repetition accuracy measured in whole words is 73% based on the online coding (i.e., whether the native experimenter asked for the target to be re-played), and 65% when the offline coding is considered. On average, the phoneme-based normalized Levenshtein distance was 20%, meaning that about 20% of phonemes were substituted, inserted, or deleted.

We then inspected whether accuracy varied as a function of word length.

```
##     Group.1 Group.2 x
## 1         2    c105 0
## 2         3    c105 0
## 3         4    c105 0
## 4         6    c105 0
## 5         8    c105 0
## 6         3    c106 0
## 7         4    c106 0
## 8         6    c106 0
## 9         2    c107 0
## 10        3    c107 0
## 11        4    c107 0
## 12        6    c107 0
## 13        3    c108 0
## 14        4    c108 0
## 15        6    c108 0
## 16        8    c108 0
## 17        2    c109 0
```

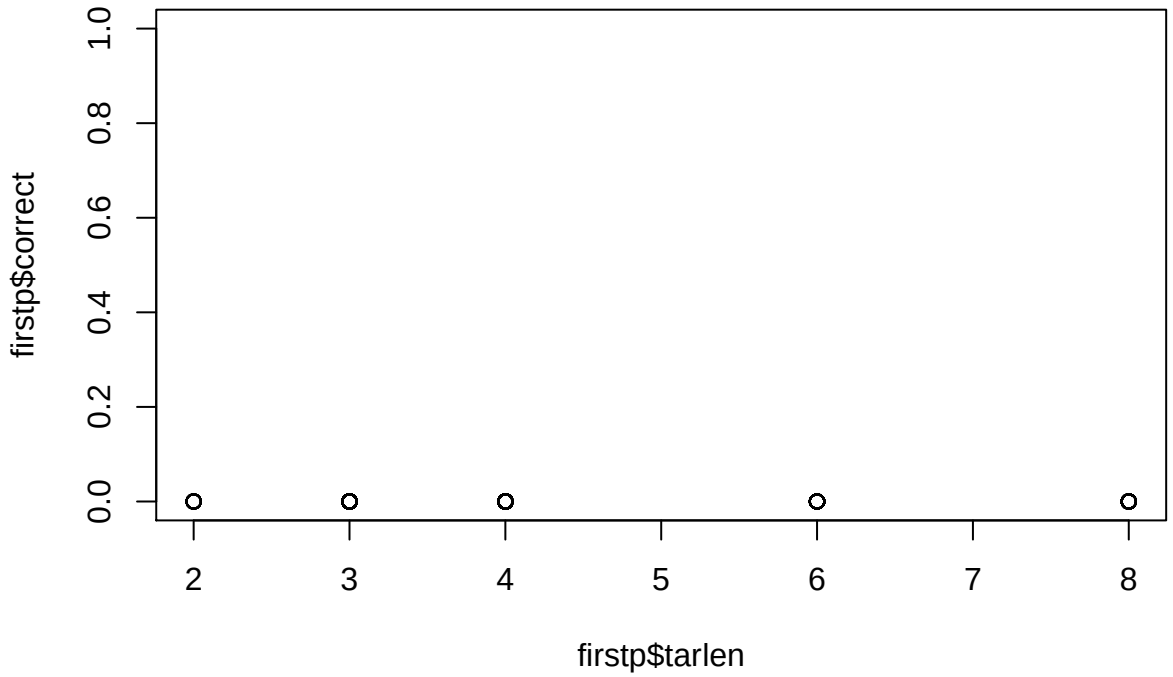
```
## 18        3    c109 0
## 19        4    c109 0
## 20        6    c109 0
## 21        3    c110 0
## 22        4    c110 0
## 23        6    c110 0
## 24        8    c110 0
## 25        3    c111 0
## 26        4    c111 0
## 27        8    c111 0
## 28        2    c112 0
## 29        3    c112 0
## 30        4    c112 0
## 31        3    c114 0
## 32        4    c114 0
## 33        6    c114 0
## 34        8    c114 0
## 35        3    c115 0
## 36        4    c115 0
## 37        6    c115 0
## 38        8    c115 0
## 39        3    c116 0
## 40        6    c116 0
## 41        8    c116 0
## 42        3    c117 0
## 43        4    c117 0
## 44        3    c118 0
```

```
## 45        4    c118 0
## 46        6    c118 0
## 47        8    c118 0
## 48        3    c119 0
## 49        6    c119 0
## 50        8    c119 0
## 51        3    c120 0
## 52        4    c120 0
## 53        6    c120 0
## 54        8    c120 0
## 55        3    c121 0
## 56        4    c121 0
## 57        3    c122 0
## 58        4    c122 0
## 59        6    c122 0
## 60        8    c122 0
## 61        3    c123 0
## 62        4    c123 0
## 63        2     c70 0
## 64        3     c70 0
## 65        4     c70 0
## 66        6     c70 0
## 67        8     c70 0
## 68        2     c71 0
## 69        3     c71 0
## 70        4     c71 0
## 71        6     c71 0
```

```
## 72        8     c71 0
## 73        3     c72 0
## 74        4     c72 0
## 75        6     c72 0
## 76        8     c72 0
## 77        3     c73 0
## 78        4     c73 0
## 79        6     c73 0
## 80        8     c73 0
## 81        2     c74 0
## 82        3     c74 0
## 83        4     c74 0
## 84        6     c74 0
## 85        8     c74 0
## 86        3     c76 0
## 87        4     c76 0
## 88        8     c76 0
## 89        3     c77 0
## 90        4     c77 0
## 91        6     c77 0
## 92        8     c77 0
## 93        2     c78 0
## 94        3     c78 0
## 95        8     c78 0
## 96        2     c79 0
## 97        3     c79 0
## 98        2     c80 0
```

```
## 99       3     c80 0
## 100      4     c80 0
## 101      6     c80 0
## 102      8     c80 0
## 103      2     c81 0
## 104      3     c81 0
## 105      4     c81 0
## 106      8     c81 0
## 107      3     c82 0
## 108      4     c82 0
## 109      6     c82 0
## 110      8     c82 0
## 111      3     c83 0
## 112      4     c83 0
## 113      6     c83 0
## 114      8     c83 0
## 115      3     c84 0
## 116      4     c84 0
## 117      6     c84 0
## 118      8     c84 0
## 119      3     c85 0
## 120      4     c85 0
## 121      6     c85 0
## 122      8     c85 0
## 123      3     c87 0
## 124      4     c87 0
## 125      6     c87 0
```

```
## 126       8     c87 0
## 127       3     c88 0
## 128       4     c88 0
## 129       3     c89 0
## 130       4     c89 0
## 131       6     c89 0
## 132       3     c90 0
## 133       4     c90 0
## 134       6     c90 0
## 135       8     c90 0
## 136       2     c91 0
## 137       3     c91 0
## 138       4     c91 0
## 139       2     c93 0
## 140       3     c93 0
## 141       4     c93 0
## 142       6     c93 0
## 143       3     c94 0
## 144       4     c94 0
## 145       8     c94 0
## 146       3     c95 0
## 147       4     c95 0
## 148       3     c99 0
## 149       4     c99 0
## 150       6     c99 0
```



- How frequent are errors that result in real words? Is that a function of item complexity? What are some common patterns of phonological errors?

- Is individual variation explainable by child age, sex, birth order, monolingual status, and/or parental education?

(MC: but we can try and do a cursory analysis based on the corpora we have from Steve and my transcription of naturalistic interactions!)

Based on previous work, one can make the following general predictions for any population:

1. Children are more accurate for mono-syllables than longer items
2. Similarly, we do not know of NWR research that manipulates the difficulty of the sounds that are included in the items, but word naming and other research suggests that children are more accurate when producing easy and/or typologically common sounds than difficult and/or typologically rare sounds [CITE]. Therefore, we expect higher accuracy for items with common sounds than in those with rare sounds.

3. Children's accuracy increases with child age.
4. Non-monolingual Yélî children are less accurate than monolingual ones when tested on the society-dominant language (we did not test any non-dominant language)
5. As revious NWR evidence on this is mixed, but general findings on language development suggest that children whose mothers are more educated are more accurate than children whose mothers are less educated.
6. To our knowledge, there is no previous NWR work on this, but other research suggests that first-born children should outperform later-born children

Although these predictions were made based on previous work, we also thought reasonable that they would not obtain for the Rossel children in particular, as follows:

1. The length distribution in Yélî words is more balanced than that in English, and thus the performance decline for poly- versus mono-syllables may be less pronounced than that for English. **Check for work on European languages that may have looked into this**
2. The Yélî sound inventory is very large and compressed, with many similar sounds that are acoustic and articulatory neighbors. Therefore, this may constitute a pressure for children to have finer auditory skills (and perhaps more precise articulations) than children speaking languages with a simpler inventory. As a result, differences between easier and harder items may be smaller in this work than in other research. **no work looking at consonants & vowels? no work looking at nasal vowels in particular?**
3. We had no reservations that children's accuracy increases with child age for the Yélî community as well.
4. Anecdotally Yélî children grow up in close-knitted communities and thus may receive significant portions of their language input from people not in their nuclear family (or at least from people other than their mothers, who tend to be the non-native speakers).

If so, the difference between monolinguals and not monolinguals may be smaller than that found in other work . That said, one recent study on the same population shows that most child-directed input in the first 2 years does come from the mother , so in so far as this input has a crucial formational role, then there may still be a performance gap between these two groups.

5. In the Rossel community, formal education plays an extremely minor role in ensuring individual's success, is not a good index of relative socio-economic status, and furthermore there is only a narrow range of variation in maternal educational attainment. This may lead to no or only very small advantages for children whose mothers are more educated, provided that the causal chain between maternal education and child language is via SES more broadly. However, if education directly boosts maternal verbal skills and the incidence of verbal behavior (as suggested by CITE), then we should still see a difference along this factor.
6. One main causal path between birth order and language development is via parental input (CITE). Given our arguments above for how mothers may not be as important among Rossel people than in other places, then the performance gap between first borns and later borns may be smaller.

Discussion

- What is the overall repetition accuracy (whole word, phoneme based, distance)?
- How does this change as a function of item complexity (number of syllables, sound complexity)?
- How frequent are errors that result in real words? Is that a function of item complexity?
- Is individual variation explainable by child age, sex, birth order, monolingual status, and/or parental education?

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