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Research Article

Children's Tolerance of Word-Form Variation

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How much morphological variation can children tolerate when identifying familiar words? This is an important question in the context of the acquisition of richly inflected languages where identical word forms occur far less frequently than in English. To address this question, we compared children's ($N = 96$, mean age 4;1, range 2;11–5;1) and adults' ($N = 96$, mean age 21 years) tolerance of word-onset modifications (e.g., for *stug: wug* and *wastug*) and pseudoaffixes (e.g., *kostug* and *stugko*) in a label-extension task. Word-form modifications were repeated within each experiment to establish productive inflectional patterns. In two experiments, children and adults exhibited similar strategies: they were more tolerant of prefixes (*wastug*) than substitutions of initial consonants (*wug*), and more tolerant of suffixes (*stugko*) than prefixes (*kostug*). The findings point to word-learning strategies as being flexible and adaptive to morphological patterns in languages.

1. Children's Tolerance of Word-Form Variation

In language development, an important question is how young children go about the task of acquiring and correctly associating new words with their referents, a process sometimes referred to as word-to-world mapping. This process has mainly been investigated in English, a language, where word forms tend to be identical or very similar across different contexts, due to the impoverished inflectional morphology of English. In this study, we explore the question of how morphological changes impact the interpretations of new words for novice language learners.

Children have been shown to have a strong bias toward mapping unfamiliar words onto unfamiliar objects [1]. They also are capable of learning new words after only a few exposures [2], an ability known as "fast mapping." In perhaps the earliest study of fast mapping, Carey and Bartlett [2] asked children to select a "chromium" tray (olive green in color) when given two choices, an object with a color (red) that they already had a name for and one they did not. They found that children were highly biased to select the nonprimary color item. To test if the child had actually learned the new color term, children were retested a year later and half of the children demonstrated retention. This fast-mapping tendency has proven to be a robust and reproducible phenomenon across many studies (e.g., [3–5]): when given an object that is familiar and one that is unfamiliar, children associate a new name with the unfamiliar object at levels far above chance. Markman and her colleagues have interpreted this bias as reflecting an innate word-learning constraint, the mutual exclusivity (ME) principle [6]. Other theorists have sought to explain this rather robust finding by proposing that children utilize a novel name for a nameless category (the Novel-Name-Nameless-Category principle (N3C) [7]) or utilize pragmatic reasoning to contrast the meanings of words in their developing vocabularies (the Principle of Contrast (PoC) [8, 9]). All of these theories explain the fast-mapping tendency by suggesting that children have learning strategies or biases that help them to identify the referents of new words. What is unclear, however, is how such learning strategies interact with morphophonological variants of familiar words. For instance, the diminutive derivation is quite common in child-directed speech across many languages [10] and children appear to successfully map both *dog* and *doggie* onto the same entity with little confusion.

It should be noted that some languages have an especially high rate of diminutive usage in child-directed speech, for example, Russian [11], Spanish [12], Dutch [13], and Lithuanian [14]; diminutives are quite common in child speech as well as child-directed speech and are the first morphological derivation that children acquire in the Baltic and Slavic languages [15]. Importantly, diminutives are not used primarily to mark a contrast between small and large objects in child-directed speech, but are instead used to convey the intimate, affectionate, and playful mood of child-focused interactions [15]. Moreover, caretakers will flexibly alternate between the diminutive and simplex forms of a noun to refer to the same referent within a conversational interaction [16, 17], and there is no evidence to suggest that this word-form variation negatively impacts on children's word learning. Thus, children's tolerance of diminutives as alternative labels would seem to indicate that there is a limit to the extent with which children conform to word-learning constraints such as ME. It further suggests that children have to adapt their word-learning strategies flexibly in response to recurrent morphological patterns. To explore the extent of children's tolerance for word-form variation we adopted a label-extension task that probes the mapping of nonwords onto familiar and novel images.

1.1. The Label-Extension Task and Children's Tolerance of Word-Form Variants. The label-extension task involves presentation of an altered word-form to investigate whether this word-form variant is extended to the familiar object or to a different object. After being introduced to the name of an object, participants are presented with a modification of that word, or a different word entirely, and asked to map this target word onto one of two objects. For example, Hupp and colleagues ([18], Experiment 1) presented adults with a novel word (e.g., *ta-te*) as the name of an object (a heart), and then asked them to identify which of two objects would be a *ta-te-be*, with the choice being a heart or a star. They reported that adults selected the same object (the heart) 17.5% of the time when given a word-form variant involving a suffix, but only 9.5% when it involved a prefix (e.g., *be-ta-te*). Thus, adults showed an overwhelming tendency to reject any word-form variant as an alternative label for a previously named object but also displayed a slight preference for suffixed words as alternative labels.

The label-extension task contrasts with a more widely used procedure in which children are given a choice between a familiar and an unfamiliar object. Merriman and Schuster [19] asked 2- and 4-year-old children to decide between a familiar or unfamiliar object after hearing a nonce word that sounded similar to the name of the familiar object. At both ages, children mapped the name-similar nonce word (e.g., *japple*) onto the familiar object (e.g., an apple) about 60% of the time. In contrast, when the nonce word (e.g., *firsh*) did not bear any similarity to the name of the familiar object, 4-year-olds (and to a much lesser extent 2-year-olds) engaged in the predictable fast mapping of the name to the unfamiliar object. Merriman and Schuster [19] introduced a wide variety of word-form modifications across items, with some items having onset-consonant additions or substitutions (e.g., *japple* for *apple, sagon* for *wagon*, *bruck* for *truck*), other items with suffixes added (e.g., *cardle* for *car*, *housler* for *house*, *pantiffs* for *pants*), and others having word-internal changes (e.g., *firsh* for *fish*, *lote* for *light*, *colck* for *clock*). Merriman and Schuster failed to detect any difference in how children responded to the items with onset modifications versus the items with suffixes added (i.e., they selected the familiar object with the similar sounding name 70% of the time when the nonce noun had an onset modification versus 71% of the time when it had a suffix added). However, modifications that changed the rime (i.e., items with word-internal changes involving vowels) were less likely to be treated as alternative labels.

Jarvis et al. [20] explored whether training altered how children treated word-form modifications similar to those used by Merriman and Schuster [19]. They hypothesized that the children in Merriman and Schuster [19] may have formed a response set that altered their pattern of responding over the course of testing. In particular, Merriman and Schuster's inclusion of trials with two familiar objects (e.g., an apple paired with a salamander) may have led the children to assume that *japple* referred to the apple as opposed to the salamander because *japple* sounded more like *apple* than *salamander.* Consequently, Jarvis et al. tested whether the inclusion of training trials with two familiar objects and a similar-sounding nonce word would lead children to be more accepting of word-form modifications in a posttest with a familiar object paired with an unfamiliar object. They found that prior to training (i.e., in a pretest), the children were highly biased to treat any word-form modification as a new word, but were significantly more accepting of the similar-sounding words as alternative labels of familiar objects in the posttest. Adults, in contrast to children, did not alter their response patterns after training, and selected the familiar object on only 14% of posttest trials. This high degree of resistance to any word-form modification in adult English-speakers matches the findings of Hupp et al. [18].

Importantly, Jarvis et al.'s results confirmed Merriman and Schuster's [19] finding that children did not treat all word-form modifications equivalently. However, the exact pattern of responding was not identical to that reported in Merriman and Schuster. In Jarvis et al. ([20], Experiment 1), word-form modifications involving replacements of word initial consonant(s) (e.g., *bruck* for *truck*) were associated with the familiar object (e.g., a truck) only 8% of the time in the pretest, whereas end modifications (e.g., *shoeler* for *shoe*) were associated with the familiar object (e.g., a shoe) 42% of the time. In both Merriman and Schuster [19] and Jarvis et al. [20], the word-ending modifications involved adding an unstressed final syllable to the word, whereas the word-onset manipulations involved an addition or substitution of a consonant to alter the word onset, rather than the addition of an unstressed prefix. This leaves open the question of whether children would treat prefixed versus suffixed words differently.

The research reported in this paper expands the previous findings in various ways: we investigate (1) whether affixed forms are tolerated more readily as alternative labels than stem modifications like the substitution of a word onset, (2) whether prefixed forms are tolerated differently than suffixed forms, and (3) whether tolerance for modified word forms is generally higher when those modifications are systematic as is characteristic for productive morphological patterns, rather than idiosyncratic and random. Before describing our methodology in detail, we briefly summarize considerations that suggest differences in tolerance between prefixed and suffixed forms.

1.2. The Role of Prefixes and Suffixes in Language Learning. The statistical distribution of inflections across human languages is a widely discussed topic among linguists interested in morphology [21–23]. Across languages, there appears to be a preference for suffixes over prefixes [24]; prefixing-only languages are rare in comparison to those with only suffixes [25]. However, exceptions to this asymmetry can be found in some of the world's languages such as the prefix-dominant Bantu languages, which feature a variety of prefixes including a diminutive prefix [26].

Prefixes and suffixes may be treated differently because modifications of beginnings versus ends of words differ in their impact on lexical processing. In one of the earliest studies on this topic, Bagley [27] presented adults with word-initial and word-final mispronunciations of consonants and found word-initial mispronunciations to be more disruptive to word recognition. Marslen-Wilson's Cohort model of word recognition [28, 29] proposed that the initial phoneme(s) of a word activate a cohort of words bearing the same sounds. As subsequent phonemes of the word are processed and a "uniqueness point" for the word is reached, the word is selected from the lexicon. In support, Nooteboom [30] found that adult Dutch speakers succeeded 95% of the time in identifying the word *Kannibal* when presented with initial fragments compared to only 60% of the time when presented with final fragments. The aforementioned findings by Hupp et al. [18] also confirm this asymmetry: adults judged the suffixed word-form variants (e.g., *ta-te-be*) as more similar to the target words (e.g., *ta-te*) than the prefixed forms (e.g., *be-ta-te*).

Similar results have been reported with 4- and 5-year-old children: Walley [31] examined the influence of word-initial input on children's recognition of spoken words through a mispronunciation detection task. She manipulated the position of the mispronounced phoneme (i.e., onset versus offset of the word) and, additionally, whether the word was presented within a sentence context (i.e., in a story) or in isolation (with or without an accompanying picture). When the mispronounced word occurred within a story, children were more successful at detecting mispronunciations involving word onsets than offsets. However, the children did not show this position effect when the words were presented in isolation, without accompanying pictures.

Another reason for the asymmetry between prefixes and suffixes with respect to tolerance of word-form variation may be that suffixes are more informative with respect to grammatical category information (e.g., information about parts of speech or noun gender). This is reflected in Slobin's [23] operating principle A_1: "grammatical realizations in the form of suffixes of postpositions will be acquired earlier than realizations in the form of prefixes or prepositions." This, in addition to Slobin's [23] operating principle A: "pay attention to the ends of words," acknowledges that the ends of words are more salient to early language learners than the beginnings. Clair et al. [32] explored to what extent prefixes and suffixes are differentially helpful in marking the grammatical categories of words. They conducted a corpus analysis of child-directed speech in English using the CHILDES database. For each affix, they calculated the frequency with which it pointed to a specific grammatical category and found that suffixes contained more consistent category information than prefixes. In a subsequent experiment, adults exposed to an artificial language were more accurate in identifying the grammatical categories of suffixed words than of prefixed words. Based on these findings, Clair et al. concluded that there are multiple advantages in learning and processing suffixes over prefixes, including faster processing time, greater facilitation, and lower interference with category identification.

In sum, initial segments of a word might facilitate word identification whereas final segments of a word might facilitate grammatical categorization leading to the hypothesis that children display greater tolerance for modifications involving suffixes than prefixes in the label-extension task.

1.3. The Present Study. To examine children's tolerance for various word-form modifications we conducted two experiments using the label-extension task. We also tested adults in addition to the children to provide a comparison group. Experiment 1 tested whether participants treated variants of novel words with substitutions of word-initial consonants (e.g., *wug* for *stug*) differently than word-form variants with prefixes (e.g., *wastug* for *stug*). Experiment 2 tested whether participants treated prefixes differently than suffixes. Both experiments used a label-extension task similar to that of Hupp et al. ([18], Experiment 1). However, in contrast to previous label-extension studies, all of which utilized nonproductive word-form variation, our experiments presented the same morphophonological modifications across all novel words. This allowed us to examine how children treat word-form variation that is systematic and productive, as opposed to idiosyncratic and apparently random. As noted above, input to language learners can include many productive word-form variations, such as diminutives in English or inflectional morphemes in highly inflected languages. Following Jarvis et al. [20], participants in both experiments received filler trials consisting of familiar words presented with two familiar objects in order to discourage a response set where the child selected the unfamiliar object on every single trial. However, these filler trials did not constitute a meaningful extension contrast and will therefore not be analyzed.

Table 1: Stimulus words for Experiment 1.

Introductory (simplex) word	Similar word trials			Dissimilar word trials		
	Diminutive	Onset modification		Diminutive	Onset modification	
Practice trials						
Horse	Horsy			Doggy		
Dog	Doggy			Horsy		
Pig	Piggy			Fishy		
Fish	Fishy			Piggy		
		Substitution	Prefix		Substitution	Prefix
Test trials						
Geck	Gecky	Weck	Wageck	Kazy	Waze	Wakaze
Kaze	Kazy	Waze	Wakaze	Gecky	Weck	Wageck
Tuz	Tuzzy	Wuz	Watuz	Dibby	Wib	Wadib
Dib	Dibby	Wib	Wadib	Tuzzy	Wuz	Watuz
Terp	Terpy	Werp	Waterp	Vikey	Wike	Wavike
Vike	Vikey	Wike	Wavike	Terpy	Werp	Waterp
Stug	Stuggy	Wug	Wastug	Mansey	Wanse	Wamanse
Manse	Mansey	Wanse	Wamanse	Stuggy	Wug	Wastug
Pabble	Pabbley	Wabble	Wapabble	Rutchery	Wutcher	Warutcher
Rutcher	Rutchery	Watcher	Warutcher	Pabbley	Wabble	Wapabble
Dappo	Dappoee	Wappo	Wadappo	Chitoffy	Witoff	Wachitoff
Chitoff	Chitoffy	Witoff	Wachitoff	Dappoee	Wappo	Wadappo
Burble	Burbley	Wurble	Waburble	Spirteny	Wirten	Waspirten
Spirten	Spirteny	Wirten	Waspirten	Burbley	Wurble	Waburble
Hacket	Hackety	Wacket	Wahacket	Jerpery	Werper	Wajerper
Jerper	Jerpery	Werper	Wajerper	Hackety	Wacket	Wahacket

2. Experiment 1: Tolerance of Different Types of Word-Onset Modification

2.1. Method. Experiment 1 involved a between-subjects manipulation of changes involving word onsets: in the onset substitution condition, participants heard word-onset modifications that involved substitution of /w/ for the word onset (e.g., *wanse* for *manse*). In the prefix condition, onsets were altered through the addition of a prefix *wa-* (e.g., *wamanse* for *manse*). In both conditions, participants were also presented with a diminutive derivation; due to its prevalence in natural language and child-directed speech, we anticipated that children and adults would readily tolerate the diminutive as an alternative name for the object. Thus, the inclusion of diminutives served as a manipulation check to determine whether the task made sense to the participants and whether they were detecting any relationship between the animal name provided on the introductory page and the test noun. We used animate targets throughout the experiment to comply with the constraint that the diminutive derivation in English applies predominantly to animal names. For the diminutive trials we used the most productive diminutive derivation in English (i.e., the suffix/I/).

2.1.1. Participants. Sixty-four children (mean age 4;0, range 2;11–4;11; 38 boys and 26 girls) were recruited and tested at several urban and rural preschools. The children came from predominantly white, middle-class communities and were monolingual speakers of American English. Each child received a child-study *t*-shirt for their participation. Sixty-four adult native speakers of English (mean age 21 years, range 18–40, 21 males and 43 females) were recruited from psychology classes at a large urban public university and received research participation credits. Half of the participants in each age group were assigned to the onset substitution condition and half were assigned to the prefix condition. For each age group, the numbers of male and female participants, and their ages, were matched across conditions.

2.1.2. Materials and Design. We created 8 monosyllabic and 8 bisyllabic pseudonouns like *stug* and *manse*, see Table 1 for a list of stimuli. These pseudo-nouns were combined with a diminutive suffix (e.g., *stuggy*) to create the diminutive control items. For participants in the prefix condition, pseudo-nouns were combined with the unstressed prefix *wa-* (e.g., *wastug*). For participants in the onset substitution condition, the first consonant was replaced with the phoneme /w/ as in *wug* for *stug*. Half of the trials per condition (i.e., "similar word" trials) presented a word-form modification that sounded similar to the name of the animal presented on the introductory page (e.g., for *manse*: *wanse* or *wamanse*), and the other half (i.e., "dissimilar word" trials) presented word-forms that were entirely unrelated to the name of the animal presented on the introductory page (e.g., for *manse*: *wug* or *wastug*). Note that the "dissimilar word" trials did not

Table 2: Examples of stimuli for novel animal trials in Experiments 1.

Picture	Simplex name	Onset modification		Offset modification
		Onset substitution	Prefix	Diminutive
	*Manse*	*Wanse*	*Wamanse*	*Mansey*
	*Stug*	*Wug*	*Wastug*	*Stuggy*

constitute a word-form modification from the point of view of the participants, but rather served as a control for whether the children engaged in fast mapping of novel items to novel referents.

Novel target words and familiar fillers were combined with 6” x 4” pictures of novel and familiar animals, respectively. Examples of novel animal stimuli are shown in Table 2. The pictures were collected from nature publications, websites, and other sources. Each trial consisted of an introductory page containing a single image of an animal and a second test page containing the introductory image next to one of a different animal. The introductory page was used to establish the name of the animal, using its simplex form, by saying, for example, “I call this animal a *stug.*” The test page was used for the forced-choice probe described below. An example trial is depicted in Figure 1.

Assignment of items to conditions (similar versus dissimilar word trials; onset versus end modification) was counterbalanced across participants, yielding 8 unique lists. At the beginning of the task, participants received two practice trials consisting of familiar words and their diminutive derivations to ensure comprehension of the instructions.

2.1.3. Procedure. Each participant was tested individually in a single session of approximately 10 minutes duration. Participants were tested by one of two male research assistants: one research assistant was involved in the preparation of stimulus materials and the other was blind to the research hypotheses. Comparison of data across research assistants yielded essentially identical results.

Participants were seated in front of a binder and were invited to play a game of pointing to the picture of the animal that was named. Participants were told that some of the animals might have made-up names they had never heard before and that they should try their best to figure out which animal might be called by the given name.

Two training trials were used to ensure understanding of the task. Each trial began with the introduction of the first animal photo labeled using the simplex form of the animal name (e.g., “I call this animal a *horse*. Can you say *horse*?”). Children were asked to repeat the simplex name to confirm that they had heard it and were paying attention. This was followed by the presentation of the two photos on the test page and the probe (e.g., “now can you tell me which animal is a *horsey*?”). Children were instructed to point to a picture,

(a) Introductory page. "I call this a *manse*. Can you say *manse*?"

(b) Test page. "Now can you tell me which animal is a *wanse*?"

Figure 1: Example of a trial in the onset substitution condition of Experiment 1.

and their responses were recorded out of sight on a tally sheet. The tally sheets were used to record whether the children selected the picture on the left or right side of each page and were scored at the end of the testing.

The first two trials were used to train the participant on how the game was played. One of the initial trials probed for the same animal that was introduced on the initial page and the other trial probed for the other animal, with the order of "similar word" and "dissimilar word" trials counterbalanced. After these two initial training trials the experiment proceeded with the test trials, which were interspersed with filler trials using familiar animals. In both the onset substitution and the prefix conditions, the test trials were presented in a quasirandom order, with no more than three "similar word" or "dissimilar word" trials occurring consecutively, and position of word-form modification (onset versus ending) randomized across trials. To illustrate the conditions, for "similar word" trials, children heard a modification of the previously introduced name: introduced to a *stug*, they were asked "which animal is a *stuggy*?" (diminutive control condition) or "which animal is a *wug*?" (onset substitution condition) or "which animal is a *wastug*?" (prefix condition); for "dissimilar word" trials, children heard an entirely different word: introduced to a *stug*, they were asked "which animal is a *mansey*?" (diminutive condition) or "which animal is a *wanse*?" (onset substitution condition) or "which animal is a *wamanse?*" (prefix condition). No corrective feedback was given during the test.

2.2. Results. Table 3 presents mean percentages of trials in which participants selected the same animal as the one previously labeled on the introductory page in Experiment 1. Choice of same animal indicates tolerance of a word-form modification. We first examine "dissimilar word" trials to ascertain whether children understood the task, and then we focus on the "similar word" trials, which contain the main manipulation of interest. Responses for "similar word" trials and for "dissimilar word" trials were analyzed in the following way: because the factor of onset modification type (onset substitution versus prefix) was nested within position of modification in the "similar word" trials (i.e., participants in both onset modification conditions also were exposed to diminutive derivations) we performed a set of planned comparisons. We first examined whether there were differences due to position of modification (onset versus ending) and effects of age for "similar words" and "dissimilar words" separately. We then performed the critical analyses just for the onset-modified "similar word" trials to examine whether there were differences due to onset modification type (onset substitution versus prefix).

As is evident in Table 3, participants rarely chose the same animal on the "dissimilar word" trials, in which the noun was entirely different from the name of the animal on the introductory page. That is, when introduced to a *manse*, and asked for a *wug* or a *wastug* or a *stuggy*, participants avoided the picture associated with *manse.* For "dissimilar word" trials, a mixed-design ANOVA with age group as a between-subjects factor, and position of modification (onset versus ending) as a within-subjects factor yielded a significant main effect of position of modification, $F(1, 126) = 4.59$, $P = 0.034$, partial $\eta^2 = 0.04$, with participants (children and adults) selecting the "same" picture somewhat more often when faced with an onset modification (10.9%), as opposed to a diminutive (6.2%). No other effects approached significance.

For "similar word" trials, the same mixed-type ANOVA yielded only a main effect of position of modification, $F(1, 126) = 27.78$, $P = 0.0001$, partial $\eta^2 = 0.16$, with more "same" picture choices for diminutive modifications (84.0%) than for onset modifications (65.6%). However, examination of the means in Table 3 indicates that this effect of position was primarily due to a large difference between the onset substitution condition and the diminutive

Table 3: Mean percentages of selections of the same animal as on the introductory page, as a function of group (onset substitution versus prefix), trial type (dissimilar versus similar word), and modification (onset versus diminutive) in Experiment 1. $N = 32$ in each group (Standard deviations in parentheses).

		Onset substitution group		Prefix group	
		Onset substitution (e.g., *wug*)	Diminutive (e.g., *stuggy*)	Prefix (e.g., *wastug*)	Diminutive (e.g., *stuggy*)
Dissimilar word trials (*manse* on introductory page)	Children	10.9 (21.0)	6.2 (16.8)	15.6 (32.2)	10.9 (21.0)
	Adults	7.8 (18.4)	4.7 (14.8)	9.4 (19.8)	3.1 (12.3)
Similar word trials (*stug* on introductory page)	Children	40.6 (41.0)	73.4 (33.6)	82.8 (32.7)	85.9 (31.7)
	Adults	57.8 (42.3)	90.6 (23.5)	81.2 (30.5)	85.9 (22.8)

condition. Whereas participants chose fewer "same" pictures in the onset substitution condition than in the diminutive condition, $F(1, 62) = 36.799$, $P = 0.0001$, partial $\eta^2 = 0.37$; the prefix and the diminutive conditions did not differ, $F(1, 62) < 1$.

To compare the effects of different types of onset modifications on "similar word" trials, we conducted a two-way ANOVA with age group and onset modification type as between-subjects factors. This ANOVA yielded a main effect of onset modification type, $F(1, 124) = 25.20$, $P = 0.0001$, partial $\eta^2 = 0.17$, with the prefix group (82.0%) selecting more "same" pictures for "similar word" trials with onset modifications than the onset substitution group (49.2%). Age group did not show any significant effects in any of the analyses. Still, to confirm that participants at each age distinguished the two types of onset modification, we conducted analyses of "similar word" trials with onset-modifications for each age group separately. These additional analyses confirmed an effect of onset modification type for children, $F(1, 124) = 20.71$, $P = 0.0001$, partial $\eta^2 = 0.25$, and for adults, $F(1, 124) = 6.46$, $P = 0.014$, partial $\eta^2 = 0.09$, with both groups selecting more "same" pictures in the prefix condition. To explore a possible developmental trend within the group of children, we calculated the correlation between children's age in months and the number of selections of the "same" picture on "similar word" trials with onset modifications. The correlation did not approach statistical significance for children in either group (onset substitution condition, $r(N = 32) = -0.06$, prefix condition, $r(N = 32) = -0.11$), which indicates that preschool children across ages responded similarly.

2.3. Discussion. The main goal of Experiment 1 was to determine whether children would distinguish different types of word-onset modifications that involved (1) substitution of initial consonants or (2) the addition of a prefix. The children's performance was contrasted with adults to explore the extent to which learners of different ages show flexibility in adapting to morphophonological changes that are systematic in the sense that they apply across different nouns, as in the case of the English diminutive derivation.

Across all analyses, children and adults responded similarly to the different experimental conditions: Onset modifications involving novel prefixes were tolerated to a much greater extent than those involving consonant substitutions. That is, *wastug* was a more acceptable variant of *stug* than was *wug*, and it was equally acceptable to the diminutive *stuggy*. This result suggests that children are able to keep track of the underlying base forms (e.g., *stug*), and treat variants that preserve the base forms (e.g., *wastug,* stuggy) differently from those that do not (e.g., *wug*). Thus, both children and adults exposed to the prefixed and suffixed words generally treated both as acceptable variations of the targets, with only a nonsignificant trend favoring the diminutives. The overwhelming tolerance for the prefixed forms suggests that acquisition of morphological knowledge may be achieved after only a short training session (cf. [33], for further evidence of rapid learning of affixes in a study with adults). The lack of a difference in tolerance for prefixed versus suffixed forms was unexpected given findings of Hupp and colleagues [18], where adults judged suffixed word-forms (e.g., *ta-te-be*) to be more similar to targets (e.g., *ta-te*) than the prefixed forms (e.g., *be-ta-te*). To further explore this issue, in Experiment 2 we held constant the morphophonological segment added to the beginning versus the end of a word, to test the effect of position more directly.

3. Experiment 2: Tolerance of Prefixes versus Suffixes

3.1. Method

3.1.1. Participants. Thirty-two children (mean age 4;3, range 3;2–5;1, 17 boys and 15 girls) were recruited and tested at the same schools as in Experiment 1. All of the children were monolingual speakers of English, and none had participated in Experiment 1. Each child received a child-study *t*-shirt for their participation. Thirty-two adult native speakers of English (mean age 22 years, range 18–43 years, 12 men, 20 women) were recruited from psychology classes at a large public university and received research participation credits for their participation.

3.1.2. Materials and Design. The materials and design of the experiment were identical to Experiment 1, with the exception that different novel word-form modifications were introduced. For the word-onset modification, the unstressed, nonce prefix *ko-* was added to the beginning of each noun, and for the word ending modification, the unstressed, nonce suffix, *-ko*, was added to the end of each noun. These modifications were manipulated within participants.

Table 4: Examples of stimuli for novel animal trials in Experiment 2.

Picture	Simplex name	Word-form modification	
		Prefix	Suffix
	*Manse*	*Komanse*	*Manseko*
	*Stug*	*Kostug*	*Stugko*

Examples of stimuli for the novel animal trials are shown in Table 4. Table 5 provides the complete list of stimuli.

3.1.3. Procedure. The procedure was the same as Experiment 1.

3.2. Results. Table 6 presents mean percentages of trials in which participants selected the same animal as the one previously labeled on the introductory page. We analyzed the selection of "same" pictures in "dissimilar word" and "similar word" trials separately, using mixed-type ANOVAs with age group as between-subjects factor and position of modification as a within-subjects factor. The analysis of "dissimilar word" trials (e.g., for *manse*: hearing *kostug* or *stugko*) produced no significant effects. Both age groups rarely selected the "same" animal for the "dissimilar word" trials (see Table 6 for means).

For "similar word" trials involving word-form modifications of previously introduced nouns (e.g., for *stug*: hearing *kostug* or *stugko*), only the main effect of position of modification was significant, $F(1, 62) = 10.19$, $P = 0.002$, partial $\eta^2 = 0.14$. Participants selected the "same" animal more often when *ko* was a suffix (e.g., *stugko*) than when it was a prefix (e.g., *kostug*), 76.6% versus 67.2%. Age group did not show any significant effects in any of the analyses. Nevertheless, to confirm the effect of position of modification at each age we conducted separate analyses: for the children, the effect of position of modification was significant, $F(1, 31) = 6.36$, $P = 0.017$, partial $\eta^2 = 0.17$, whereas for the adults, the effect of position of modification was marginally significant, $F(1, 31) = 3.89$, $P = 0.057$, partial $\eta^2 = 0.11$. Finally, to explore a possible developmental trend within the group of children, we calculated the correlation between children's age in months and the number of selections of the "same" picture on "similar word" trials. A negative correlation approached statistical significance for the prefix condition, $r(N = 32) = -0.31$, $P = 0.08$, and the suffix condition, $r(N = 32) = -0.33$, $P = 0.06$. This pattern of results indicates that older children were somewhat more likely than younger children to select the "different" picture across trials, perhaps due to their greater reliance on a word learning strategy such as ME or N3C.

Table 5: Stimulus words for Experiment 2.

Introductory (simplex) word	Similar word trials		Dissimilar word trials	
	Suffix	Prefix	Suffix	Prefix
Practice trials				
Horse	Horsy		Doggy	
Dog	Doggy		Horsy	
Pig	Piggy		Fishy	
Fish	Fishy		Piggy	
Test Trials				
Gep	Gepko	Kogep	Kazeko	Kokaze
Kaze	Kazeko	Kokaze	Gepko	Kogep
Tuz	Tuzko	Kotuz	Dibko	Kodib
Dib	Dibko	Kodib	Tuzko	Kotuz
Terp	Terpko	Koterp	Vikeko	Kovike
Vike	Vikeko	Kovike	Terpko	Koterp
Stug	Stugko	Kostug	Mansko	Komanse
Manse	Mansko	Komanse	Stugko	Kostug
Pabble	Pabbleko	Kopabble	Rutcherko	Korutcher
Rutcher	Rutcherko	Korutcher	Pabbleko	Kopabble
Dappo	Dappoko	Kodappo	Chitofko	Kochitoff
Chitoff	Chitofko	Kochitoff	Dappoko	Kodappo
Burble	Burbleko	Koburble	Spirtenko	Kospirten
Spirten	Spirtenko	Kospirten	Burbleko	Koburble
Hacket	Hacketko	Kohacket	Jerperko	Kojerper
Jerper	Jerperko	Kojerper	Hacketko	Kohacket

Table 6: Mean percentages of selections of the same animal as on the introductory page, as a function of trial type (dissimilar versus similar word) and condition (prefix versus suffix) in Experiment 2. $N = 32$ in each group (standard deviations in parentheses).

		Prefix (e.g., *kostug*)	Suffix (e.g., *stugko*)
Dissimilar word trials (*manse* on introductory page)	Children	10.9 (27.6)	12.5 (28.4)
	Adults	6.2 (16.8)	6.2 (21.1)
Similar word trials (*stug* on introductory page)	Children	60.9 (41.6)	71.9 (38.0)
	Adults	73.4 (40.1)	81.2 (35.4)

3.3. Discussion. Experiment 2 contrasted children's tolerance of word-form modifications involving prefixes versus suffixes, using the same affix in both positions across nouns. These affixed forms were predominantly interpreted as referring to the same animals as the uninflected introductory forms. Despite this overall bias to accept word-form modifications, participants were more accepting of *ko* when it was a suffix than when it was a prefix. This bias favoring suffixes matches the position effect reported by Hupp et al. ([18], Experiment 1) despite large differences in adults' overall tolerance of the word-form variants across the two studies. In Hupp et al., each word was altered with a unique prefix or suffix, whereas we used the same affix across all items. Our participants picked up on the productive usage of the experimental affix seemingly right away, as we failed to find any effect of trial position in follow-up analyses.

Although Jarvis and colleagues [20] also reported a position effect in a word-learning task, this study compared children's tolerance of word-form variants that had onset-substitutions (e.g., *japple*) with their treatment of suffixed nouns (*shoeler*). To our knowledge, our study is the first to test for a position effect, holding constant the complexity of the affixed material. Our results complement the word recognition studies of Walley [31] that showed that children were more sensitive to modifications involving word onsets than word offsets.

4. General Discussion

This study examined how systematic patterns of word-form variation influence children's ability to map words onto referents. It addressed the question as to whether children and adults treat words with onset substitutions differently from prefixed words, and whether they treat prefixed words differently from suffixed words, using an established experimental framework, a forced-choice label-extension task.

To confirm that children understood the task, a familiar word-form variation (i.e., the diminutive derivation common in child-directed speech) provided the necessary comparison in the first Experiment 1. If the participants rejected the diminutives, it would suggest that the task was not making sense to them. Also, following Jarvis and colleagues [20], on half of the trials, children heard a word totally dissimilar to the previously introduced animal name, in order to establish that the fast mapping mechanism was present. In this respect, the "dissimilar word" condition served as an additional manipulation check that the task was understood. In the "dissimilar word" condition, children were observed to fast map novel word forms onto previously unseen novel animals, in agreement with predictions of ME [6] or N3C [7].

Although English is a language with a relatively impoverished inflectional morphology, the children and adults in our study appeared to readily accept the novel prefixes or suffixes after very limited exposure to the recurring affixes. This result confirms other findings [34–36] that children show some tolerance for multiple words referring to the same referent. Our study adds to these findings by suggesting that language learners are able to track systematic and productive word-form variation across words, and adjust their word-learning strategies to accommodate recurring affixes (see also [33]). In contrast to previous studies using the label-extension task [18, 20], which presented a wide variety of word-form modifications making it impossible to systematically compare the impact of prefixes versus suffixes, or of affixes versus onset substitutions, we observed that adults, as well as children, were able to parse a nonce prefix or suffix from a word and map the stem onto the same referent. This indicates that systematic word-form variation invites greater tolerance than idiosyncratic, random variation.

At the same time, our participants were much less accepting of modifications that involved replacements of word-initial consonants. Previous research [19, 20] has shown that children do not treat words with onset modifications as alternative labels of previously named objects (e.g., *japple* does not mean *apple*), even after training. Our Experiment 1 replicated this general finding that children are more likely to choose a novel object when the initial phoneme was altered than when the word form involved the addition of an affix. Again, the stimuli used in Jarvis et al. [20] used a wide variety of word-form modifications which prevented systematic comparisons of the impact of prefixes versus suffixes, or of affixes versus onset substitutions. Our study provides new insights into this question. Experiment 1 showed that adding a separate syllable to the beginning of the word did not have the same effect as changing the initial consonant. Words with onset substitutions were generally treated as novel nouns, whereas children showed the ability to parse the prefix *wa-* from the word stem and treated the prefixed word as a word form variant just like the diminutive. Thus, in accordance with the cohort model [28], the process of elimination of lexical candidates with shared word beginnings prevents participants from activating lexical items with different word beginnings such as *weetle* as a competitor for *beetle* or, as in this study, *wanse* as a competitor for *manse*. In contrast, in the prefix condition, participants appeared to have been able to parse the prefixes from the word stems which enabled them identify the similar sounding target word. Children's apparent ability to recognize the base forms (stems) of words in variants such as *wastug* or *stuggy* suggests sensitivity to the fact that, in English, stems can occur in multiple positions within complex words. Position-independent identification of word stems has been demonstrated in adults in visual-word recognition tasks [37], but has yet to be demonstrated in children. Representations of suffixes, in contrast to stems, appear to be position (or context) specific, such that interference effects on visual word recognition vary in accordance with the position of a suffix, for example, *shootment* is harder to reject as a nonword than *mentshoot* [38].

Experiment 2 showed that suffixed words were more likely to be accepted as word-form variants than prefixed words, although a similar trend in Experiment 1 failed to reach statistical significance. As discussed earlier, suffixes may create more acceptable word-form variants than prefixes due to their universal tendency to provide cues to grammatical categories, and this may be reflected in the universal "operating principles" that the ends of words are more salient than the beginnings, which have been postulated to guide early language learners [23]. Those principles were supported by the observation that case marking seems to be learned earlier in languages that use suffixes compared to those that use articles to mark case. An alternative to a universal bias is the idea that children's experience with the distributional characteristics of their native language leads them to adapt their word-learning strategies to the morphological and grammatical properties of the language input. Specifically, in English, the native language of our participants, suffixes are more frequent comprising 181 different forms [39] and have broader productivity than prefixes, which comprise only 56 forms and modify a smaller set of word types. Thus, the present results do not allow us to decide whether the observed preference for suffixed over prefixed word-form variants represents a universal word-learning bias or the product of language-specific learning. In future research, the asymmetry between acquisition and acceptance of prefixes versus suffixes should be tested crosslinguistically by examining languages with different distributions of prefixes and suffixes (e.g., Bantu languages). In addition, cross-linguistic comparison should address whether having been exposed to a morphologically rich language is associated with different patterns of word-form tolerance than exposure to morphologically more impoverished languages such as Chinese or, in our case, English. Finally, to test the generality of these findings, future studies should also vary the phonological complexity of the prefixes and suffixes.

The findings presented here suggest that native English-speaking preschool age children and adults tolerate prefixed and suffixed words as labels for familiar referents when the introduced morphological variants are used consistently, as is the case with morphologically productive changes in natural languages. One possibility is that children simply learn to tolerate word-form variants that preserve the base forms of words (e.g., *stug* embedded in *kostug or stugko*) over those that do not (e.g., *wug*)—this possibility requires further testing to determine whether children can readily learn morphological patterns that involve stem changes as well as affixation. Children and adults are much less tolerant of modifications involving initial phonemes, which suggests that the emergence of sensitivity to the structure of words leads to the appropriate adjustment of word learning strategies.

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