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6–month–olds are sensitive to English morphology

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Abstract

Each language has its unique way to mark grammatical information such as gender, number and tense. For example, English marks number and tense/aspect information with morphological suffixes (e.g., *-s* or *-ed*). These morphological suffixes are crucial for language acquisition as they are the basic building blocks of syntax, encode relationships, and convey meaning. Previous research shows that English-learning infants recognize morphological suffixes attached to nonce words by the end of the first year, although even 8-month-olds recognize them when they are attached to known words. These results support an acquisition trajectory where discovery of meaning guides infants' acquisition of morphological suffixes. In this paper, we re-evaluated English–learning infants' knowledge of morphological suffixes in the first year of life. We found that 6–month–olds successfully segmented nonce words suffixed with *–s*, *–ing*, *–ed* and a pseudo-morpheme *-sh*. Additionally, they related nonce words suffixed with *–s*, but not *-ing*, *-ed* or a pseudo-morpheme *–sh* and stems. By 8–months, infants were also able to relate nonce words suffixed with *–ing* and stems. Our results show that infants demonstrate knowledge of morphological relatedness from the earliest stages of acquisition. They do so even in the absence of access to meaning. Based on these results, we argue for a developmental timeline where the acquisition of morphology is, at least, concurrent with the acquisition of phonology and meaning.

KEYWORDS

infants, morpheme based models, morphological acquisition, segmentation, verbs, whole word models

1 | INTRODUCTION

Acquiring any language involves discovering its smallest meaningful units, i.e., morphemes. In this paper, we present research to address how infants discover the basic building blocks of syntax - grammatical morphemes that attach to other morphemes to signal number, tense and aspect. The grammatical morphemes of English involve a small, yet critical set of suffixes like *–s*, *–ed*, and *–ing*. When and how do infants first learn such morphological suffixes?

Classic research has established that English-learning infants start producing morphological suffixes between 18 and 24–months (e.g., Brown, 1973; de Villiers & de Villiers, 1973). Around this time, children are also sensitive to morphosyntactic agreement; e.g., they listen longer to grammatical English sentences where *is* is followed by verbs ending in the suffix *-ing* but not ungrammatical ones where *can* is followed by verbs ending in the suffix *-ing* (e.g., Golinkoff et al., 2001; Hirsh-Pasek & Golinkoff, 1996; Santelmann & Jusczyk, 1998; Soderstrom, 2002; Soderstrom et al., 2002, 2007; Van Heugten & Christophe, 2015; Van Heugten & Johnson, 2011; Van Heugten & Shi, 2009).

Even before producing them, infants show some knowledge of morphological suffixes. In perception experiments, English–learning 7.5–month–olds use the suffix *–ing* to segment frequent, familiar words *kiss*, *give*, *drink* and *walk* from sentences (Willits et al., 2014; but not nonce words, Willits p.c.). Testing infants with nonce words, however, shows a different timeline of development; 15– but not

Author order is alphabetical; both authors contributed equally to the paper.

8-month-olds show a preference for lists of nonce stems after being familiarized with those same stems suffixed with *–ing*, but not a pseudo-morpheme *-dut* (Mintz, 2013). That is, early in development, infants' knowledge of morphological suffixes seems item-specific, not abstract, only later generalizing to nonce words (for similar results in Hungarian, see Ladányi et al., 2020).

This developmental time course, where infants demonstrate knowledge of morphology first in the context of familiar words only later generalizing to nonce words, is consistent with *whole word* models (cf. Plunkett & Marchman, 1993; Tomasello, 2000). Whole word models have been quite successfully applied to predict the acquisition trajectory of children's past tense production (e.g. Bybee, 1995; Joanisse & Seidenberg, 1999; Rumelhart & McClelland, 1986). Most recently, Baayen et al. describe morphological learning as an epiphenomenon; specifically they propose that infants discover suffixes like *–s* and *–ing* incidentally, during the course of learning overlapping phonological forms and their meanings (Baayen et al., 2015; Ramscar et al., 2013, 2018). Because morphemes are not independently represented in such models, early knowledge of morphology is item-specific, not abstract. Additionally, before the acquisition of meaning, morphological relatedness of pairs like *win-wins* is indistinguishable from relatedness based on phonological form alone, like in *win-winch*.

An alternative proposal has infants constructing abstract linguistic representations based on the distributional regularities in their input from the earliest stages of acquisition. In these *morpheme* based models, individual grammatical suffixes themselves are represented in the mental lexicon (Pinker, 1999; Pinker & Prince, 1988; Pinker & Ullman, 2002). Thus, infants may demonstrate knowledge of the combinatorial properties of individual morphemes, as they are learning multiple words with overlapping form, *before* they learn their meanings. Therefore, the ability to combine individual morphemes is not item-specific (i.e., restricted to familiar words) in early acquisition. Crucially, in these models, morphological relatedness (*win–wins*) is quite distinct from relatedness based on phonological form alone (*win–winch*).

Marquis and Shi's (2012) experiments on French–learning infants provide evidence for the plausibility of morpheme based models. They show that 11–month–olds familiarized with nonce stems listened significantly longer to sentences where the nonce stems were suffixed with the highly frequent and familiar French suffix *–e*. However, 11–month–olds failed to listen longer when the nonce stems were suffixed with the pseudo–morpheme *–u*, unless they were pre–exposed to nonce forms inflected with *–u* for 2 minutes. Thus, Marquis and Shi demonstrate 11-month-olds' knowledge of suffixes even when presented in the context of nonce words. Based on these results, they argue that infants' knowledge of suffixes is abstract at 11 months, and that infants can learn forms of suffixes without access to meaning.

Because Marquis and Shi used nonce words, we can be sure that French–learning 11–month–olds generalized the suffix *–e* to instances they had not previously encountered. This is consistent with Marquis and Shi's claim that French-learning infants' knowledge of morphological suffixes at 11-months is abstract and productive. However, we know from parent reports that over 50% of French–learning 11–month–olds understand at least 3 verbs with the *–e* suffix; in fact, a third of the infants understand about 10 verbs with this suffix (Trudeau & Sutton, 2011; by–word norms retrieved from Wordbank http://wordbank.stanford.edu/). Thus, in the absence of data from younger infants, Marquis and Shi's results are equally compatible with whole word models where infants learn to use suffixes with familiar words first and generalize it to novel words later in development, i.e., by 11–months.

Research Highlights

- At 6 months, English-learning infants segment suffixed nonce words from fluent speech
- They relate stems and nonce words with *-s* not *-ing*, *-ed* or pseudo-morpheme *–sh*
- At 8 months, they relate stems and nonce words with *–ing*
- English-learning infants are sensitive to morphology starting at 6-months
- From the earliest ages, morphological and phonological relatedness are distinct
- Infants detect morphological relatedness even in the absence of access to meaning

At its core what distinguishes whole word and morpheme based models is whether or not morphological–relatedness is distinct from phonological–relatedness, before the acquisition of meaning. Under whole word accounts, morphological relatedness is *not* different from phonological overlap before the acquisition of meaning. In contrast, under morpheme based accounts, morphological relatedness is distinct from phonological overlap even before infants have access to meaning.

In this paper, we present five experiments with English learning 6- and 8-month-olds to address the following questions: What is the developmental trajectory of English-learning infants' sensitivity to morphological suffixes? What is the role of meaning in acquisition of morphological suffixes? Is morphological relatedness different from phonological overlap before infants have access to meaning? Is knowledge of morphology item-specific or abstract from the outset? We use the results from these experiments to arbitrate between whole word and morpheme based models in order to identify the representations and mechanisms implicated in morphological acquisition.

2 | PART I: WHOLE WORD OR MORPHEME BASED MODELS?

2.1 | Experiment 1: Can 6–month–olds segment inflected words?

In Experiment 1, as a precursor to testing infants' acquisition of morphology, we wanted to establish that 6–month–olds can segment words inflected with all three English suffixes, *–s*, *–ing* and

–*ed*. We also tested them with a pseudo suffix –*sh*. We chose to test 6–month–olds because it is the earliest age at which English–learning infants have been shown to successfully segment words (Bortfeld et al., 2005; Johnson et al., 2014).

However, any comparison of infants' ability to segment words inflected by English –*s*, –*ing* and –*ed* is complicated by the fact that –*s* is most often a plural suffix on nouns, whereas both –*ing* and –*ed* are used predominantly to inflect verbs. Testing infants as young as 6-months was one way to mitigate the effects of differences in word class associated with these suffixes. Cross-linguistically, infants have been shown to display knowledge of word class at 12 months or later (e.g., Bernal et al., 2010; Echols & Marti, 2004; Golinkoff & Hirsh-Pasek, 2008; Höhle et al., 2004; Mintz, 2006; Waxman & Gelman, 2009; see He & Lidz, 2017 for the most recent review). There is no evidence that 6-month-olds have any knowledge of word class.

Nonetheless, the extant developmental research shows a substantial delay in young infants' ability to segment and assign meanings to verb forms compared to noun forms. English-learning infants have been reported to segment nouns at 6–month (Bortfeld et al., 2005; see also Mersad & Nazzi, 2012 for similar results in French) but verbs only at 13–months (Nazzi et al., 2005). Some of this difficulty is likely rooted in that, unlike English nouns, verb forms tend to be in the middle of sentences, not in the salient beginnings and ends. Further, verb forms are less likely to attract phrasal stress compared to nouns (Conwell, 2017; Nespor & Vogel, 1986; Watson et al., 2006). Finally, the phonological properties of verb and noun forms differ systematically, particularly their stress patterns (Kelly & Bock, 1988) and phonotactics (Albright, 2008; Berg, 2000; Sereno & Jongman, 1990), such that verb forms tend to be less typical compared to noun forms (Black & Chiat, 2003). Consider for instance, that nouns, but not verbs in English have the canonical stress-initial pattern.

It is also very difficult for infants to assign meaning to verb forms (see Golinkoff & Hirsh-Pasek, 2006 for a review). Verbs are less concrete (Snedeker & Gleitman, 2004); they label complex transitory events (Gentner, 1982), often between nouns (Hirsh-Pasek & Golinkoff, 1996); and verb meanings are less restricted than that of nouns . In fact, recent research shows that infants as young as 6–months know the meanings of many more noun forms than verbs (Bergelson & Swingley, 2012).

The difference in the word class associated with plural –*s* and –*ing* and –*ed* thus, poses a potential challenge when comparing infants' acquisition of morphological suffixes, even at 6-months. We controlled for this confound by using stimuli where –*s* was used as the 3rd singular verbal suffix, not plural. This allowed us to present all three suffixes with verb forms. But recall that English-learning infants have been shown to segment verbs only at 13-months (Nazzi et al., 2005). To provide 6–month–olds optimal conditions to demonstrate segmentation of inflected words, we made two modifications that have been successful in facilitating infants' segmentation. First, nonce target words were placed immediately adjacent to the highly familiar word *Mommy*/*Mama*, a context known to facilitate segmentation of adjacent nouns, cross–linguistically (Bortfeld et al., 2005; Mersad & Nazzi, 2012). Second, all nonce words were used intransitively. Corpus counts show that this is the most common verbal form in speech directed to infants (Kim, 2015). Crucially, this allowed us to place half of the nonce target words at the ends of sentences. Edge aligned, i.e., sentence–initial or sentence–final, words are acoustically and perceptually salient. In fact, nouns in sentence–final and/or sentence–initial position are segmented earlier when compared to nouns in sentence–medial positions (Seidl & Johnson, 2006, 2008).

As a control, in addition to testing infants' segmentation of words suffixed with –*s*, –*ing* and –*ed*, we also tested whether 6-month-olds could segment words suffixed with a pseudo-morpheme –*sh*. Infants have no experience with this pseudo-morpheme, and no access to its meaning. We picked –*sh* as the pseudo-morpheme for two reasons. First, both –*s* and –*ed* are typically produced as a single phoneme [–*s*, or –*z*, or –*t* or –*d*], so we wanted the pseudo-morpheme to be a single phoneme. Second, we wanted to be sure that infants could clearly hear the pseudo-morpheme at the ends of words. At the ends of words, stop consonants like [–*p*, –*k* and –*b*, –*g*] are not only acoustically less salient, but also confused quite often by adults (Wang & Bilger, 1973), with each other, and with English suffixes [–*s*, –*z* and –*t*, –*d*]. In contrast, –*sh*, the only other voiceless sibilant in English besides –*s*, is loud, and as a result, confused by adults much less often with either [–*s*, –*z*] or [–*t*, –*d*] at the ends of words (Wang & Bilger, 1973). Thus, –*sh* was selected for its auditory and perceptual properties.

Suffixing a nonce word that ends in a consonant with –*sh* however, creates words like *babsh* that are phonotactically illegal in English. More generally, adding any single phoneme to the end of nonce words typically creates consonant clusters that are illegal in English. We did not expect the illegal clusters themselves to hinder 6–month–olds' ability to segment words because there is little evidence to suggest that English learning 6–month–olds are sensitive to phonotactics (Jusczyk et al., 1994; however see also Ferry et al., 2016 or Benavides-Varela & Mehler, 2015 for some evidence that Italian-learning infants might be sensitive to word edge syllables). Nonetheless, to confirm that infants did not treat illegal sequences like *babsh* any differently than legal sequences like *babs*, we also tested 6–month–olds' ability to segment words suffixed with the pseudo-morpheme –*sh*. We reasoned that infants should successfully segment forms like *babsh* as long as their performance is not disrupted by the illegal consonant cluster at its end.

To test infants, we familiarized 6-month-olds with two suffixed nonce words embedded in sentences. Then, we presented them with four isolated, suffixed forms - two familiar and two novel. If English-learning 6-month-olds can segment verb forms, they should listen significantly longer to familiar compared to novel suffixed nonce words, as has been typically reported in word segmentation studies with natural language stimuli.

2.1.1 | Participants

The final sample included data from 120 (30 per suffix; 54 female) 6-month-olds (mean = 183 days; range 155–203). Participant profiles are summarized in Table 1. We estimated infants' language exposure from a parental language questionnaire (Sundara & Scutellaro, 2009). Only data from infants who had at least 90% of their language input in English were included. Further, based on parental reports, none of the infants had a history of speech, language, or hearing difficulties, and were in good health on the day of testing. Additional infants were tested but their data were discarded without further analysis due to fussiness (n = 22), parental interference (n = 2), having a cold or ear infection on the day of testing (n = 2), technical difficulties (n = 2) or because neither *mommy* nor *mama* was used consistently with the baby (n = 6).

2.1.2 | Stimuli

The four CVC nonce target words used in all five experiments were *bab*, *dop*, *kell* and *teep*. These words were created to have different vowel qualities. Also, two of the four final consonants were voiceless (in do*p* and tee*p*) and the other two were voiced (ba*b* and ke*ll*), and crucially no words ended in sibilants (e.g., –*s*, –*z*, –*sh*). This is because the English suffix –*s* is realized in three different ways ([s], [z], [əz]). Words ending in sibilants are suffixed with the [əz] allomorph; we avoided them because the complete syllable allomorph [əz] is likely to be perceptually more salient than the segmental allomorphs [s] or [z]. We also deliberately avoided using [t] and [d] as final consonants because in American English these words have an additional syllable when conjugated with the past tense ([ɪd]).

We recorded four six–sentence passages, each containing one of the four nonce target words suffixed with either –*s*, –*ed*, –*ing* or the pseudo-morpheme –*sh*. Each passage had a *mommy* and a *mama* version – where the suffixed word was preceded by the known word *mommy* or *mama*. Infants were tested on either the *mommy* or the *mama* version depending on the form used regularly in the infant's home. The sample passages used for testing are presented in the Appendices A, B and C. We also recorded 15 repetitions of each isolated suffixed word as well as the stem. These were concatenated with an inter–stimulus interval of about 600 ms to create 4 lists of suffixed words each for –*s*, –*ed*, –*ing* and –*sh*, as well as 4 lists of the stems *bab*, *dop*, *kell* and *teep*.

The stimuli were recorded by a 25–year–old female native English speaker from Southern California who was not familiar with the purpose of the study. She was instructed to read the words and passages in an animated voice as if talking to a pre–verbal infant. The stimuli were recorded in a soundproof booth using a Shure SM10A head–mounted microphone. All stimuli were digitized at a sampling frequency of 22,050 Hz and 16–bit quantization.

For the passages, the average duration was 22.1 s (SD = 0.8), and the average pitch was 243.3 Hz (range 92–424). The intensity of the passages was equalized to 75 dB. The average duration of nonce target words was 592 ms (SD = 138) in the passages and 740 ms (SD = 74) in the lists. The average pitch of nonce target words was 213 Hz (SD = 38) in the passages and 239 Hz (SD = 74) in the lists. The average intensity of the nonce target words was 76.5 dB (SD = 2.4) in the passages and 80.1 dB (SD = 2.6) in the lists. All the measurements and analyses were done using PRAAT (Boersma & Weenink, 2013). The average loudness level for stimuli during playback was 73 dB.

2.1.3 | Procedure & design

The Headturn Preference Procedure was used to test infants (Jusczyk & Aslin, 1995; Kemler-Nelson et al., 1995). Infants sat on their caregiver's lap in the center of a three–sided booth. On each side panel, a red light was located at eye level. A green light was mounted on the center panel at eye level and a camera was mounted above the green light behind this panel. The experimenter observed the infant through a monitor connected to the camera. The experimenter recorded the direction and duration of the infants' head turns, which determined the presentation of the speech stimuli. Both the caregiver and the experimenter wore Peltor noise cancelling headphones that delivered masking music so that they could not influence the infants' behavior. Infant looking time to the flashing lights recorded by the computer program was used as a proxy for listening time.

Each trial began when the green light on the center panel flashed. Once the infant oriented towards the center panel, one of the red lights on the side panels began to flash. When the infant turned her head towards that light, auditory stimuli began to play. Stimulus presentation

TABLE 1 Profile of participants used in Experiments 1–5.

Experiment	Infants in final sample (n = 30/suffix)	Average age (range)	Average English exposure (range)	Attrition
1	120 (54 female)	183 days (155:203)	99% (90:100)	34
2	120 (60 female)	181 days (164:206)	99% (90:100)	19
3	120 (55 female)	183 days (165:199)	98% (90:100)	9
4	30 (18 female)	249 days (235:259)	99% (90.4:100)	1
5	30 (12 female)	243 days (221–257)	90% (90:100)	12

continued until the infant looked away from the flashing light for more than two consecutive seconds or until the end of the trial.

In Experiment 1, infants were familiarized with two suffixed nonce words (e.g., either *babs*, *dops* or *kells*, *teeps*, counterbalanced) embedded in passages till they accumulated 45 s of listening time to each. Then, in the test phase, they were presented with familiar and novel, isolated, suffixed words (*babs*, *dops*, *kells* and *teeps*) in three blocks for a total of 12 trials. As is typical, significantly greater listening time to familiar compared to novel trials was interpreted as evidence of segmentation.

2.1.4 | Analyses

Listening time data were analyzed using linear mixed effects models in R using *lme4*. The fixed effects included the between–subjects variables Suffix (–*s*, –*ing*, –*ed*, –*sh*) and Condition (*bab*, *dop* or *kell*, *teep*), and the within–subjects variable Block (1, 2, or 3) and Trial type (familiar vs novel) and all their interactions. Additionally, the model included a random intercept for Subject, to allow for differences in baseline listening times. We also included a random slope for Trial type by Subject. If the model failed to converge, the random slope of Trial type by Subject was eliminated. We report results from the highest level random effect structure that converged (Barr et al., 2013). Fixed effects were evaluated against the full model using the anova() function, *F*–values greater than 2 are reported as significant. Planned comparisons were done using z–ratios from the *emmeans* package in *R*.

2.1.5 | Results & discussion

Overall, infants listened significantly longer to familiar compared to novel isolated suffixed nonce words (Figure 1). The final *lmer* model, with a random intercept for Subject, confirmed this. There was a significant main effect of Trial type (*F*–value = 38.2), and it did not interact with Suffix in any combination. Planned comparisons confirmed that infants were able to segment words inflected with each of the four suffixes. The effect of Trial type was significant for –*s* [*z ratio* = 2.6, *p* = 0.008], –*ing* [*z ratio* = 2.5, *p* = 0.01], –*ed* [*z ratio* = 3.3, *p* = 0.0008] and –*sh* [*z ratio* = 4.0, *p* = 0.0001].

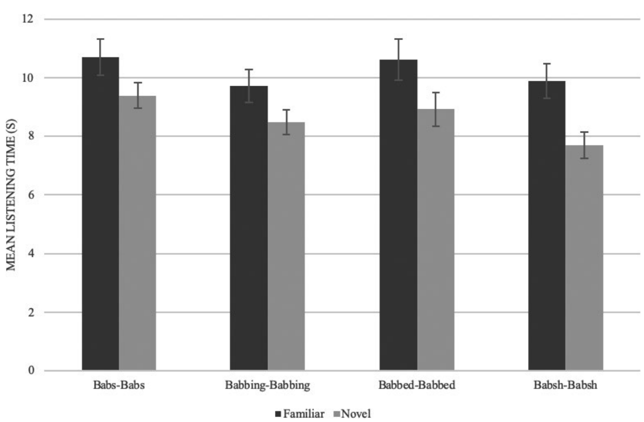

FIGURE 1 Mean listening times (±SE) to familiar and novel isolated suffixed words after 6–month–olds were familiarized with suffixed words embedded in passages (Expt 1).

Thus, 6–month–olds were able to segment morphologically complex words following the familiar word *Mommy*/*Mama* whether they were suffixed with –*s*, –*ing*, –*ed* or the pseudo-morpheme –*sh*. These results also establish that infants can segment verb forms as early as noun forms when preceded by known words, highlighting the importance of top–down cues in word segmentation. Additionally, as expected based on Jusczyk et al.'s (1994) findings, there was no evidence that infants treated nonce words suffixed with the pseudo-morpheme –*sh* with illegal consonant clusters, like *babsh*, any differently from sequences like *babs*, *babbed* or *babbing*. Crucially, these results provided us a baseline to determine whether infants relate suffixed words to stems.

2.2 | Experiment 2: Do 6–month–olds relate suffixed words to stems?

In Experiment 2 we again familiarized infants with passages with two suffixed nonce words till they accumulated 45 seconds of listening time to each. As in Experiment 1, these nonce words were suffixed with –*s*, –*ing*, –*ed* and the pseudo-morpheme –*sh*. However, in the test phase, we presented infants with just the stems of the 4 nonce words (*bab*, *kell*, *teep* and *dop*). We reasoned that if infants were able to relate suffixed words like *babs*, *teeping*, *kelled*, or *dopsh* with their stems, two of the four stems should be potentially familiar to them. Significantly greater listening times to potentially familiar stems were interpreted as evidence that infants successfully related suffixed words to stems.

We again used nonce stimuli in the experiments. Only if infants' knowledge is abstract, not item-specific, should they be able to relate nonce suffixed target words and stems. Moreover, we presented suffixes with verb forms, so infants could have no access to meaning. Recall that in whole word models, prior to the acquisition of meaning, morphological relatedness of pairs like *win*–*wins* is indistinguishable from relatedness based on phonological form alone, like in *win*–*winch*. If infants rely only on phonological overlap, they should relate nonce words inflected with all four suffixes to stems. This is because the onsets of all inflected forms whether they were suffixed with real English –*s*, –*ing*, –*ed* or the pseudo-morpheme –*sh* overlap phonologically with the stems.

However, if morphological relatedness is distinct from phonological onset overlap as in morpheme based models, we minimally expected 6–month–olds to fail to relate words suffixed with the pseudo-morpheme –*sh* to stems, because they have no experience with –*sh* as a suffix of English. In fact, based on English-learning infants' experience with individual suffixes, we can make a more specific prediction. Table 2 summarizes the type frequency of English inflectional suffixes in the 1.47 million word Brent Corpus (Brent &

Siskind, 2001) from the CHILDES database. Because 6-month-olds have no knowledge of word class (see He & Lidz, 2017 for review), and given the homophony of the plural *–s* and 3rd singular *–s*, infants hear the suffix *–s* most frequently in their input. This is indexed by the high type frequency of *–s* in Table 2. Based on their experience with English, 6-month-olds should at least be able to relate words suffixed with *–s* to stems in contrast with their performance on words suffixed with the pseudo-morpheme *–sh*.

2.2.1 | Methods

Participants

Another 120 (30 per suffix; 60 female) 6–month–olds (mean = 181 days; range 164–206) were tested as shown in Table 1. 19 additional infants were tested but their data were excluded without further analysis due to fussiness (n = 11), neither *mommy* nor *mama* was used consistently at home (n = 6), or parental interference (n = 2).

Analysis

The analysis was identical to that in Experiment 1.

2.2.2 | Results & discussion

The listening time data from Experiment 2 are presented in Figure 2. The final lmer model had a random intercept of Subject. Overall, there was a significant interaction between Suffix, Condition, Block and Trial type (*F*-value = 2.4). Planned comparisons showed that the effect of Trial type was significant for *–s* [*z ratio* = 2.6, *p* = 0.009], but not *–ing* [*z ratio* = 1.2, *p* = 0.2], *–ed* [*z ratio* = 0.2, *p* = 0.8], or the pseudo-morpheme *–sh* [*z ratio* = –0.3, *p* = 0.8].

Thus, infants listened significantly longer to potentially familiar nonce stems compared to the novel nonce stems, only when familiarized with nonce words suffixed with *–s*. That is, 6–month–olds were able to relate words suffixed with *–s* but not *–ing*, *–ed* or the pseudo-morpheme *–sh*, to stems. We take this as evidence that for 6–month–olds, morphological relatedness is distinct from phonological onset overlap. Because infants succeeded when tested with nonce words, we also take this as evidence that even at the outset of acquisition, prior to the acquisition of meaning, morphological relatedness is abstract.

2.3 | Experiment 3: Do 6–month–olds relate bare stems to suffixed words?

In Experiment 2, we showed that unlike previous studies, 6-month-olds were able to relate nonce words suffixed with *-s* and stems. To replicate and strengthen our findings, we reversed the order of presentation of passages and word lists (see also Goyet et al., 2013; Jusczyk et al., 1994; Nazzi et al., 2014). This time we familiarized infants with two isolated nonce stems until they accumulated 30 s of listening time to each. Then, in the test phase, infants heard familiar and novel suffixed nonce words embedded in passages. Significantly greater listening times to passages with potentially familiar suffixed words would provide evidence that infants successfully related suffixed words and stems.

2.3.1 | Methods

Participants

Again, a total of 120 (30 per suffix; 55 female) 6–month–olds (mean = 183 days; range 165–199) were tested as shown in Table 1. Nine additional infants were tested but their data were discarded due to fussiness (n = 7), or because neither *mommy* nor *mama* was used consistently at home (n = 2).

Analysis

The analysis was identical to that in Experiment 2.

2.3.2 | Results & discussion

The looking time results are presented in Figure 3. The final lmer model had a random intercept for Subject and a random slope for Trial

TABLE 2 Frequencies of the English morphemes in infant directed speech from the Brent corpus.

Inflectional morpheme	Word class	Function	Type frequency	Token frequency
–s	Verb	3rd person sg.	200	2,547
	Noun	Possessive	175	1,784
	Noun	Plural	867	8,252
Total *–s*			1,242	12,583
–ing	Verb	Present prog.	432	7,264
	Noun	Gerund	135	5,296
Total *–ing*			582	12,578
–ed	Verb	Past tense	298	1,588
	Adjective	Past participle	183	762
Total *–ed*			481	2,350

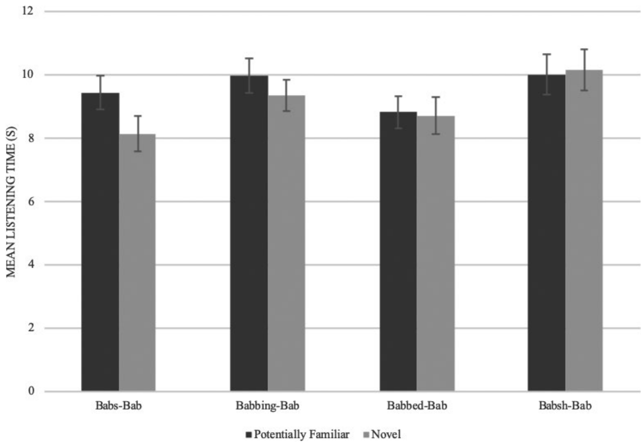

FIGURE 2 Mean listening times (±SE) to potentially familiar and novel isolated stems after 6-month-olds were familiarized with suffixed words embedded in passages. (Expt 2).

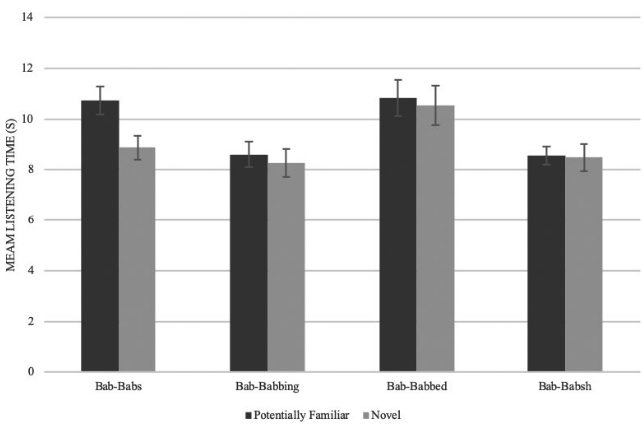

FIGURE 3 Mean listening times (±SE) to the passages with potentially familiar and novel suffixed words after 6-month-olds were familiarized with isolated stems. (Expt 3).

type by Subject. The only significant interaction in the final model was that of Suffix and Trial Type (F-value = 2.3). Planned comparisons confirmed that like in Experiment 2, the effect of Trial type was significant only for *–s* [*z ratio* = 3.5, p = 0.0005], not *–ing* [*z ratio* = 0.6, p = 0.5], or *–ed* [*z ratio* = 0.5, p = 0.6] or the pseudo-morpheme *–sh* [*z ratio* = 0.1, p = 0.9]. That is, infants listened significantly longer to potentially familiar passages compared to potentially novel passages with nonce words suffixed with *–s*, when familiarized with stems alone. Thus, 6–month–olds were also able to relate stems to words suffixed with *–s*, but not *–ed* or *–ing* or the pseudo-morpheme *–sh*.

One unlikely explanation for our results is that perhaps 6–month–olds simply cannot hear the difference between *bab* and *babs*. There are some claims that word-final segments are less perceptually salient for infants (Soderstrom, 2002; Wang & Seidl, 2015; Zamuner, 2006; but see also Eilers et al., 1977; Tincoff & Jusczyk, 2003; Jusczyk., 1977). Nonetheless, in a direct test, English–learning 6–month–olds have been shown to successfully discriminate morphologically–relevant word–final contrasts, specifically *neek* vs. *neeks* and *keet* vs. *keets* (Fais et al., 2009). More importantly, note that final [t] and [d] in the words suffixed with *–ed* are shorter and quieter than final [s] and [z] at the ends of words suffixed with *–s* (Klatt, 1976; Lehiste, 1960; Malékcot, 1968). Thus, words suffixed with *–ed* are perceptually more similar to the stem than words suffixed with 3rd person singular *–s*. Nonetheless, infants successfully related words with *–s* but not *–ed* to the stems and vice versa. Thus, it is unlikely that the 6–month–olds we tested somehow failed to distinguish *bab* and *babs* yet succeeded in distinguishing *bab* from *babbed*.

English–learning 6–month–olds' success relating *bab* and *babs*, but not *bab* and *babbed* or *bab* and *babsh* cannot be explained based on the segmental frequency of the sounds that constitute the suffixes either. In the same 1.47 million Brent corpus, *–s* and *–z* occur word–finally 52,651 times; *–t*, *–d* occur 91,275 times; and *–sh* occurs 1909 times. The low segmental frequency of word final *–sh* might explain why infants failed to relate *bab* and *babsh*; however, it cannot explain infants' failure to relate *bab* and *babbed*.

Finally, it is also unlikely that infants simply related words suffixed with *–s* but not *–ing* or *–ed* or the pseudo-morpheme *–sh*, with stems because of the phonological overlap in the onset of the words. One could argue that the onset of *babbing* is additionally different from *bab* because of the resyllabification of the final consonant [–b] with the *–ing* suffix, as in *ba–bing*. However, there is no reason to believe that there is greater onset overlap between *bab* and *babs*, than there is between *babbed* or *babsh* and *bab*. What we see instead is that in the absence of sufficient exposure to the suffix in the input, stems are treated as part–words, like *dock* in *doctor*, and English–learning infants do not relate words, like *doctor* with part–words like *dock* (Jusczyk et al., 1999).

Results from Experiment 3, together with the results of Experiment 2, show that English-learning 6–month–olds related nonce words with the suffix *–s* and stems. However, they were unable to relate stems and nonce words with the pseudo-morpheme *–sh*, in either direction. These results can be explained only if, even in the absence of access to meaning, 6–month–olds treated *–s*, but not *–sh*, or even *–ing* and *–ed* as a possible suffix of English. These findings are incompatible with whole word based models in general, and more specifically, with Baayen et al. (2015) proposal that morphological relatedness is merely an artifact of overlap in phonological form and meaning.

3 | PART II: ACQUISITION TRAJECTORY FOR ENGLISH SUFFIXES

3.1 | Experiment 4: Do 8-month-olds relate suffixed words to bare stems?

Given the absence of referential context, access to verb meaning, or knowledge of word class, English–learning 6–month–olds' abilities must be based on the combinatorial properties of *–s*. However, 6-month-olds failed to relate nonce words suffixed with *–ing* and stems. When are infants able to do so?

As we saw in Table 2, after *–s*, *–ing* is the next most frequent suffix of English based on type frequency. In Experiments 4 and 5, using the same methodology as in Experiments 2 and 3, we tested 8–month–olds' ability to relate nonce words suffixed with *–ing* and stems and vice versa. Recall that previous research shows that English learning 8–month–olds can use *–ing* to segment familiar words like *kiss*, *give*, *drink* and *walk* (Willits et al., 2014). However, Mintz (2013) reports that at the same age infants failed to relate nonce words suffixed with *-ing* and stems.

A closer look reveals several critical differences in the stimuli and experimental design used by Mintz and our experiments. In Mintz's relevant experiments (2 and 4), each infant was familiarized with two disyllabic targets suffixed with *-ing* and two disyllabic targets suffixed with the pseudo-morpheme *-dut*, embedded in sentences. Half these disyllabic targets had stress on the first syllable, and the other half had stress on the second syllable. The familiarization phase was not contingent on infant looking, and fixed at 90 s. Then, infants were trained on the contingency between auditory stimuli - pure tones, and looking behavior, in 4 intervening trials. Finally, in the test phase, infants were presented with all 4 familiarized disyllabic targets.

Instead of familiarizing infants with targets suffixed with both the real, and pseudo-suffix within the same experiment (Mintz, 2013), we used a between-subjects design in Experiments 2 and 3. In Experiments 4 and 5 as well we tested infants separately on the real suffix *-ing*. This allowed us to familiarize infants to each of the two suffixed words embedded in passages for at least 45 s, a duration much longer than that used by Mintz. Additionally, our experimental design was entirely infant-controlled. We have found in other paradigms that completely infant-controlled designs are more sensitive when testing young infants (Sundara et al., 2018). Having a completely infant-controlled design also meant that we could present the familiarization and test phase consecutively, without intervening training trials, as is typical in word segmentation experiments. Having intervening trials likely increased the memory load in Mintz's experiment, making it more difficult for infants (Houston & Jusczyk, 2003).

Finally, unlike in Mintz's experiment, all targets in our experiment were monosyllabic for two reasons. First, we wanted the experimental stimuli to mimic infants' ambient language experience; there is a greater prevalence of monosyllabic verbs in English child-directed speech (Brent & Siskind, 2001; Kim, 2015). Second, we used monosyllabic targets to ensure that the suffixed forms with *-ing* were disyllabic, and always had stress on the initial syllable. We think this is crucial because young English-learning infants segment disyllabic words only with the strong/weak stress pattern predominant in English (Jusczyk et al., 1993; Thiessen & Saffran, 2003). In contrast, whether young English-learning infants can even segment trisyllabic suffixed words used by Mintz (either strong/weak/weak or weak/strong/weak) remains an open question (see Houston et al., 2004 for the only published paper on English-learning infants segmentation of three-syllable words). By using disyllabic suffixed words with the predominant stress pattern of English, we could be sure that if infants failed to relate stems and nonce words suffixed with *-ing* in our experiments, it was not because of a failure to segment the suffixed forms themselves during familiarization. If acquisition of morphological suffixes is abstract, and unfolds without access to meaning, 8-month-olds should also relate nonce words suffixed with *–ing* and stems at the same age as they succeed in relating familiar words suffixed with *–ing* and stems.

3.1.1 | Methods

Participants

Thirty full–term monolingual English–learning 8–month–olds (18 females) participated in this Experiment (mean = 249 days; range 235–259). Selection criteria were the same as in previous experiments; their profiles are also presented in Table 1. One more infant was tested but their data were excluded, because they failed to complete testing due to fussiness.

Design

Paralleling Experiment 2, in Experiment 4 as well, infants were familiarized with passages. We familiarized 8–month–olds with passages with two nonce words (*bab*, *dop* or *kell*, *teep*, counterbalanced) suffixed with *–ing* till they accumulated 45 seconds of listening time to each. We presented infants with just the stem of all four nonce words (*bab*, *dop*, *kell* and *teep*) in the test phase.

Analysis

In order to probe the developmental trajectory, we analyzed the data from 8-month-olds tested in this experiment (Experiment 4) in conjunction with the data from 6-month olds reported previously (Experiment 2). The fixed effects included the between–subjects variables Age (6mo, 8mo) and Condition (*bab*, *dop* or *kell*, *teep*), and the within–subjects variable Block (1, 2, or 3) and Trial type (familiar vs novel) and all their interactions. Additionally, the final model included a random intercept for Subject; this was the highest level random effects structure that converged.

3.1.2 | Results & discussion

As shown in Figure 4, there was no significant interaction involving Age when infants were familiarized with passages. However, planned comparisons confirmed that the effect of Trial type was significant only for 8–month–olds (*z ratio* = 2.0, $p = 0.04$); as we have reported previously in the results from Experiment 2, 6-month-olds failed to relate nonce words suffixed with *-ing* and bare stems. That is, English learning 8-month-olds succeeded in relating nonce words suffixed with *-ing* and stems.

3.2 | Experiment 5: Do 8-month-olds relate bare stems to suffixed words?

In Experiment 5, we reversed the order of testing; we familiarized 8-month-olds with bare stems then tested them on nonce words suffixed with -*ing*, embedded in passages. Like in Experiment 4, we did not test 8-month-olds on the pseudo-suffix; our results from 6-month-olds suggest that from the earliest age, English-learning infants distinguish pseudo-suffixes from the real suffix -*s*.

3.2.1 | Methods

Participants

Thirty full–term monolingual English–learning 8–month–olds (12 females) participated in Experiment 5 (mean = 243 days; range 221–257). Selection criteria were the same as in previous experiments; their profiles are also presented in Table 1. Twelve more babies were tested but their data were excluded because they failed to complete testing due to fussiness (n = 9), or technical difficulties (n = 3).

Design

In Experiment 5, paralleling Experiment 3, infants were familiarized with just the stem. That is, 8–month–olds were familiarized with two isolated nonce stems (*bab*, *dop* or *kell*, *teep*) until they accumulated 30 s of listening time to each. Then in the test phase, infants heard two familiar and two novel suffixed nonce words embedded in passages.

Analysis

The analysis in Experiment 5 was identical to that in Experiment 4.

3.2.2 | Results & discussion

When familiarized with stems, the interaction of Age and Trial type was significant (*F*-value = 2.5). Further, planned comparisons confirmed that the effect of Trial type was significant only for 8–month–olds (*z ratio* = 3.0, p = 0.003). In sum, the significant interaction with Age confirmed that English-learning infants' ability to relate bare stems and nonce words suffixed with -*ing* embedded in passages improves between 6- and 8-months.

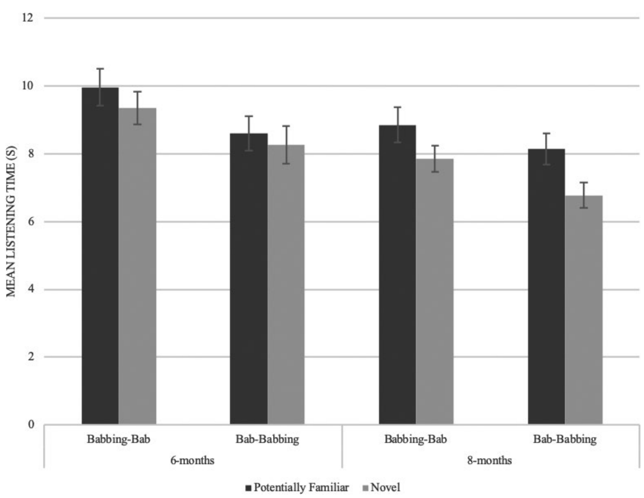

FIGURE 4 Mean listening times (±SE) to the nonce words suffixed with –*ing* and stems from 8-month-olds (Expt 4 and 5). Data from 6-month-olds (Expt 2 and 3) are also presented for comparison.

4 | GENERAL DISCUSSION

Our experiments showed that English–learning infants can segment nonce words suffixed with English –*s*, –*ing*, or –*ed* or even the pseudo-morpheme –*sh*. Nonce words in our experiments were used as verb forms. Previously, only English-learning 13-month-olds have been shown to successfully segment verb forms. By eliminating the differences between the contexts of noun and verb forms - by placing the verb forms adjacent to familiar words like *Mommy*/*Mama*, and at the beginnings and ends of sentences, we could facilitate infants' ability to segment verb forms as early as noun forms.

Next, we showed that at the earliest age at which infants can segment words from fluent speech, i.e., at 6–months, English-learning infants related nonce words suffixed with –*s* and stems. However, they failed to relate nonce words suffixed with –*sh*, –*ing* or –*ed* and stems. By 8–months, English–learning infants also successfully related nonce words suffixed with –*ing* and stems. Whether infants relate nonce verbs inflected with –*ed* and stems at a later age, as expected based on its even lower type frequency, remains to be determined.

Our results are incompatible with whole word models where morphological acquisition is simply a by-product of infants learning sequences with overlapping phonological forms and meanings (Baayen et al., 2015; Bybee, 1995; Joanisse & Seidenberg, 1999; Ramscar et al., 2013, 2018; Rumelhart & McClelland, 1986; Schone & Jurafsky, 2001) and consequently, theories of language acquisition premised on those models (Bybee, 1995; Tomasello, 1992). Recall that overlap in phonological form alone fails to account for our finding that 6-month-olds relate forms suffixed with –*s* and stems because they failed to relate *babsh* (or even *babbed*) to *bab*, despite similar overlap. Given that we tested infants on nonce words, we can also be sure that the 6- and 8-month-olds we tested did not access meaning.

Instead, our results are consistent with several proposals where infants initially discover suffixes from a distributional analysis of sound sequences (Aronoff et al., 2006; Baroni, 2003; Marquis & Shi, 2012; Pinker, 1999; Pinker & Prince, 1988; Pinker & Ullman, 2002) and support acquisition theories with a role for the morphological suffix (Christophe et al., 1997, 2008; Mintz, 2003; Morgan et al., 1996; Shi, 2005). The idea that highly frequent sequences of sounds are stored in the mental lexicon is itself not novel (e.g. Albright & Hayes, 2003; Brent, 1999; Goldwater et al., 2009; Thiessen & Saffran, 2003). Infants have been shown to store frequent sequences that span word boundaries (Ngon et al., 2013). What we show here is that such sequences may also be smaller than a word – as in the case of the English morphological suffix –*s* or –*ing*. Storing suffixes themselves allows the early acquisition of morphology to be abstract, instead of item-specific.

However, almost all existing proposals where distributional analysis is used to discover morphemes reference function (Pinker, 1999; Pinker & Prince, 1988; Pinker & Ullman, 2002) or word class (Aronoff et al., 2006). Such proposals cannot be reconciled with our findings: there is no evidence that 6- or 8-month-olds have access to morpheme function or word class, yet they successfully relate suffixed forms and stems.

In fact, in our experiments, we show that English-learning infants discover *–s* before *–ing*; this is likely only *because* of their inability to distinguish *–s* used on nouns as a plural or possessive marker and *–s* signaling 3rd singular verbs. That is, lacking sensitivity to word class, infants are able to leverage the homophony among morphemes, a propensity that is ubiquitous cross-linguistically. If this is correct, it opens up the possibility of generating a novel set of predictions about the timeline of morphological acquisition in languages other than English.

Consider French for example. The most frequent morpheme in the Lyon corpus of French child directed speech (Demuth & Tremblay, 2008) is *–e*, which marks French 2nd plural present and imperatives, and past participles, and is homophonous with the masculine singular noun and adjective marker. This is followed by *–t* which marks masculine and feminine singular nouns as well as feminine singular adjectives. The two most frequent suffixes in the OreaPine corpus of Spanish child directed speech (Aguado-Orea & Pine, 2015) are *–a*, followed by *–o*. The *–a* suffix can mark 3rd singular present, 1st or 3rd singular imperfect, or 2nd singular imperative verbs; it can also mark feminine singular nouns including diminutives. Similarly, the *–o* suffix can mark either 1st singular present verbs or masculine singular nouns including diminutives. Developmental data are needed to confirm whether these are indeed the earliest suffixes discovered by infants learning French or Spanish as a distributional analysis would predict.

An account of initial suffix discovery based on a distributional analysis of sound sequences is by no means error free. For instance, an inspection of the Brent corpus yields a number of false positives where a word-final segment can be misidentified as a suffix (e.g. *rice* as *rye* with an *–s*). If young infants erroneously relate sequences like *rye-rice*, even as they successfully relate *dop-dops* and *teep-teeps*, it would provide strong evidence that early morphological acquisition is driven by a distributional analysis of sound sequences alone. This would additionally mean that infants have yet to learn to exploit the small, yet significant, difference in duration of sounds like [s] and [z] when they are used as segments rather than morphemes (Seyfarth et al., 2018).

The error rate in morpheme detection mentioned above varies by the specific allomorph being evaluated. For example, 92% of word-final [z]s in the Brent corpus are morphemes compared to only 52% of word-final [s]s. The accuracy of discovering the voiced allomorph of English *–s* produced [z] as in *babs* or *kells* is also higher than for the voiceless allomorph produced [s] as in *dops* or *teeps*; the type frequency for the [z] allomorph is 764 compared to 262 for the [s] allomorph. Both the precision and accuracy data on the voiced and voiceless allomorphs of *–s* reported here favor the [z] allomorph over the [s] allomorph. In our experiments with the *–s* suffix, we did test infants on both variants; however, because of our experimental design we are unable to tease apart the effects of the specific allomorph. Specifically, in Experiments 2 and 3, infants were familiarized with nonce words suffixed with one voiced and one voiceless allomorph each, either *babs* and *dops*, or *kells* and *teeps*. Although there are no qualitative differences in the patterning of results between the two test items within each condition, we do not have the power with the current design to draw definitive inferences about the [z] vs [s] allomorph. Follow-up experiments will be needed to confirm such fine-grained predictions for the acquisition trajectory.

Some existing models of word segmentation that exploit the distribution of sound sequences without access to meaning, function or word class do indeed discover suffixes (Goldwater et al., 2009; Pearl & Phillips, 2018; Phillips & Pearl, 2015). Suffixes, often seen in the output of a wide range of unigram- and bigram-based word segmentation models, are typically characterized as “errors.” Critically in such model outputs there is no distinction between words/stems and suffixes.

Yet we know that infants and adults differentiate between words and suffixes. For instance, being vowel–less, the English *–s* suffix (like other consonantal suffixes) violates what is known as the possible word constraint (PWC, Norris et al., 1997). The PWC restricts the sequences in the speech string that language learners consider as viable word candidates. Such a constraint is thought to facilitate word segmentation and recognition (Norris et al., 1997). Consistent with the PWC, 12–month–olds (Johnson et al., 2003) and adults (Cutler et al., 2002; Norris et al., 1997) find it easier to spot words within longer words, if doing so does not strand a single consonant as a residue. For example, adults find it difficult to spot *sea* in *seash* compared to a sequence like *seashub*. In Experiments 2 and 3, we see that like adults, and their older peers, English–learning 6–month–olds also failed to relate the pseudo-morpheme inflected sequences like *babsh* (or *kellsh*, *teepsh* or *dopsh*) to *bab* (or *kell*, *teep*, or *dop*). This is in line with previous findings that infants and adults are reluctant to entertain parses of the speech input that strand a single consonant as a residue. In our experiments, infants successfully related the same nonce target words inflected with *–s* to stems. Note, that doing so strands a single consonant, *–s*, as a residue. That is, 6-month-olds behaved as if consonantal suffixes like *–s* are exceptions to the PWC.

Additionally, cross-linguistically, suffixes are fewer, more frequent, shorter, do not bear primary stress, and have a simpler syllable structure compared to stems (or words). In these ways, suffixes like *–s* or *–ed* or *–ing* resemble free functional morphemes, like English *a*, *an* and *the*. We know from previous research that even newborns can discriminate between function and content words based on their phonological and acoustic properties alone (Shi et al., 1998, 1999). So, there is some reason to believe that infants may distinguish between words and suffixes, even early in acquisition.

Whatever the relationship between words and suffixes, our results show that infants are learning them simultaneously, consistent with proposals that acquisition involves simultaneous extraction of multiple levels of structure (see also Canini & Griffiths, 2011; Feldman et al., 2013; Johnson, 2016; Swingley, 2009). Further, the finding that infants begin to extract morphological suffixes at 6-months raises the possibility that morphological acquisition itself guides the acquisition of phonology, instead of phonological acquisition guiding morphological acquisition, as has been assumed previously (e.g., Albright & Hayes, 1999; Barrett, 1982; Blevins, 2004; Tomasello, 2000).

In summary, English-learning 6–month–olds are able to relate nonce words suffixed with *–s*, but not the pseudo-morpheme *–sh* and stems. By 8-months, English-learning infants also relate nonce words suffixed with *-ing* and stems. Our findings provide evidence against the claim that the learning of morphology is an epiphenomenon resulting from overlap of form and meaning in young infants' lexicons. Instead, our results support the representation of morphological suffixes in the lexicon of infants as young as 6 months. Further, the age at which infants begin to represent morphological suffixes is predicted by the combined type frequency of that morpheme in their input, without reference to its meaning, function or word class. To obtain a comprehensive understanding of morphological acquisition, further research is needed to evaluate formally explicit models of how these representations are learned against the developmental trajectory uncovered from infant experiments.

DATA SHARING

The data that support the findings of this study are available from the corresponding author upon request.

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CONFLICTS OF INTEREST

We have no conflict of interest to declare.

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APPENDIX A

bab

Mommy **babs** and sings at the same time. I feel so happy whenever mommy **babs**. I play the piano and mommy **babs**. Mommy **babs** if she sees me dancing around. Mommy **babs** while grandma and grandpa eat. If I jump up and down mommy **babs**.

dop

I get so excited when mommy **dops**. Mommy **dops** when my brother and I play the drum. Mommy **dops** when she is proud of me. Daddy dances while mommy **dops**. Mommy **dops** every time she sees me eating. My sister and I jump when mommy **dops**.

kell

My daddy always laughs whenever mommy **kells**. Mommy **kells** a lot and I love it. Grandpa says he smiles, because mommy **kells**. I really like when mommy **kells**. Mommy **kells** when I play blocks with my brother. Mommy **kells** whenever she is happy.

teep

My brother smiles every time mommy **teeps**. Mommy **teeps** whenever she is happy. My sister and I sing and mommy **teeps**. Mommy **teeps** a lot and so does daddy. I get so excited when mommy **teeps**. Mommy **teeps** when I play with my sister.

APPENDIX B

bab

Mama is **babbing** and singing at the same time. I feel so happy cause mama is **babbing**. I am playing the piano and mama is **babbing**. Mama is **babbing** while I dance around. Mama is **babbing** as grandma is eating. I am jumping up and down as mama is **babbing**.

dop

I am so excited cause mama is **dopping**. Mama is **dopping** and my brother is playing the drum. Mama is **dopping** and I am proud of her. Daddy is dancing but mama is **dopping**. Mama is **dopping** so that I can eat my cereal. My sister is jumping cause mama is **dopping**.

kell

My daddy is laughing and mama is **kelling**. Mama is **kelling** and it makes me happy. Grandpa is smiling as mama is **kelling**. I am cooking while mama is **kelling**. Mama is **kelling** while the stove is on. Mama is **kelling** yet my sister is sleeping.

teep

My brother is smiling but mama is **teeping**. Mama is **teeping** and I feel so happy. My sister is singing and mama is **teeping**. Mama is **teeping** loudly and so is daddy. I am so excited cause mama is **teeping**. Mama is **teeping** while I am playing with my sister.

APPENDIX C

bab

Mama **babbed** and sang at the same time. I felt so happy whenever mama **babbed**. I played the piano and mama **babbed**. Mama **babbed** when she saw me dancing around. Mama **babbed** while grandma and grandpa ate. I jumped up and down and mama **babbed**.

dop

I got so excited when mama **dopped**. Mama **dopped** when my brother and I played the drum. Mama **dopped** when she was proud of me. Daddy danced while mama **dopped**. Mama **dopped** as she saw me eating. My sister and I jumped when mama **dopped**.

kell

My daddy always laughed whenever mama **kelled**. Mama **kelled** a lot and I loved it. Grandpa said he smiled, because mama **kelled**. I really liked when mama **kelled**. Mama **kelled** when I played blocks with my brother. Mama **kelled** whenever she was happy.

teep

My brother smiled every time mama **teeped**. Mama **teeped** whenever she was happy. My sister and I sang and mama **teeped**. Mama **teeped** a lot and so did daddy. I got so excited when mama **teeped**. Mama **teeped** when I played with my sister.