

Infants Attention to Affixes

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One of the major language acquisition tasks that infants must accomplish is the development of a lexicon. Developing of the lexicon is a complex task that involves many different components of language: segmenting a group of sounds from fluent speech, mapping this arbitrary set of sounds with meaning, categorizing the word in terms of syntactic roles and breaking morphologically complex words into stems and affixes. This last step of extracting morphemes from words is an important step in word learning, structuring the lexicon and marking grammatical relationships within a sentence. In terms of basic word learning, morphology may aid in segmentation of words and phrases. For example, free morphemes such as *the* or *is* appear at consistent locations within a phrase (at the beginning of the phrase in English) and thus can help mark phrasal boundaries. Bound morphemes are prefixed or suffixed to words, either as inflectional morphemes plural *-s* or *-ing* or as derivational morphemes, e.g., *pre-* or *-ment*, and thus may help in demarcating beginnings or endings of words. In addition, even though languages vary considerably in the degree in which they use morphology, morphology can provide crucial information both for the categorization of words in the lexicon and for marking syntactic relationships. Thus, developing sensitivity to and knowledge of morphemes could greatly aid in both perceiving and structuring incoming speech.

Currently, however, little is known about the perception of bound morphemes in the very early stages of language acquisition. Much of the work in studying the acquisition of morphology has focused on the production of morphology among preschool children (e.g., Berko, 1958; Brown, 1973; Cazden, 1968; Clark, 1998; de Villiers & de Villiers, 1973; Gerken, Landau, & Remez, 1990). This work has shown that children begin using some morphology with their earliest words (between 12 and 20 months), and using systematic morphology during their first year of speech, i.e. by age 2 2-1/2 years (Clark, 1998). Thus, it is apparent that children are able to extract and analyze bound inflectional morphemes from the speech stream sometime prior to the first year of speech, and they are able to use those patterns to actively build morphological paradigms. For derivational morphology, much of the evidence suggests that it is acquired somewhat later than inflectional morphology. For example, children learning English may use some derivational suffixes such as *-er* between two and two and a half, but productive use of derivational morphemes is rare before age 3 (Clark, 1998).

In addition to outlining general developmental trends, production data concerning morphology has suggested that children find it easier to process suffixes than they do prefixes (Clark, 1998). This evidence comes from cross-linguistic studies of polysynthetic languages which mark inflection with both prefixes and suffixes. Data from children learning Mohawk (Mithun, 1989) and K'iche Mayan (Pye, 1992) suggest that children learning these language acquire the ends of words, in particular, the inflectional suffixes earlier than they acquire the inflectional prefixes. In addition, there is experimental evidence showing that

children find nonsense prefixes harder to imitate than nonsense suffixes (Kuczaj, 1979), again suggesting a preference for suffixes over prefixes in early child production.

Currently, however, we do not know whether infants are sensitive to affixes in words. There is evidence that syllable-based units are salient to infants and children. (Bertoncini & Mehler, 1981; Jusczyk, Kennedy & Jusczyk, 1995). In some languages, the syllable and the morpheme boundaries coincide quite closely, and so recognizing recurrent syllables may be a first step in acquiring morphemes. English is such a case where many morphemes are whole syllables. However, not all languages function this way. More synthetic languages, for example, have a mismatch between morphemes and syllables, where one syllable may contain several morphemes. Indeed, evidence from the acquisition of both Mohawk (Mithun, 1989) and K'iche Mayan (Pye, 1983; Pye, 1992) suggest that the first productions of children learning these languages are often final, stressed syllables that often do not correspond to morphemes. Thus, the final syllables of these languages appear to be salient units for children, even though they do not map onto morphemes. Infants cannot know from the outset whether they are learning a language such as English, where morphemes and syllables coincide to a large degree or whether they are learning K'iche, where little such correspondence is present.

At the same time, however, there are some recent results suggesting that extracting recurring patterns at the ends of words may be problematic for infants. Jusczyk, Bauman, and Goodman (1999) examined 9-month-old infants' sensitivity to syllable structure and suggested that infants at this age are most attentive to commonalities that occurred at the beginning of CVC syllables produced in isolation. The infants in this study showed significant preferences for word lists that consisted of shared CV=s or shared initial consonants. In contrast, the infants did not show a listening preference for lists that shared a common rime (VC) or a shared vowel nucleus (V). Goodman, Jusczyk, and Baumann (2000) found parallel results for 14- to 18-month-old infants: the infants attend to common onsets, but not common rime. This suggests that for 9- to 18-month olds at least, the beginning of the syllable is more salient than the end of the syllable.

These results, then, seem to raise a paradox concerning early acquisition of morphemes at the ends of words, i.e. suffixes. There is evidence that infants and young children readily process some suffixes. Yet, 9- to 18-month-old infants are not sensitive to patterns at the ends of syllabic units, the very location where suffixes are likely to be found. These results might suggest that extracting phonological information about suffixes, which also occur at the ends of words, may prove to be problematic as well.

Thus, we still have a number of unanswered questions concerning how infants begin to extract bound morphemes from the speech stream. In particular, the question remains as to whether infants will demonstrate sensitivity to recurrent common syllables, such as those that make up either prefixes or suffixes. In particular, are infants sensitive to suffixes, especially if those suffixes have a whole syllable in common? Note that we are not addressing the complex issue of whether (or how) infants are representing these bound morphemes in their early lexicons. Instead, we are addressing a question concerning more fundamental perceptual abilities: do infants respond to phonological similarities, in particular, the recurrence of whole syllables?

The present study explored 9- to 20-month-old infants' sensitivity to affixes by examining their responses to commonalities present in words with common syllabic affixes. For each experiment, lists of bisyllabic items were constructed so that experimental lists contained items that shared a common element (such as a suffix). The control lists were composed of bisyllabic items which contain no common syllables. We hypothesized that if infants detected a regularity among the items in the experimental lists, such as common suffixed elements, they would listen longer to these lists than to the control lists. Experiments 1, 3 and 4 examined 9- to 20-month old infants' sensitivity to common suffixes, while Experiment 2 examined 9-month-olds sensitivity to prefixes.

Experiment 1

For both perception and production, developmental psycholinguists have consistently hypothesized that word endings are especially important for young language learners. For production, suffixes appear to be acquired more easily than prefixes (Kuczaj, 1979; Mithun, 1989; Pye, 1983), and children produce final syllables more accurately than non-final syllables (Blasdel & Jensen, 1970; Echols & Newport, 1992). Several studies have suggested that young children attend especially to final and stressed syllables of words in their early perception, which leads to more accuracy in their early productions (Blasdel & Jensen, 1970; Echols, 1993; Echols & Newport, 1992). These findings echo Slobin's (1973) classic operating principle for language acquisition: "Pay attention to the ends of words." Thus, final syllables themselves appear to be perceptually important for young learners, even though the 9- to 18-month-old infants in the studies by Goodman et al. (in press) and Jusczyk et al. (to appear) did not attend to the end (rime) in lists of single syllables. Because of this, we begin our investigation by exploring whether infants are sensitive to common suffixes.

In order to explore this question, we used the Headturn Preference Procedure (HPP) to test 9-month-old infants with lists of bisyllabic nonsense words. Nine-month-olds were chosen for the initial study because of previous work indicating that infants at about this age have begun to display sensitivity to the language specific phonetic properties of both free functor morphemes and sound patterns (e.g., Shady, 1996; Shafer et al., 1998). Thus, it is conceivable that infants of this age will also demonstrate sensitivity to commonalities found with suffixes that consist of whole syllables.

During the course of the experiment, the infants heard two types of lists. Half of the lists (Suffixed lists) contained a nonsense syllable followed by a common suffix, whereas the other half (Control lists) contained two nonsense syllables which varied with each word. We hypothesized that if infants attend to the presence of a common suffix element in the items, then they should show a significant listening preference for the Suffixed lists over the Control lists.

Method

Participants. The participants were 24 American infants (11 males, 13 females). Each of the infants in this experiment, and in all succeeding ones, was an American infant from

monolingual English-speaking homes. The infants were approximately 9 months old, with a mean age of 39 weeks, 5 days (range 34 weeks, 2 days to 42 weeks, 3 days). In order to obtain data from 24 infants, 26 infants had to be tested. The data from the additional infants were excluded for the following reason: experimental failure (2).

Stimuli. A female, native American English speaker recorded 16 lists of 12 bisyllabic nonsense words. The initial syllable in all cases was a nonsense syllable with a CVC pattern. The final syllable was either an English suffix or another nonsense syllable. Eight of the lists contained an initial CVC nonsense syllable followed by repetitions of a suffix (-er, -ful, -hood, -ish, -ing, -ment), while the remaining 8 Control lists contained two nonsense syllables, with the final syllables matched for syllable shape with the Suffixed list. For example, in the foil Control matched to the Suffixed list with -er, the second syllables all had the shape VC, while in the Control list matched to the Suffix list -ful the second syllables were all CVC. Both the Suffixed and Control lists were produced with stress on the initial syllable, as is common for English bisyllabic words using suffixes. Examples of Suffixed and Control lists are shown in Table 1.

Table 1: Examples of Suffix and Control Lists

(Stimuli given narrowly transcribed in International Phonetic Alphabet)

Suffixed List #2	Control List #2	Suffixed List #4	Control List #4
[zʌg]-ful	[mæz-lʌf]	[kowz]-ish	[tijb-uk]
[dʌz]-ful	[tuwk-mawp]	[tajɔ]-ish	[mawɔ-n]
[bowm]-ful	[gijɔ-nob]	[nʌs]-ish	[zajn-ɔb]
[gajn]-ful	[nejʌ-kær]	[*uwig]-ish	[bojg-ɔf]
[mæf]-ful	[ɔɔ*-dajt]	[puwm]-ish	[pʌm-ajd]
[tuwp]-ful	[*ajn-rɔm]	[gʌk]-ish	[sɔz-awt]
[ɔb]-ful	[sɔp-pɔs]	[bæf]-ish	[gowp-ojl]
[kij*]-ful	[bojm-sif]	[dɔ*-ish]	[*æʌ-æs]
[*ejv]-ful	[dowb-bojn]	[fawp]-ish	[dʌ*-owr]
[fojs]-ful	[kɔd-gɔl]	[vojn]-ish	[nɔk-um]
[nɔk]-ful	[zawk-teg]	[mijd]-ish	[ɔowd-ep]
[vawt]-ful	[pʌg-fud]	[ɔɔt]-ish	[vuwt-ijg]

Design and Procedure. Infants were tested with the Headturn Preference Procedure (HPP). Each infant was seen for one experimental session. Each infant heard the same set of four stimulus lists (2 Suffixed and 2 Control) during the practice phase. The order of presentation for the 12 test lists (6 Suffixed and 6 Control) was randomized for each subject, as was the side of presentation for each list. A session was completed when the infant received all 12 test lists.

Results. Mean listening times to the Suffixed and the Control lists were calculated for each of the 24 subjects. The mean listening times were averaged for the Suffixed lists and the Control lists. Across all subjects, the average listening times were 9.20 sec. (SD = 5.22 sec.)

for the Suffixed lists and 7.95 sec. (SD = 4.96 sec.) for the Control lists. There was a mean difference between the Suffixed and Control lists of -0.18 sec. A paired t-test indicated that this difference in average listening times was not significant ($t(23) = -.398, p > .69$).¹

In contrast to early reports about the importance of word final syllables in the early productions of older language learners, the results of this experiment indicate that 9-month-olds in the present study were not attentive to the occurrence of a common suffix across different items in a list.

These results have several possible explanations. One is that infants of this age do not attend to similarities in unstressed syllables, but only in stressed ones. (The syllables in Mohawk and K'iche that children extract for production are final, stressed syllables (Mithun, 1989; Pye, 1983; Pye, 1992). A second interpretation is that 9-month-old infants do not attend to similarities in suffixes because they are not developmentally tuned into the ends of words. Thus, it is possible that only older infants or children who have begun to acquire the syntactic organization of the language will attend to word final morphemes.

To explore these two possibilities, we conducted further experiments. Experiment 2 examines 9-month-old infants' sensitivity to similarities in unstressed initial syllables, while Experiments 3 and 4 examine older infants (14- and 20-months, respectively) sensitivity to similarities in suffixes.

Experiment 2

There is considerable evidence that initial onsets are highly salient portions of syllables for infants and young children as well as adults. Perception studies (Jusczyk et al., 1999) have demonstrated that 9- to 14-month infants demonstrate sensitivity to similarities in initial onsets of single syllable words. For older children, (Cole, 1981) has found that 4- to 5-year-old children are more accurate at identifying mispronunciations at the beginnings of words than at the ends of words. Because of this, it is possible that although 9-month-old infants did not demonstrate sensitivity to similarities in the final unstressed syllables of nonsense words, they will demonstrate sensitivity to the similarities in the unstressed initial syllables in bisyllabic words. At the same time, the fact that this syllable is unstressed may make it harder for 9-month-olds to detect the similarities in the initial syllable. There is evidence that infants learning English prefer lists of words where stress falls on the initial syllable, over lists that have initial unstressed syllables (Jusczyk et al., 1993). Thus, it is possible that 9-month-old infants will not attend to the similarities in these initial prefixes because they are unstressed.

In order to explore these questions, we used the Headturn Preference Procedure (HPP) to test 9-month-old infants with new lists of bisyllabic nonsense words. Half of the lists (Prefixed lists) contained a common, unstressed prefix followed by a nonsense syllable, whereas the other half (Control lists) contained two nonsense syllables which varied with each word. We hypothesized that if infants attend to the presence of a common prefixed element in the items, then they should show significant listening preference for the Suffixed lists over the Control lists.

¹ See Excel file "Affixdata, 9 mo suffix" for these data.

Method

Participants. The participants were 24 American infants (13 males, 11 females) from monolingual English-speaking homes. The infants were approximately 9 months old, with a mean age of 40 weeks, 2 days (range 38 weeks, 5 days to 42 weeks, 1 day). In order to obtain the 24 infants, 30 infants were tested. Infants were excluded for the following reasons: equipment failure (1), fussiness (1), parental interference (2), and unresponsiveness to the flashing lights (2).

Stimuli. A female, native American English speaker recorded 16 lists each with 12 bisyllabic nonsense words. The initial syllable of each nonsense word was either an English prefix or a nonsense syllable and the final syllable in all cases was a nonsense syllable with a CVC pattern. The 8 Prefixed lists contained the same prefix repeated for each word in the list (*re-*, *pro-*, *dis-*, *con-*, *un-*, *sub-*, *ex-*, *bi*) while the other 8 Control lists contained a nonsense syllable as the initial syllable in each word. Both the Prefixed and Control lists were produced with an unstressed initial syllable and a stressed final syllable. Examples of Prefixed and Control lists are shown in Table 2.

Table 2: Examples of Prefix and Control Lists

(Stimuli given narrowly transcribed in International Phonetic Alphabet)

Prefixed List	Control List
pro-[fijb]	[voj-kejz]
pro-[kʌf]	[sowk-bojp]
pro-[dæs]	[nowf-tæz]
pro-[g·v]	[grij-h☆n]
pro-[bawp]	[ejd-mowt]
pro-[hejz]	[hʌ-nuwd]
pro-[tojn]	[ij★-dʌf]
pro-[sow★]	[powb-fajg]
pro-[nuwk]	[lajz-sow★]
pro-[m☆g]	[av-grijb]
pro-[pajt]	[sluw-★♦k]
pro-[★♦d]	[mʌg-puwv]

Design and procedure. These were identical to Experiment 1.

Results. Mean listening times to the Prefixed and the Control lists were calculated for each of the 24 subjects. The mean listening times were averaged for the Prefixed lists and the Control lists. Across all subjects, the average listening times were 9.20 sec. (SD = 5.22 sec.) for the Prefixed lists and 7.95 sec. (SD = 4.96 sec.) for the Control lists. There was a mean difference between the Suffixed and Control lists of 1.25 sec. A paired t-test indicated that

this difference in average listening times was significant ($t(23) = 2.533$, $p < .02$). These results indicate that 9-month-olds listened significantly longer to lists with common initial syllables. Because the initial syllables in this study were unstressed, this result suggests that infants are sensitive to commonalities in some unstressed syllables.²

When coupled with Experiment 1, these results suggest that 9-month-old infants are responding to the similarities between common prefixes but not to similarities between common suffixes. To provide further statistical confirmation of this observation, we performed a one-way ANOVA on the difference scores (avg. listening times for Experimental lists - avg. listening times for Control lists) from the first two experiments. A significant effect was found for Affix Type (Prefix vs. Suffix), $F(1, 46) = 4.331$, $p < 0.04$.

Thus, it appears that the infants are responding more to the similarities between common prefixes than they are to similarities between common suffixes. This suggests that our results in the first experiment were not due to the failure of 9-month-olds to detect similarities in unstressed syllables. Rather, it appears that position (word initial vs. word final) plays a larger role than stress in 9-month-olds' sensitivity to similarities in common affixes. 9-month-olds do show sensitivity to similarities in initial unstressed syllables (prefixes), but not final unstressed syllables (suffixes).

Experiment 3

The results from experiments 1 and 2 suggested that it was the position of the repeated syllable, rather than the lack of stress, that determined whether or not 9-month-olds would demonstrate sensitivity to similarities in the suffix. Because of this, we turn to our second possible explanation for 9-month-olds lack of sensitivity to repetition in suffixes, namely that 9-month-olds did not show sensitivity to suffixes because they are not yet attending to the ends of words or final syllables. There is evidence from a variety of sources that suggests that 9-month-olds are beginning to comprehend some words (e.g., Benedict, 1979) and build a lexicon (Jusczyk, 1997; Jusczyk & Aslin, 1995), but there is little evidence that infants of this age are attentive to the morphosyntactic relationships within in the language (Shady, 1996). Indeed, many of the claims about sensitivity to ends of words have been posited to account for morphological learning among slightly older children, (Peters, 1983; Slobin, 1973). Thus, it may be that attention to commonalities in final syllables develops just prior to or just as children are beginning to develop knowledge about the morphosyntactic relationships within the sentence.

To explore this possibility, we tested 14-month-old infants for their sensitivity to common suffixes in English. We chose 14-month-olds because while 14-month-old infants are not generally reported to use words in combination, there is growing evidence that infants of this age are beginning to pay attention to the structure of sentences. For example, Hirsh-Pasek & Golinkoff (1996) found that 14-month-infants were able to use constituent structure in interpreting sentences. This in turn raises the possibility that infants of this age may be

² See Excel file, "Affixdata, 9 mo prefix2 for these data".

beginning to pay attention to those parts of words, such as suffixes, that are important for marking these kinds of relationships. Because of this, we tested 14-month-old infants on the Suffixed and Control lists. Once again, we hypothesized that if the infants are sensitive to the similarities in repeated suffixes, then they should look longer for the Suffixed lists than the Control lists.

Method

Participants. The participants were 24 American infants (12 males, 12 females) from monolingual English-speaking homes. The infants were approximately 14 months old, with a mean age of 60 weeks, 3 days (range 58 weeks, 3 days to 62 weeks, 6 days). In order to obtain data from 24 infants, 28 were tested. Infants were excluded for the following reasons: crying or fussiness (3), and unresponsiveness to the flashing lights (1).

Stimuli, design, apparatus and procedure. These were identical to Experiment 1.

Results. Mean listening times to the Suffixed and the Control lists were calculated for each of the 24 subjects. The mean listening times were averaged for the Suffixed lists and the Control lists. Across all subjects, the average listening times were 8.26 sec. (SD = 2.12 sec.) for the Suffixed lists and 7.83 sec. (SD = 2.88 sec.) for the Control lists, Figure 2. There was a mean difference between the Suffixed and Control lists of 0.43 sec. A paired t-test indicated that this difference in average listening times was not significant ($t(23) = .950, p > .35$).³

These results suggest that as with 9-month-olds in Experiment 1, 14-month-old infants are not sensitive to repetitions of suffixes. These results parallel results found by (Goodman et al., 2000) which found that neither 9- nor 14-month-old infants demonstrated sensitivity to lists with common rime (e.g., *bod, lod, zod, vod*).

Experiment 4

Neither 9- nor 14-month-old infants demonstrated sensitivity to repetitions in common suffixes. This leaves unanswered, however, the question of when sensitivity to common suffixes might develop. It is possible that this sensitivity to suffixes does not develop until the infants lexicon has become more robust or at a time when children are beginning to get ready to produce word combinations themselves. There is growing evidence that children who are 18- to 20-months of age are becoming sensitive both to syntactic structure and to the function of inflectional affixes within English. It has been shown that 17-20 month olds are sensitive the order of noun phrases for determining syntactic roles, (Gleitman, 1990; Hirsh-Pasek & Golinkoff, 1996; Naigles, 1990), demonstrating general sensitivity to syntactic structure. In terms of sensitivity to the role of functional affixes in English, Santelmann and Jusczyk (1998) found that 18-month-old infants demonstrate

³ See Excel file "Affixdata, 14 mo suffix" for these data.

sensitivity to the fact that *is* and *-ing* co-occur in English sentences, and Golinkoff, Hirsh-Pasek and Schweisguth (2001) found that 18-month-old infants show a preference for *-ing*, but not *-ly* or *-lu* at the end of verbs.

These studies show that by 18-20 months, infants are sensitive to general syntactic relationships and are furthermore beginning to show knowledge of some inflectional morphology in English in both perception and production. Thus, if sensitivity to repetitions in suffixes in general develops together with developing sensitivity to inflectional morphology, then it is possible that 20-month-old infants will demonstrate sensitivity to the repetition in suffixes where 9- and 14-month-old infants did not. Because of this, we tested 20-month-old infants for their sensitivity to repetitions in suffixes. Once again, we hypothesized that if the infants are sensitive to the similarities in repeated suffixes, then they should look longer for the Suffixed lists than the Control lists.

Method

Participants. The participants were 24 American infants (13 males, 11 females) from monolingual English-speaking homes. The infants were approximately 20 months old, with a mean age of 87 weeks, 2 days (range 85 weeks, 0 days to 89 weeks, 4 days). In order to obtain the 24 infants for this study, 29 were tested. Infants were excluded for the following reasons: crying (4), and unresponsiveness to the flashing lights (1).

Stimuli, design, apparatus and procedure. These were identical to Experiment 1.

Results. Mean listening times to the Suffixed and the Control lists were calculated for each of the 24 subjects. The mean listening times were averaged for the Suffixed lists and the Control lists. Across all subjects, the average listening times were 7.45 sec. (SD = 2.66 sec.) for the Suffixed lists and 7.06 sec. (SD = 3.28 sec.) for the Control lists. There was a mean difference between the Suffixed and Control lists of 0.39 sec. A paired t-test indicated that this difference in average listening times was not significant ($t(23) = .785, p > .44$).⁴

Discussion. As with infants at younger ages, these results suggest that the 20-month-olds did not display a significant preference for the Suffixed lists over the Control Lists. However, even though there is no significant difference within any of the ages, it is possible that there is a developmental change going on in how infants are responding to these stimuli. In particular, because the 9-month-olds showed a slight, insignificant preference for the Control lists and the 14- and 20-month-olds showed a slight, insignificant preference for the Suffixed lists, it is possible that there is a developmental shift toward the ends of words. To explore this possibility, a one-way ANOVA was conducted on the difference scores with age-group as a between group factor. This test revealed no significant difference between groups, $F(1, 69) = .531, p > .59$. This suggests that sensitivity to the suffixes does not change between 9- and 20- months.

⁴ See Excelfile "Affix data, 20 mo suffix" for these data.

The results from all four studies are summarized in Table 3 below.

Table 3: Summary data for Affix Studies

Study	Natural (Std Dev)	Unnatural (Std Dev)	Difference (Std Dev)	t-statistic	p-value
9 suffix	8.739 (2.781)	8.922 (2.417)	-0.183 (2.254)	t(23) = -.398	0.6947
9 prefix	9.196 (5.223)	7.949 (4.964)	1.248 (2.413)	t(23) = 2.533	0.0186*
14 suffix	8.260 (2.120)	7.829 (2.876)	0.431 (2.22)	t(23) = .950	0.3519
20 suffix	7.453 (2.658)	7.06 (3.276)	0.393 (2.455)	t(23) = 1.044	0.3074

* = significant at the 0.05 level

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