

CHILDREN'S OVERREGULARIZATION OF ENGLISH PAST-TENSE VERBS
RESULTS IN MORE PHONOTACTICALLY PROBABLE FORMS

By

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Abstract

Why do children make verb overregularization errors (e.g. *winned* instead of *won*)? Previous studies suggested that children's discovery of the past-tense *-ed* verb rule led to these errors. However, later studies found that children recognize overregularized forms of verbs months before they produce them. Therefore, this thesis explores another possible explanation for children's overregularizations in production based on the fact that certain sound sequences are more likely to occur in English than others. This likelihood is phonotactic probability. We suggest that the use of overregularized verbs results in more phonotactically probable sentences given English. The experiment presented examined utterances containing overregularized verbs from two children's corpora and compared their phonotactic and biphone probabilities to the utterance with the correct form of the irregular. Results from the experiment determined that in most cases, the use of the overregularized verb form resulted in higher phonotactic probability given English. Therefore, it is concluded that phonotactic probability might provide a partial explanation for why children produce overregularized forms like "winned."

Keywords: Overregularization; English past tense, Phonotactic probability

Introduction

Overregularizations like “goed” or “tooths” are some of the most common grammatical errors made by children and have been the focus of many language learning studies (Brown, 1973; Bybee & Slobin, 1982; Cazden, 1968, Kuczaj, 1977; Plunkett & Marchman, 1991). With respect to verbs specifically, most verbs in the English language add the suffix *-ed* to form the past tense. However, irregular verbs do not follow this set of rules but rather undergo peculiar changes such as vowel change (*win-won*), the replacement of an ending consonant or vowel (*feel-felt*), complete substitution otherwise known as suppletion (*go-went*), or undergo no change (*fit-fit*) (Marcus et al., 1992).

For decades researchers said the appearance of past tense overregularizations in production was evidence of children discovering the rule. That is, children begin to say things like “goed” when they discover that verbal past tense is usually marked by the addition of *-ed*. However, Figueroa & Gerken (2019) found that 16-month-olds seem to “overregularize” in perception, months before they do so in production. Their study consisted of three separate experiments on sixteen toddlers from English-speaking homes with no family history of speech, language, or hearing disorders. The first experiment looked at whether children would distinguish between overregularized verbs and phonotactically matched nonce verbs (e.g.: /vɑ:ŋəld/, /spɛft/) marked for the past tense. Results determined that the children would look longer at a light when presented with overregularized real verb stimuli over nonce *+ed* stimuli. This suggests that children prefer previously encountered verbs that follow their knowledge of the distribution of the *-ed* morpheme and their interpretation of past tense formation rules, in this case, the addition of *-ed* to English verbs without exception. The second experiment assessed listening times between overregularized verbs and English nouns *+ed* (e.g.: book-ed, orange-ed).

The results showed a preference toward the overregularized verb stimuli the toddlers were presented, which demonstrated toddlers' knowledge of *-ed* morpheme distributional properties, specifically that *-ed* does not co-occur with nouns. It also ruled out whether only familiarity with the presented words explained the results from the first experiment.

The final experiment assessed the children's ability to distinguish between overregularized verbs and their correct forms. This experiment was used to rule out the possibility that perhaps the sound properties of the overregularized stimuli drove the results from Experiment 2, since the overregularized verbs were significantly more phonotactically probable (that is, they sounded more like well-formed English words) than their correct counterparts. However, results showed no significant difference, meaning that the sound properties did not influence the results of the previous experiment as they still recognized the correct irregular form of verbs, as they likely had previously encountered those forms throughout their daily lives. The overall findings demonstrate that children have a clear expectation that English verbs co-occur with an *-ed* morpheme. However, the last experiment also showed that 16-month-olds, have no preference for overregularized verbs over correct irregular verbs, or vice versa, suggesting 16-month-olds are open to the possibility that either form is correct. Finally, they also suggest that children are aware that *-ed* co-occurs with verbs and not nouns, which would mean they are overregularizing the past tense formation rule in perception months before doing it in production. So what's happening when children produce overregularized forms if they have already known the rule for many months?

The hypothesis explored in this thesis is that English phonotactics may instead influence toddlers' use and production of overregularized verbs. Phonotactics refers to the study of how phonemes, or sound units, are typically or usually combined in a given language (Nordquist,

2020). Phonotactics can reflect an absolute ban on certain sound combinations (e.g., /bw/) at the beginning of English words, but also the statistical probability of sound sequences (e.g., more English words start with /t/ than with /m/). Studies focusing on phonotactic probability and word recognition in adults (both monolingual and bilingual) found that when presented with nonwords in a memory performance task, participants recalled nonwords with higher phonotactic probabilities better than nonwords with lower phonotactic probabilities, which suggests that more English-like sound patterns are more easily recognized and therefore memorized (Frisch et al., 2000). Other studies looking at the same influence of phonotactic probability (Vivitch, et al., 2004) and biphone probability (Thorn & Frankish, 2005) on nonword recall found similar findings suggesting once again that familiarity with certain speech sounds heavily influences participants' ability to more easily recognize and remember new stimuli. Such phonotactic influences on children have not been thoroughly researched. One study did find that the ease at which a child is able to learn novel words is positively affected by the phonotactic knowledge of previously learned words (Jones et al., 2021). One other study focused on children and word learning processes found that phonotactic probability may impact novel word recognition so long as the sound sequences within the words were acceptable for the language the child spoke (Storkel, et al., 2013).

Given these findings, we explore the possibility that past tense overregularizations in production are driven by English phonotactics. Specifically, we hypothesize that children make overregularization errors because it makes for more phonotactically probable sentences for English.

Methods

Two corpora of monolingual English-speaking children were used from the CHILDES database (MacWhinney, 2000): Adam and Sarah (Brown, 1973). This corpus is a collection of play sessions conducted between 1962 and 1966 in Cambridge, Massachusetts and was analyzed in Brown (1973)'s groundbreaking work on child language acquisition. Both children were speakers of Standard American English. Adam was from a professional family while Sarah was from a working-class family. A total of 44 utterances were extracted for the study from Adam's transcripts and 37 utterances from Sarah's transcripts.

The Computerized Language Analysis, or CLAN program, which was designed specifically to analyze data transcribed in the format of CHAT, the standard for CHILDES transcripts, was used to retrieve sentences with overregularized verbs (MacWhinney, 2000). A command in CLAN allowed for a retrieval of instances of overapplication of "-ed." The CHILDES transcripts contain typographical errors and inconsistencies, and a few past tense overregularizations may have gone undetected by the automatic search procedure performed by CLAN. In order to account for potential undetected overregularizations, each instance of irregular verbs were retrieved via a CLAN command then double-checked by hand.

Phonotactic & Biphone Probabilities

In this study, we focus on phonotactic and biphone probability which refer to the frequency of phoneme occurrence at a particular place in a word and the frequency that two sounds co-occur next to each other, respectively, in a given language. Estimates of the phonotactic probability for each word in the utterances with the correct verb form (e.g. 'threw') were calculated using THE PHONOTACTIC PROBABILITY CALCULATOR (Vitevich & Luce, 2004). This database provides measures of positional segment frequency and biphone frequency, derived from a sample of approximately 20,000 words in the Merriam-Webster

Pocket Dictionary. For example, the calculation of /ænd/ ('and') will calculate the likelihood that the sound /æ/ will appear at the beginning of an English word, that the sound /n/ will appear in the second position, etc. The calculator will return the positional segment frequencies for each phoneme (.030, .058, and .038, respectively), for each positional biphone frequency (/æn/ = .005 and /nd/ = .008), the sum of all phoneme probabilities (.126), and the sum of all biphone probabilities (.013). For the purpose of this study, the mean of all the positional segments frequencies and biphone frequencies for each word in the utterance with the correct verb form were found. In the above example, the probabilities included would be .042 (.126/3) and .006 (.013/2), respectively.

THE IRVINE PHONOTACTIC ONLINE (IPhOD) was used to calculate the phonotactic and biphone probability of the overregularized verb forms (e.g. 'threwed'), as this dictionary contains a collection of English words and pseudowords (Vaden, Halpin, & Hickok, 2009). The Phonotactic Probability Calculator was not used because it cannot run the overregularized pseudowords.

Using the mean phonotactic probability for each utterance with the overregularized and correct verb form, a phonotactic probability (PP) difference was calculated based on Formula 1.

$$\text{PP difference} = \text{Mean PP with } \underline{\text{correct form}} - \text{Mean PP with } \underline{\text{overregularized form}}$$

Formula 1

Based on the value of the mean differences derived from the equation, any negative (-) value meant the utterance had a greater phonotactic probability with the overregularized verb form, resulting in more English-like utterances given English phonotactics. Positive values (+) meant the utterance with the correct irregular verb form resulted in more English-like utterances given

English phonotactics. The same process was conducted with the mean differences in biphone probability (BP) for each of the utterances. See Formula 2.

$$\text{BP difference} = \text{Mean BP with } \underline{\text{correct form}} - \text{Mean BP with } \underline{\text{overregularized form}}$$

Formula 2

Results

Adam

From the 37 utterances analyzed for Adam, there were only five utterances that Adam produced wherein his overregularization did not improve the phonotactics at the segment level or the biphone level. Thus, 86% (32/37) of the overregularized verbs resulted in more English-like utterances given English phonotactics. Note that the mean difference between the utterance as uttered with the overregularized form versus the correct irregular verb was the same for five utterances, resulting in a mean difference value of zero (e.g., *grewed-grew*). These will be included in the analysis, nonetheless. A series of paired Wilcoxon Signed-rank tests were conducted to compare mean phonotactic probabilities for sentences as Adam uttered them, that is, with overregularized verbs (**Group OR**) vs. those same sentences with the overregularized verb replaced with its correct counterpart (**Group COR**; e.g., ‘made’ for ‘maked’).

This was done with the mean phonotactic probabilities at the segmental level and at the biphone level. *At the segment level:* The medians of Group OR and Group COR were 0.055 and 0.046, respectively. A Wilcoxon Signed-rank test shows that there is no effect of Group ($p > 0.05$).

At the biphone level: The medians of Group OR and Group COR were 0.0029 and 0.0030, respectively. A Wilcoxon Signed-rank test shows that there is no effect of Group ($p > 0.05$).

Although there wasn’t a significant effect of group, the mean difference between Group OR and

Group COR favored the overregularized form at the segmental level ($M = -0.005$, $SD = 0.018$) and at the biphone level ($M = -0.003$, $SD = 0.012$).

Next, we investigated whether there was a significant effect of Group on the segmental phonotactic probabilities of the utterances that *did* result in a more likely sentence given English sound sequences. The medians of Group OR and Group COR were 0.057 and 0.044, respectively. A Wilcoxon Signed-rank test shows that there is a significant effect of Group ($p < 0.0001$). When Adam overregularized a verb and the overregularization resulted in a more phonotactically probable utterance, there was a significant difference in the segmental phonotactic probabilities between the sentence as uttered (i.e., with the overregularized verb) and when the correct form was substituted.

Adam's results showed the total use of 21 unique overregularized verbs across his analyzed utterances. From those, seven verbs that Adam overregularized resulted in a less phonotactically probable utterance were: *feeled*, *teached*, *doed*, *runned*, *sleeped*, *falled*, and *drived*. In one instance the use of the overregularized verb resulted in the same phonotactic probability - *growed* (vs. *grew*).

The figures use the following ratio to illustrate the impact of overregularizing the verb form on the sound sequences of the utterances: (Mean PP with overregularized form)/(Mean PP with correct form). Values greater than one represent utterances where the use of the overregularized irregular resulted in a more English-like utterance, while any values less than one represent utterances where overregularized form resulted in a less probable English-like utterance. Figure 1 shows that a greater number of the utterances were more phonotactically probable at the segmental level when the overregularized form of the verb was used by Adam versus the correct form.

Adam's results for biphone probability analysis for the utterances showed that the addition of *-ed* to the end of verbs, or use of the overregularized verb form, resulted in more English-like sound combinations. Figure 2 shows a much narrower distribution in the biphone differences, than the phonotactic probability of Figure 1. However, in the majority of the cases, the use of the overregularized resulted in more phonotactically probable utterances based on the end sound pairings.



Fig. 1: Adam's segmental probability.



Fig. 2: Adam's biphone probability.

Sarah

From the 44 utterances analyzed for Sarah, five utterances were not taken into account. This was because the overregularization of “go” to “goed” results in completely different sounds than the correct form of the irregular (*go-went*), it is suppletive. The mean between two utterances with the correct and overregularized irregular verb was the same, resulting in a mean difference value of zero (*grewed-grew*). These were included in the analysis. From the remaining 39 sentences, there were five utterances wherein the overregularized form did not create a more phonotactically probable English sentence at the segment or biphone level. Overall, 87% (34/39) of the utterances with an overregularized verb form resulted in more English-like utterances at the segmental or biphone level, given English phonotactics.

A series of paired Wilcoxon Signed-rank tests showed that, unlike Adam, there are significant effects of Group at the segmental level and at the biphone level. *At the segment level:* The medians of Group OR and Group COR were 0.055 and 0.044, respectively. A Wilcoxon Signed-rank test shows that there is a significant effect of Group ($p < 0.03$). *At the biphone level:* The medians of Group OR and Group COR were 0.0030 and 0.0025, respectively. A Wilcoxon Signed-rank test shows that there is a significant effect of Group ($p < 0.002$). When Sarah overregularized a verb and the overregularization resulted in a more phonotactically probable utterance, there was a significant difference in the phonotactic probabilities between the sentence as uttered (i.e., with the overregularized verb) and when the correct form was substituted, at both the segmental and biphone levels. The mean difference between Group OR and Group COR favored the overregularized form at the segmental level ($M = -0.007$, $SD = 0.015$) and at the biphone level ($M = -0.002$, $SD = 0.005$).

Sarah's results showed the total use of 23 unique overregularized verbs across her analyzed utterances. The verbs that Sarah overregularized resulting in less phonotactically probable utterances were: *goed*, *runned*, *hided*, *slided*, *falled*, and *losed*. In one instance the use of the overregularized verb resulted in the same phonotactic probability - *gowed* (vs. *grew*). Figure 3 shows the distribution of phonotactic probability based on the ratio described above between the utterance with the overregularized versus correct irregular verb form. The overall trend of the graph shows a majority of the utterances being more phonotactically probable for English with the overregularized verb form.

Sarah's results for biphone probability analysis for the utterances, also showed that the *-ed* ending of the overregularized verb forms resulted in a more English-like biphone probabilities. Figure 4 highlights the finding for the biphone distribution, after the removal of utterances with "*goed*". Similar to Adam's, the distribution is much narrower, meaning that the differences between the mean biphone probability of the utterance with the correct irregular versus overregularized verb form were smaller in value. However, the majority of these differences showed that the use of the overregularized verb resulted in more phonotactically probable utterance given English.

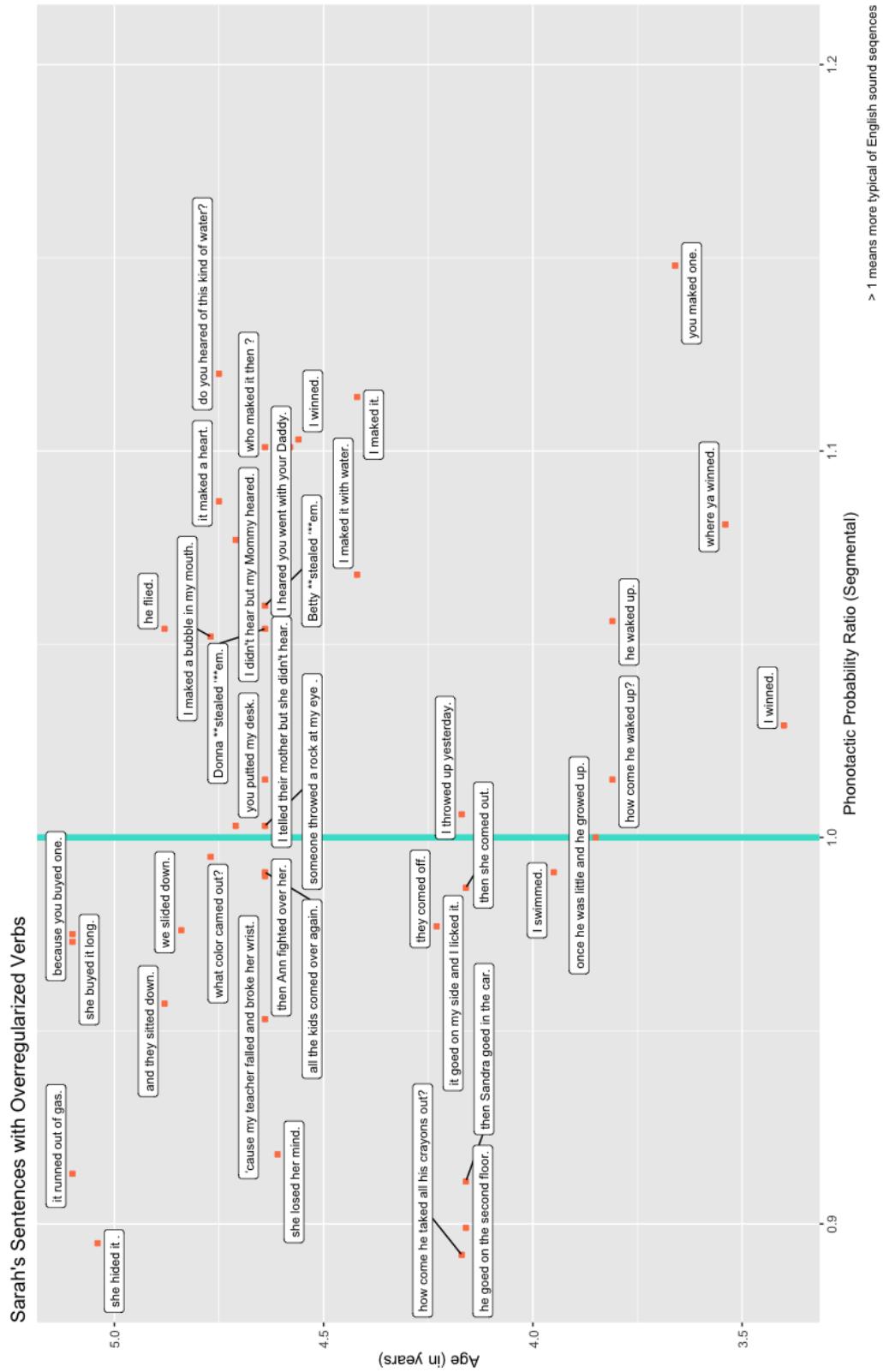


Fig. 3: Sarah's segmental probability.

General Analysis

There was overlap in the use of some overregularized verbs by both children. The overlapping verbs consisted of *waked*, *winned*, *taked*, *runned*, *throwed*, *falled*, *growed*, *comed*, and *maked*. From these nine verbs, only two (*runned* and *falled*) resulted in the utterance being less phonotactically probable for English, and one (*growed*) resulted in the same phonotactic probability. The remaining overregularized verbs (*waked*, *winned*, *taked*, *throwed*, *comed*, and *maked*), therefore, resulted in more phonotactically probable utterances given English. As far as the biphone probability results, both children displayed similar results, where the use of an *-ed* ending (which overregularized the verb) resulted in more English-like utterances. Figure 5 shows the segment phonotactic probability ratio for both Adam and Sarah, from this graph it can be confirmed that in the majority of instances, the use of overregularized verbs resulted in greater segment phonotactic probability. Figure 6 highlights the biphone probabilities for both children, and confirms the same findings that a greater number of utterances resulted in a greater biphone probability with the use of the overregularized verb, with *-ed* ending, than in instances where the correct irregular verb form was used.

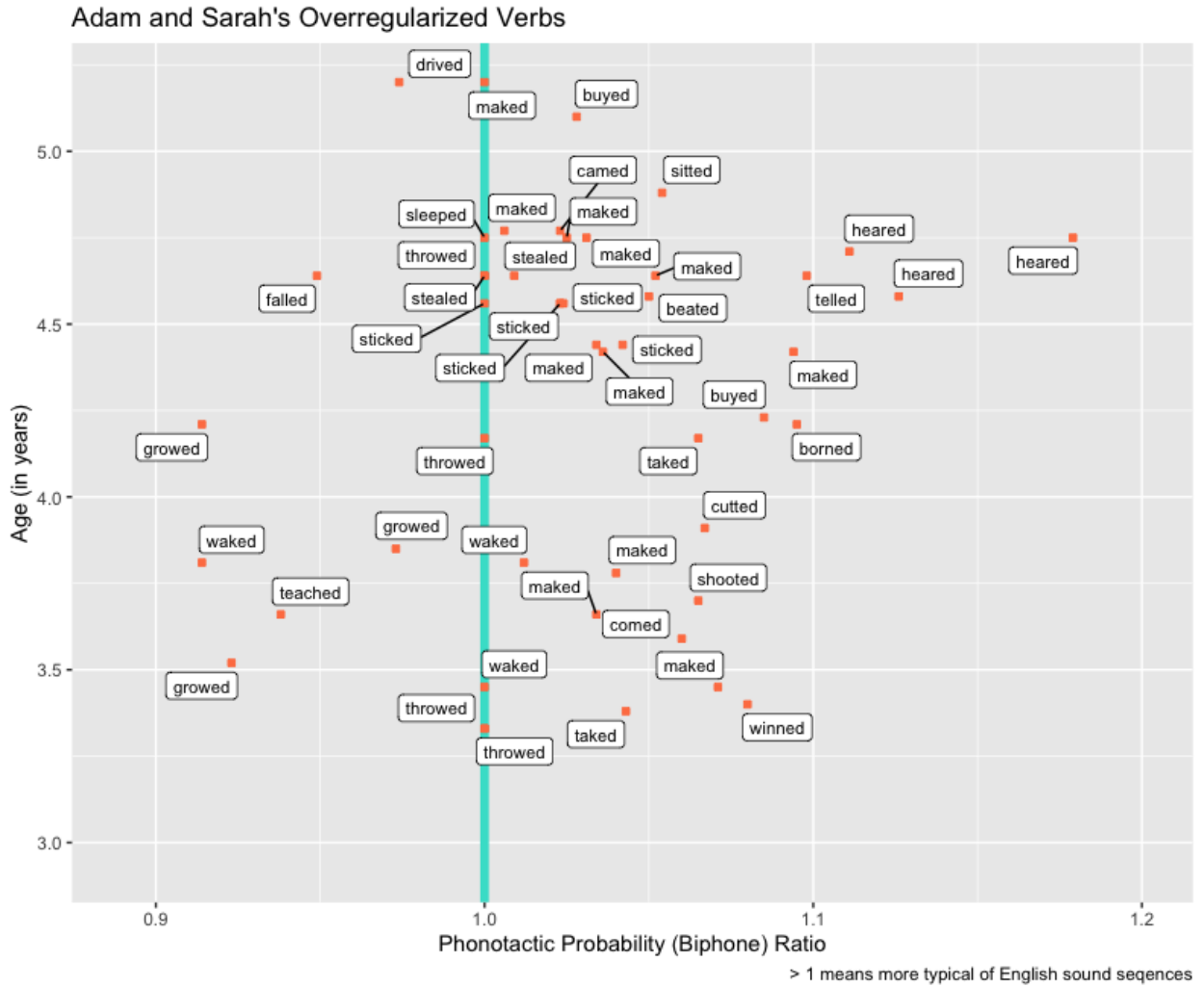


Fig 6. Adam's and Sarah's biphone probabilities. *Note.* The ratio corresponds to the entire utterance. Only the verbs are shown for readability.

Discussion

The goal of this study was to determine whether past tense overregularizations in production are driven by English phonotactics. I began this investigation because researchers have previously suggested that children begin to produce overregularized forms when they "discover" the past tense rule. But the findings of Figueroa and Gerken (2019) suggest that children know something about the past tense rule many months before they begin producing overregularized forms. Since it seems children aren't learning the rule for the first time in production, what's driving these overregularizations? I hypothesized that these errors were

produced because overregularized forms are more phonotactically probable in English. The results for both children showed that when they used an overregularized verb for (vs. the correct form of the irregular), the majority of the utterance ended up being more phonotactically probable for English when looking at both the segment and biphone probabilities.

Results from each child's utterances demonstrated that the use of the overregularized verb due to it being more phonotactically probable for English was not by chance. In 86% of Adam's, and in 87% of Sarah's analyzed utterances this was shown to be true. Further, when the utterances of both children are added, it was the case for 87% of the utterances that the overregularized form resulted in a more phonotactically probable utterance.

When analyzing the results of both children, seven overregularized verbs overlapped between them: *waked*, *winned*, *taked*, *runned*, *throwed*, *falled*, *growed*, *comed*, and *maked*. Only two of these resulted in utterances that were less probable given English phonotactics (*runned* and *falled*). This may be due to the fact that children are less familiar with these verbs. Additionally, a series of paired Wilcoxon Signed-rank tests conducted for Adam and Sarah showed a significant effect of group (overregularized vs. correct): when each child overregularized a verb and the overregularization resulted in a more phonotactically probable utterance, there was a significant difference in the phonotactic probabilities between the sentence as uttered (i.e., with the overregularized verb) and when the correct form was substituted, at both the segmental and biphone levels (with the caveat that, for Adam, there was only a significant effect of Group on the segmental phonotactic probabilities of the utterances that *did* result in a more likely sentence given English sound sequences). This is important because it means that the addition of the *-ed* morpheme at the end of the overregularized form, had a greater impact on whether the utterance was more phonotactically probable for English. In conclusion, this small

study suggests that phonotactic probability might provide at least a partial explanation for why children produce overregularized forms like "goed." This study certainly suggests that it would be worth looking at a larger group of children to see if the pattern found here continues to hold.

APPENDIX A: ADAM'S UTTERANCES INCLUDED IN THE STUDY

Utterance	Utterance with Correct Irregular
what that feeled like?	what that felt like?
and I throwed it back to the chicken.	and I threw it back to the chicken.
they going to take some and they taked it out and they work.	they going to take some and they took it out and they work.
know what I maked ?	know what I made ?
why Paul waked up?	why Paul woke up?
Mommy he growed enough.	Mommy he grew enough.
and the company man comed	and the company man came
somebody teached me to sing.	somebody taught me to sing.
I almost doed a somersault.	I almost did a somersault.
I want to be shooted .	I want to be shot .
one runned away from me.	one ran away from me.
I maked the bridge.	I made the bridge.
how could it go up if it's not flied ?	how could it go up if it's not flew ?
I cutted this.	I cut this.
I growed back up.	I grew back up.
is that where I was borned ?	is that where I was born ?
he shoulda have holded his horses.	he shoulda have held his horses.
we maked a turtle didn't we today?	we made a turtle didn't we today?
it's sticked to the floor.	it's stuck to the floor.
it's just sticked together.	it's just stuck together.
he sticked me.	he stuck me.
I sticked him back.	I stuck him back.
he sticked this bird.	he stuck this bird.

the galloping horse winned	the galloping horse won
Adam winned didn't he?	Adam won , didn't he?
I beated everyone that I tried to shoot.	I beat everyone that I tried to shoot.
we winned .	we won .
one winned .	one won .
I beated Robin.	I beat Robin.
he maked his smaller.	he made his smaller.
I blowed it up.	I blew it up.
you know that lady that came and sleeped with us?	you know that lady that came and slept with us?
the tail falled off.	the tail fell off.
yeah my daddy drived it in.	yeah my daddy drove it in.
I maked a cane a long big old giant snake.	I made a cane a long big old giant snake.
I feeled anything else.	I felt anything else.

APPENDIX B: SARAH'S UTTERANCES INCLUDED IN THE STUDY

Utterance	Utterance with Correct Irregular
I winned .	I won .
where ya winned .	where ya won .
you maked one.	you made one.
he waked up.	he woke up.
how come he waked up?	how come he woke up?
once he was little and he growed up.	once he was little and he grew up.
he goed to heaven.	he went to heaven.
I swimmed .	I swam .
Robin goed .	Robin went .
he goed on the second floor.	he went on the second floor.
then Sandra goed in the car.	then Sandra went in the car.
then she comed out.	then she came out.
how come he taked all his crayons out?	how come he took all his crayons out?
I throwed up yesterday.	I threw up yesterday.
it goed on my side and I licked it.	it went on my side and I licked it.
she taked my chair.	she took my chair.
he buyed a Halloween something.	he bought a Halloween something.
they comed off.	they came off.
I maked it.	I made it.
I maked it with water.	I made it with water.
I winned .	I won .
I heard you went with your Daddy.	I heard you went with your Daddy.
she losed her mind.	she lost her mind.

someone threwed a rock at my eye .	someone threw a rock at my eye .
who maked it then ?	who made it then ?
'cause my teacher falled and broke her wrist.	'cause my teacher fell and broke her wrist.
Donna stealed 'em.	Donna stole 'em.
Betty stealed 'em.	Betty stole 'em.
I telled their mother but she didn't hear.	I told their mother but she didn't hear.
then Ann fighted over her.	then Ann fought over her.
all the kids comed over again.	all the kids came over again.
you putted my desk.	you put my desk.
I didn't hear but my Mommy heared .	I didn't hear but my Mommy heard .
do you heared of this kind of water?	do you heard of this kind of water?
it maked a heart.	it made a heart.
what color camed out?	what color came out?
I maked a bubble in my mouth.	I made a bubble in my mouth.
we slided down.	we slid down.
and they sitted down.	and they sat down.
he flied .	he flew .
she hided it.	she hid it.
because you buyed one.	because you bought one.
she buyed it long.	she bought it long.
it runned out of gas.	it ran out of gas.

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