Does Grammatical Number Support the Acquisition of Number Words?

Anna Shusterman, Abigail Seevak, Petra Mišmaš, Franc Lanko Marušič, and Rok Žaucer

1. Introduction

How do children learn the meanings of number words? Researchers agree that learning the meanings of number words requires specific input (Pica et al, 2004; Gordon, 2004; Frank et al., 2008; Flaherty & Senghas, 2011; Spaepen et al., 2011). This is not a controversial statement: at the very least, children need to learn the mappings between specific number words and the corresponding exact number concepts. However, there is significant debate about what counts as relevant input that supports the acquisition of number word meanings.

Recent research has considered an array of putative mechanisms, including acquisition of a stable count list (Davidson et al., 2012); experience with small number words (one, two, and three; Piantadosi et al., 2012; Gibson et al., 2020); and support for integrating the counting procedure with meaning (Mix et al., 2012; Cheung et al., 2022). Some accounts have emphasized the fact that number word meanings track with general vocabulary development (Negen & Sarnecka, 2012; Shusterman et al., 2022; Slusser et al, 2019), suggesting that number development, both conceptual and linguistic, rests on a foundation of general language acquisition. Populations with limited or delayed access to language, or limited exposure to number words, do not easily acquire counting nor do they seem to develop an alternative, non-linguistic, system of enumeration (e.g., Flaherty & Senghas, 2011; Spaepen et al., 2011; Shusterman et al., 2022). Furthermore, the process of number word acquisition is famously slow and protracted (e.g., Fuson, 1988; Wynn, 1990), and number words are not "fast-mapped" in the way that some other kinds of words are. Thus, it is clear that elaborated language input is necessary for learning the meanings of number words.

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But what is the relevant language input that supports this learning process? In this paper, we consider one hypothesis: that *morphosyntax* provides cues to the meanings of number words. Some theoretical accounts emphasize a role for morphology and syntax in number acquisition (Bloom & Wynn, 1997; Syrett et al., 2012; Barner et al., 2009; Spelke, 2017). The accounts draw in various ways on the affordances of morphological markers and syntactic structures to help children notice how language refers to quantitative information generally and numerical information specifically. For example, Bloom & Wynn (1997) and Carey (2009) speculate that children might notice the overlapping distributions of syntactic frames used for both number words and quantifiers like "some" or "many".

What is the evidence for this hypothesis? First, for children acquiring some languages such as English and German, quantifier and number acquisition are correlated (Barner et al, 2009; Dresen et al, 2021). By contrast, in languages with fewer grammatical cues to number, such as Mandarin, there is a lesser or zero correlation between quantifier and number knowledge (Yang & Wang, 2022). This pattern suggests that, in the presence of overlapping syntactic distributions or other grammatical cues to number, children can benefit from the overlap to realize that both kinds of terms refer to quantities. Second, children may notice that both quantifier and number terms are arranged on scales (e.g., 7 is more than 4, most is more than more), and this parallel might invite the child to seek out the ordering of the number words. Third, quantification in language in general might draw children's attention to quantities, encouraging them to seek out labels for those quantities. Related to this hypothesis, children might have their attention drawn to singularities vs pluralities when they learn the singular-plural distinction. This in turn might help children recognize "one" as a quantity, which could be an important step for coming to understand counting. Indeed, the counting process is structured by increments of one, and cardinal values can be generated by counting (see also Leslie et al, 2008; Carey, 2009).

In this vein, recent cross-linguistic work has highlighted a possible role for *grammatical number marking* in number learning (e.g., Almoammer et al., 2013; LeCorre et al., 2016, Sarnecka, 2014). This argument focuses on cross-linguistic differences in grammatical number marking – i.e., number marking that is obligatory rather than optional in a language for the utterance to be grammatical. Some languages (e.g., Mandarin, Japanese) have no obligatory singular/plural distinction, while other languages (e.g., English, Spanish) have a singular/plural distinction. Still others have even more refined categories such as singular/dual/plural (e.g., Slovenian and some Arabic varieties). Several studies report different acquisition patterns for number words that correspond to the grammatical number marking in that language. For example, children learning Russian, which has a singular-plural distinction in grammar, learn the number word "one" sooner than children learning Japanese, which lacks a singular-plural distinction (Sarnecka et al., 2007). The general claim is that grammatical number marking (e.g., singular-plural distinction), when present, can help children orient to the marked quantities (i.e., one vs. more than one). This in turn helps children

to learn the corresponding number words, and to do so earlier than children learning languages without the grammatical marking.

However, the effects of cross-linguistic differences are difficult to interpret, for two reasons. First, the languages being compared differ on many dimensions, not just in grammatical number marking. Second, the languages are embedded in distinct cultures where practices such as speaking to children or counting with children may vary widely; even within the same culture, such practices differ across families (Dearing et al., 2022). Thus, these findings have significant confounds.

One solution for addressing these confounds is to examine dialects that vary on grammatical number marking, while sharing most other aspects of language and culture. Both Slovenian and Arabic have regional variation in how strongly the dual is marked, creating a minimal difference in grammatical number within the same language and society. In the dialects with strong dual marking, the dual form is distinguished from the singular and plural pervasively, in multiple parts of the sentence including nouns, adjectives, and subject-verb agreement.

If, as hypothesized, grammatical number marking causally influences children's ability to learn number words, then differences in grammatical number marking between dialects and languages should predict differences in the acquisition of number words. Two previous studies have provided support for this claim. Children hearing dual marked language, both in Slovenian and in Arabic populations, showed substantially earlier knowledge of the word "two" than English-speaking children (Almoammer et al., 2013). In fact, in that paper, fully 40% of the Slovenian children in the 24-29 month old age bracket already knew the meaning of "two", an age range where English-speaking children are just starting to learn "one". Furthermore, within a Slovenian sample, children who lived in a region with strong dual-marking learned the meaning of "two" earlier than children who were learning a dialect that did not include the dual (Marušič et al., 2016). In both of these prior studies, the early timing for acquiring "two" in just the dual-exposed children lent support to the idea that exposure to the dual facilitated acquisition of "two". The current paper builds on this foundation to further explore the possibility that dual marking supports children's acquisition of "two".

We note that this proposal represents a syntactic bootstrapping account of number acquisition. In this context, unlike some other syntactic bootstrapping accounts, it is not the immediate use of the syntactic cue within an utterance that directs the child to the meaning of an unknown word in that utterance. Rather, the proposal is broader: the syntactic environment more generally directs children's attention toward the idea that numerical quantity is the kind of concept that is expressed by language. That semantic insight then helps children to notice and learn cardinal number meanings. For example, if the dual is marked by morphology, children might notice that the idea of pairs or two-ness is something that gets coded in language. Children hearing the dual might then have an advantage for learning the word "two", even if "two" is not more frequent in the input or without other explicit support for learning "two", such as practice with counting.

The goal of the current study was to further interrogate and test the hypothesis that morphosyntactic cues, in this case grammatical number marking, can support semantic development, in this case number word learning. Similar to previous studies, we operationalized number learning using the Give-N task (Schaeffer, 1974; Wynn, 1990; Almoammer et al, 2013). This paradigm as well as other tasks have revealed a protracted developmental pattern such that children learn the meaning of "one" first and are referred to as "one-knowers", then "two", then "three" and sometimes "four". Most theorists have argued that after learning "four", children typically make a generalization to higher numbers (e.g., Carey, 2009; but see Krajcsi & Fintor, 2023 for a dissenting view). Consistent with other studies that have explored the relationship between morphosyntax and number learning, we used the Give-Morphology, also called Give-M, task (Almoammer et al., 2013; Marušič et al., 2016). In both tasks, children are asked to provide some quantity of objects on each trial. Since the current study focused on younger children, the experimenter just asked for "one", "two" or "three" objects in the Give-N task, and used the singular, dual, or plural marking in the Give-M task (e.g., "Can you give me *a* button-*singular*").

To address the question of the relationship between grammatical number marking and semantic number word learning, we asked three questions about the acquisition process in young children. First, we wanted to know how early children show evidence of knowing "two". In the Almoammer et al. (2013) sample, 40% of children just over the age of two already knew the meaning of the word "two" as defined by the Give-N task – an unusual pattern of successful performance in such young children, according to most reports using this method in other populations. If this report is correct, then 2-knowers should appear in Slovenian, dual-exposed samples prior to 24 months of age.

Second, we wanted to establish the order of acquisition of dual marking and knowledge of "two". If dual marking indeed facilitates number word learning, then we should hypothesize that the dual marking is acquired first, and the meaning of "two" afterward; thus, children should pass Give-M for dual trials before they pass Give-N for "two" trials, assuming the tasks are matched for difficulty. Additionally, performance on measures of dual marking (Give-M) and measures of number word knowledge (Give-N) should be correlated, even from a young age.

Third, we wanted to learn more about the process and timing of learning the morphosyntax of the dual relative to singular and plural markings. While acquisition of the singular and plural are relatively well characterized (e.g., Wood et al., 2009), acquisition of dual marking is more rare in the world's languages and less studied in developmental research.

2. Study 1

2.1. Study 1 Overview

Our first aim was to replicate the finding that Slovenian children exposed to the dual-marked dialect learn the word "two" (i.e., are 2-knowers on Give-N) as early as 24 months, and to extend this finding to determine the earliest age range

at which this knowledge can be observed. For comparative purposes, we collected data using identical methods from two Slovenian samples in regions with dual marking (Celje and Ljubljana; see Marušič et al., 2016, Fig. 1, for distribution of dual marking) and one English-speaking sample, focusing on young children between 18 and 32 months of age.

2.2. Study 1 Methods

Participants. Participants in this study were young English-speaking children (n=59; mean age = 24.75 months, SD = 3.45 months, range 18-32 months) and two groups of Slovenian-speaking children (group 1: n=66; group 2: n = 81; combined mean age 24.70 months, SD = 3.63, range 18-32 months). Data were collected in 2016.

Give-N. All children completed Give-N (Give-N) with requests for 1, 2, and 3 objects. Children were presented with a pile of 10 buttons and a plate. They received 3 blocks of 3 trials each in a pseudorandom order, resulting in 9 total trials and 3 trials per set size. In Give-N, children were presented with a pile of 10 buttons and asked "Can you put N on the plate?" Consistent with well-established criteria (Wynn, 1992), children were designated as a pre-knower or an N-knower (1-knower, 2-knower, or 3-knower) based on whether they could (a) give N objects when requested on at least 2 of the 3 trials; (b) fail to give N+1 objects when requested on at least 2 of the 3 trials requesting N+1; and (c) avoid giving N objects for trials requesting sets higher than N. For example, a child who gave one object for every trial would not be designated a 1-knower, since they also gave 1 when asked for sets of 2 and 3 and therefore failed to distinguish the meaning of "one" from other number words.

Give-M. All children completed Give-M with requests using language marked for singular, dual, and plural sets (e.g., "Give me a button"; "Give me some buttons"). As there is no dual marker in English, the dual trials for English-speaking children used plural language. In Slovenian, each of these three types of requests utilized distinct articles and noun endings:

Ali lahko daš gumb/gumba/gumbe na krožnik?
Q can give button.sg/button.du/button-pl on plate
'Can you put button(s) on the plate?'

The order of trials was identical to Give-N, with 3 requests of each set size in a pseudorandom order, resulting in 9 total trials.

2.3. Study 1 Results and Discussion

In Study 1, we focused our analysis on performance on the Give-N task, in order to see whether young 2-knowers were far more prevalent in the Slovenian sample than in the English sample. In contrast to the prediction, few Slovenian participants in the 18-32 month age range were 2-knowers (Fig. 1; n=3 and n=5 in the two data sets). Furthermore, the frequency of 2-knowers in the Slovenian

samples did not differ from that in the English-speaking sample (n=1 in English sample; Fig. 1; Fisher's-exact $p > .3$). This was surprising because we used the same methodology as past studies in locations with prevalent dual marking. Thus, we did not replicate the finding from three published reports that children acquiring a dual-marked language learn "two" relatively early (Almoammer, Marušič et al., 2016; Marušič et al., 2021); in Almoammer et al. (2013), 40% of children in the 24-29 age bin were already 2-knowers, whereas in the current study only 8% of children in that age range were 2-knowers, with a mean age of 29 months – the oldest end of the range.

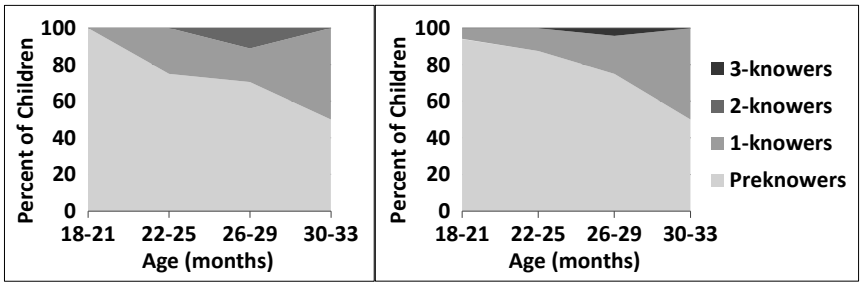

Figure 1. Distribution of Slovenian (left) and English (right) Give-N categories by age

One possible explanation for the discrepancy is that the previous dataset overestimated the prevalence of young Slovenian 2-knowers. Another possibility is that use of the dual is decreasing (Jakop, 2008), such that data collected in later years might yield lower estimates of the prevalence of young 2-knowers, though this is admittedly unlikely in such a short time span. A third possibility is that other aspects of sampling effects, such as differences in socioeconomic status, affect the course and timing of language acquisition and explain differences in these samples (Marušič et al., 2016). However, we have no specific evidence to support any of these hypotheses, particularly since the second Slovenian sample was collected in Ljubljana in many of the same daycare centers reported in Marušič et al. (2016). Thus, we report these discrepant findings to contribute to the record and future estimates on prevalence of young 2-knowers in dual-exposed participant samples in Slovenia.

The broader research question concerned the relationship between grammatical number marking and number word learning. Indeed, there were a handful of 2-knowers in the Slovenian sample. Was their early acquisition of "two" facilitated by exposure to the dual? If so, we would expect that they would show some sensitivity to dual marking in the Give-M task. Past studies have reported a correlation between acquiring the dual and learning number words (Almoammer et al., 2013; Marušič et al., 2016). Accordingly, we expected that the young 2-knowers would also know the dual.

Additionally, if dual marking facilitates acquisition of "two", we might also predict that acquisition of dual marking would temporally precede acquisition of

"two". Thus, despite the lack of knowing "two", we might see evidence that the young Slovenian participants understand dual marking.

To address these predictions, Study 2 used the Give-M measure to ask: Were the Slovenian children who did know "two" also the ones who had acquired the dual? Further, do we see evidence that children at this young age are acquiring the dual?

3. Study 2

3.1. Study 2 Overview

In Study 2, we focused on Slovenian children's performance on the Give-M task, in relation to their performance on Give-N. In doing so, we realized that past studies using the Give-M ("Give-Morphology") task used different analytic methods to evaluate children's knowledge than those that are used to analyze Give-N performance. To know "two", that is, to be called a 2-knower on Give-N, children have to not only respond correctly when asked for a given number, they also have to avoid providing that set size as a response to requests for other numbers. A child who provided sets of two objects to every number requested (in this case, "one", "two", and "three") would not be said to know "two" because they would not have distinguished it from other quantities. However, in previous analyses of Give-M, performance was analyzed using percent correct. Thus, a child who gave two objects on every trial would be coded as 100% correct for knowing the dual, even though they had clearly not distinguished the dual from other quantification markers.

In Study 2, we analyzed Give-M data both ways to see whether knowledge of the dual marker correlated with and preceded knowledge of the word "two", as would be predicted if grammatical number facilitates number word learning. We first analyzed the data using percent correct, as done in past studies. We then developed a coding scheme for Give-M data analogous with Give-N, in which children had to provide correct responses on the target request (singular, dual, plural) and exclude that response (giving one, giving two, giving three or more) from their responses to the *other* requests.

There may be valid reasons to question coding Give-M in the same ways as Give-N. Many researchers have noted that quantifiers like "a" and "some" do not have exact meanings as do number words like "one" and "five" (see for example, Marušič et al., 2021). For example, if the experimenter says "Give me *a* button", it might be an acceptable response to give two buttons. However, evidence suggests that such responses are not adult-like. In these contexts, English-speaking adults tend to constrain the acceptability of singular and plural forms to single and plural sets (Barner et al., 2009). Furthermore, for the purposes of this study, which is focused on the dual, even children who are slightly older and further along in learning the Slovenian dual - just five years old – restrict interpreting dual requests to sets of two in the Give-M task (Marušič et al., 2021, Exp. 1). Using the adult-like interpretation as an indicator of correctness, it is reasonable to say that it is incorrect to give two objects in response to a singular or plural request.

3.2. Study 2 Methods

Study 2 provided a new analysis of one of the Slovenian datasets from Study 1, as well as an open dataset using the same methods (N = 49; mean age = 30.37 mos., SD age = 4.41 mos; Marušič et al., 2021). We used the Study 1 dataset from Ljubljana, which is the most comparable to the previously published Slovenian data as they were also collected there (Almoammer et al., 2013; Marušič et al, 2016, 2021). Give-N data were analyzed as described in Study 1.

Following Marušič et al. (2016, 2021), Give-M data were analyzed using percent correct on each of the three trial types (singular, dual, plural). Percent correct analysis only counted whether children correctly gave the expected response for each type of trial (e.g., gave one object for a singular request).

Give-M data were also analyzed a second way, adapted from the typical criteria for Give-N (Wynn, 1992). To count as "knowing" the singular, dual, or plural, children had to 1) provide the expected responses on at least 2 of the 3 trials for that request type, and 2) avoid providing that response on at least two-thirds of the other trials. In other words, to be a singular-knower, children had to respond correctly (i.e., give one object) on 2 out of 3 singular prompts, and they had to avoid giving one object as a response to dual and plural requests on 2 out of 3 of dual and plural prompts. Knowing dual and plural followed the same logic. We did not use the third criterion of Give-N, that children who are N-knowers give incorrect responses on trials asking for N+1 or higher, but rather assessed knowledge of each morphological form separately. For Give-N, designating a child a 2-knower entails that they are also correct on requests for "one" but incorrect on requests for "three". However, no such entailment applies in the case of Give-M.

3.3. Study 2 Results and Discussion

We first assessed performance on Give-M as a function of children's give-N level. As can be seen in Fig. 2, 1-knowers appear to perform very well on requests for the singular and 2-knowers appear to perform better than other knower levels on requests for the dual. However, this is somewhat misleading. For example, Pre-Knowers look like they are scoring above 60% correct on plural trials, but this pattern is expected if children provide a handful of objects on every trial, without differentiation. Similarly, the high performance of 1-knowers on singular trials - over 80% correct - is counteracted by their poor performance on the other trial types, indicating a pattern of giving one object in response to a variety of requests, not just singular. While 2-knowers showed the best performance of all children on dual trials, a more sensitive analysis is needed to see whether they differentiate the dual from other trial types.

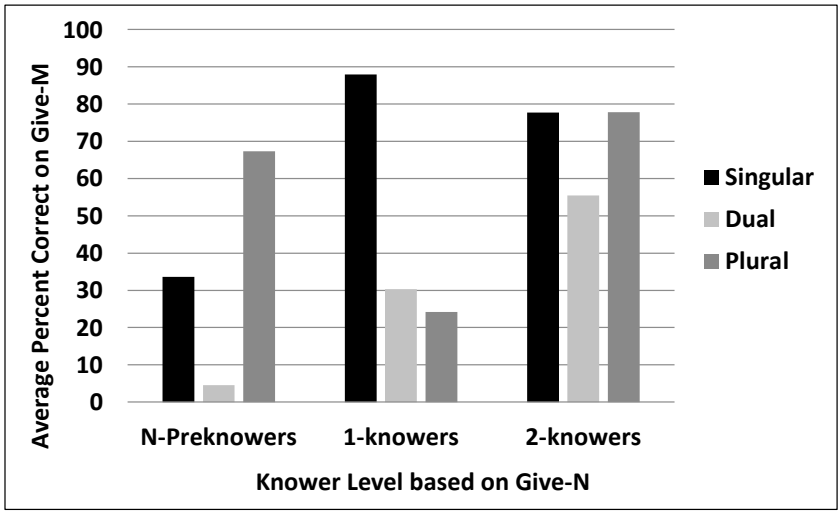

Figure 2. Slovenian children's correct responses on Give-M as a function of Give-N knower-level.

Turning to the new analysis, we identified children who did not know any of the number morphology (N = 52); singular-only knowers, i.e., children who gave one item for singular requests and not for other requests (N = 3); plural-only knowers (N = 3); children who gave more than two items for plural requests but not for singular/dual requests; and full-knowers, i.e., children who differentiated the singular, dual, and plural forms (N = 3). Five participants were excluded who did not give a consistent response pattern. We did not find any dual-only knowers.

We then assessed performance on Give-M relative to Give-N, to see whether children's performance on the two tasks aligned. Of the 1-knowers on Give-N, most (64%) did not meet the criteria to be a singular-knower. Of the three 2-knowers on Give-N, two did not meet the criteria to be a dual-knower. These data suggested that knowledge of the dual does not precede knowledge of "two", and similarly that knowledge of the singular does not precede knowledge of "one", when analyzed this way (Fig. 3). However, any conclusions are limited by the very small number of 2-knowers in the sample - just three of them.

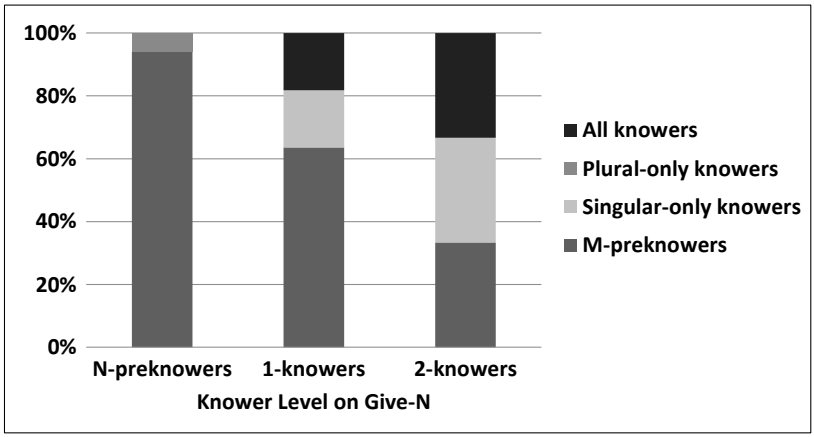

Figure 3. Slovenian data, Give-M performance grouped by Give-N.

In answer to the second research question, then, we did not find evidence to support the claim that grammatical number precedes or correlates with acquisition of number words. Furthermore, we observed idiosyncratic paths through learning the dual. Some children, the ones we designated plural-only knowers, were consistent about giving 3 or more objects in response to plural morphology, but they blended responses to the singular and the dual, providing 1 or 2 objects to either request. This suggests that they had lumped the dual in with the singular, while pulling out the plural form first. Other children, those we designated singular-only knowers, gave 3 or more objects in response to dual requests. They seemed to blend the dual in with the plural, while extracting the singular form first. This analysis provides a first demonstration that the pattern of acquiring the dual form is not universal.

3.4. Study 2 Replication with Open Data

In order to better evaluate these conclusions, we turned to data from a previously published paper, using an open data set of Slovenian children learning the dual-marked dialect. The dataset included Give-N and Give-M run using identical methods to the current study with a similar age range (N=55, 24-43 months; mean = 30.37 months; SD = 4.41 months). There were 16 pre-knowers, 10 1-knowers, 18 2-knowers, 10 3-knowers, and 1 4-knower based on Give-N. The large sample of 2-knowers made it possible to better evaluate the new analytic approach and the hypotheses.

First, we assessed the Give-M data with percent correct to ensure that our results were consistent with those published by the authors (which they were). Then we performed the knower level analysis on Give-M. Five participants were excluded who either didn't respond at least once to each prompt or whose responses didn't fit a knower level grouping. We identified the same categories of Give-M performance as we had in our first sample: 19 pre-knowers, 14 singular-only knowers, 3 plural-only knowers, and 13 all-knowers. We found no children

who were dual-only knowers; in other words, no children identified the meaning of the dual before the singular and plural. As before, we found children who blended the dual with the singular (the children we designated plural-only knowers), and children who blended the dual with the plural (singular-only knowers).

We then evaluated the relationship between Give-N and Give-M performance (Fig. 4). Consistent with the previous analysis, most (55.6%) 1-knowers did not meet the criteria for being a singular-knower, and most (64.3%) 2-knowers did not meet the criteria for being a dual-knower. In addition, these data had 3-knowers, and most of them (54.6%) did not respond correctly to the plural prompts. The correlation between knowing two and knowing the dual was significant, $r(48) = .23$, $p = .054$, one-tailed, but this did not hold after controlling for age, $r(45) = .20$, $p = .09$, one-tailed. The correlation between knowing two and percent correct on dual trials was also not statistically significant ($r = .13$, $p = .19$). Previous studies have compared percent correct on the dual trials and reported a significant difference between 1-knowers and 2-knowers (Marušič et al., 2016) in children exposed to the dual form. In this data set, however, comparisons of dual knowledge across Give-N knower levels were also not significantly different, neither using percent correct as the dependent measure, nor using the new dual-knower analysis introduced here (Kruskal-Wallis and Wilcoxon tests, all p's > .2).

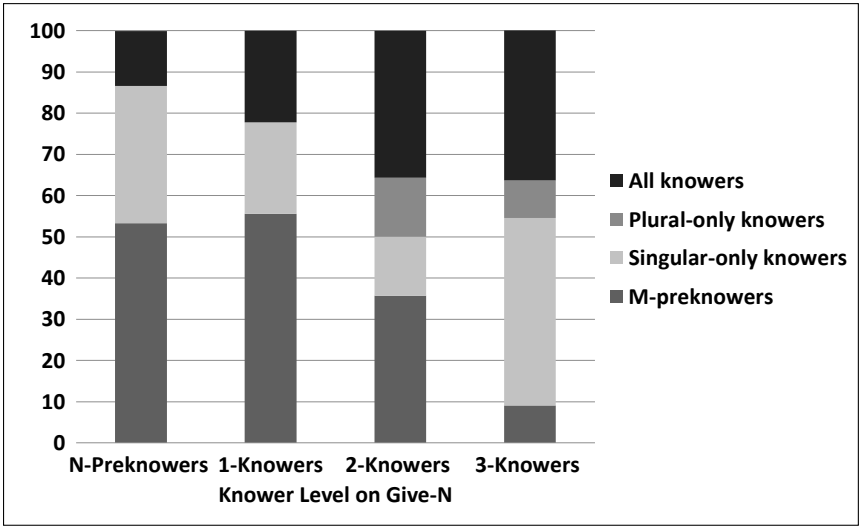

Figure 4. Slovenian data, Give-M performance grouped by Give-N level (data from Marušič et al, 2021).

In sum, the initial observations made from a small number of 1- and 2-knowers were replicated in a dataset with more children who had learned some number word meanings. Addressing the main hypotheses of this paper, there was little evidence that knowledge of the dual morphological forms correlated with or

preceded acquisition of the number word "two". Most children who knew the word "two" did not yet know the dual form. The same lack of relationship was observed for the word "one" and the singular form.

Second, we made two observations about the acquisition of the dual form. Looking at the order of acquisition, the dual was the last of the three forms to be learned; no child knew the dual without also knowing the singular and the plural. Furthermore, children's initial interpretations of the dual form were not universal. Some children first lumped the dual with the singular form, while others lumped it with the plural form. In the current analysis, more children pulled out the singular first, mixing the dual with the plural, and often interpreted the dual form as 3 or more. This may represent a dominant pattern in the acquisition of the dual form, at least in Slovenian.

4. General Discussion

The goal of this study was to evaluate the claim that grammatical number marking can facilitate number word learning. Following the example of Almoammer et al. (2013) and Marušič et al. (2016), we relied on the case of Central Slovenian, a dialect of Slovenian with strong dual marking. We tested three claims that fall from the hypothesis that grammatical number marking facilitates number word acquisition, and specifically that exposure to a dual-marked language environment facilitates the acquisition of the word "two": first, that very young children exposed to a dual-marked language environment will acquire the word "two" relatively early, as young as 24 months; second, that acquisition of the dual form will correlate with acquisition of the word "two"; and third, that acquisition of the dual form will precede acquisition of "two".

In contrast to previous endorsements of the relationship between dual-marking and acquisition of "two", none of the three claims are supported here. In two searches for 2-knowers in regions of Slovenia reported to have strong dual marking, including one dataset in Ljubljana, where 2-knowers have been prevalent in past studies, we identified very few 2-knowers. The cause of this discrepancy is not known, but potentially important. One possibility is that there is a reduction in the use of dual morphology amid a process of pluralization (e.g., Jakop, 2008). However, there is no evidence of such a major shift over a few years in this community. A second possibility is that there were critical differences in experimental methods; again, however, this seems unlikely given evidence that the Give-N task is highly robust to variations in phrasing, trial order, and other significant methodological choices (Marchand et al., 2022). The most likely option, in our view, is that this is the result of a sampling issue such that some studies found higher rates of 2-knowers, this study found a lower rate, and the true population value may be somewhere in the middle. Further research can help to establish the lower bounds of the ages for becoming a 2-knower as well as the prevalence of 2-knowers in areas with dual marking.

The central contribution of this work is to question what it means to say that children "know" the dual form on the Give-M task, an analog of Give-N. If grammatical number facilitates number learning, we would expect evidence that

grammatical number marking is acquired before number words. We therefore need a way to assess whether children have learned grammatical number marking. We argue that percent correct is an insufficient measure and can yield misleading conclusions. For example, a child who modally gives the whole pile on every trial of Give-M would appear to "know" the plural, since she would score 100% correct on those trials. Including all trials in each child's analysis, using the same logic as Give-N analyses to determine whether children have differentiated one from from another, provides a sharper picture of when children have mastered particular morphological forms. Using this new analysis, both with our dataset and with a previously published one, we find a lack of correspondence between knowledge of dual morphology and knowledge of two. Our results suggest that most children in a putatively dual-rich language environment did not learn number morphology (singular, dual) before the corresponding number word ("one", "two"). Our data raise similar doubts about the relationship between acquiring singular marking and learning "one".

These results suggest that the dual form is acquired last, after the singular and the plural, and that it is not acquired particularly early. Similarly, a production study on Saudi Arabian Arabic indicated that the dual was produced correctly after the singular and the plural forms (Alabdulkarim, 2021). If the dual is learned late even when it is robust in the input, it is less plausible as a mechanism that facilitates learning. It is difficult to imagine how children who are exposed to the dual form, but who have not yet learned its meaning, can draw the right set of inferences to use the dual form to bootstrap number words.

Despite different analytic approaches, our interpretation of the data largely agrees with that of Marušič et al. (2021). Analyzing the same data using percent correct, they concluded that children's understanding of grammatical number morphology at this age is "emerging but not yet complete." We endorse this conclusion, drawing on more stringent criteria for demonstrating knowledge of morphology. Our analysis suggests that children's knowledge is not just emerging, but that they have barely begun to differentiate the dual from other forms before two and a half years of age. Further, we find little evidence that the children who acquire number early are the ones who also mastered the morphology. The challenge for proponents of the grammatical number hypothesis is to explain how such a spare understanding of grammatical number can support number acquisition.

We note that grammatical number cannot be necessary for number word learning; some languages do not have any obligatory number marking. Previous studies have reported a lack of correlation between grammatical number marking and number word learning in the non-dual dialect of Slovenian (Marušič et al., 2016), and a lack of correlation between quantifier and number acquisition in Mandarin, which has limited grammatical cues to number (Yang & Wang, 2022). Our results resemble the pattern of findings in populations without strong grammatical cues to number, although the data were collected in a dual-prevalent area. The question is whether number marking facilitates (or delays) number learning, and if so, by what mechanism.

Together, these findings complicate claims that exposure to grammatical number scaffolds number word learning. While morpho-syntactic cues may yet be important for number word learning, more precision is needed to specify the mechanism and to show how grammatical number explains the number learning process. In a previous proposal, the syntactic bootstrapping process was described as exposure to the dual helping children learn the number "two" because "both encode dual sets" (Marušič et al., 2016). Thus, the bootstrapping mechanism seems to be rooted in attention: grammar helps children notice and attend to sets of two, realize that this property of sets - twoness - can be picked out by language, and open their minds to the idea that other aspects of language will also pick out this property of the world. While provocative, stronger evidence is needed that this kind of bootstrapping is plausible and that it can explain learning in this case.

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