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Brief article

The role of exposure to isolated words in early vocabulary development

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Abstract

Fluent speech contains no known acoustic analog of the blank spaces between printed words. Early research presumed that word learning is driven primarily by exposure to isolated words. In the last decade there has been a shift to the view that exposure to isolated words is unreliable and plays little if any role in early word learning. This study revisits the role of isolated words. The results show (a) that isolated words are a reliable feature of speech to infants, (b) that they include a variety of word types, many of which are repeated in close temporal proximity, (c) that a substantial fraction of the words infants produce are words that mothers speak in isolation, and (d) that the frequency with which a child hears a word in isolation predicts whether that word will be learned better than the child's total frequency of exposure to that word. Thus, exposure to isolated words may significantly facilitate vocabulary development at its earliest stages.

Keywords: Speech segmentation; Child-directed speech; Infant-directed speech; Word learning; Isolated words

1. Introduction

Between the ages of 9 and 21 months, children typically progress from speaking at most a handful of words to speaking over 200 (Fenson, Dale, Reznick, Bates, & Thal, 1994). To learn a word, a child must store its sound pattern, its meaning, and an association between the two. Since fluent speech contains no known acoustic analog of the blank spaces between words of printed English, children must segment the

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speech signal in order to learn words from multi-word utterances. Early in the study of language acquisition, the segmentation problem received little attention; it was tacitly assumed that children learned words primarily from isolated occurrences. In the 1980s, it was suggested (Peters, 1983; Pinker, 1984) that words learned in isolation could help children segment multi-word utterances containing novel words. However, there was little systematic empirical evidence for this hypothesis. In fact, there was some evidence that infant-directed speech does not reliably provide isolated words (Aslin, Woodward, LaMendola, & Bever, 1996).

In the last 10 years there has been tremendous progress in understanding infants' ability to segment fluent speech. By 7.5 months, infants can recognize words that they have heard in fluent speech when those words are later presented in isolation (Jusczyk & Aslin, 1995) and can even do so after a 2-week delay (Jusczyk & Hohne, 1997). Further, 8-month-old infants are able to exploit patterns in sequences of nonsense syllables to help isolate word-like units from synthesized speech that lacks any other segmentation cue (Saffran, Aslin, & Newport, 1996). This research has been accompanied by a shift away from the view that early vocabularies are learned primarily from isolated words.

In this paper, we revisit the potential role of isolated words in early word learning. It has long been known that infant-directed speech tends to consist of short utterances (e.g. Snow, 1977) separated by relatively long silent pauses (Fernald et al., 1989). Recently, the question of isolated-word frequency has been addressed in a study of a single subject (van de Weijer, 1998). This paper reports a multi-subject investigation of four empirical questions:

1. Are isolated words a normal and reliable feature of spontaneous infant-directed speech?
2. Do children hear repeated instances of a variety of distinct words in isolation?
3. Does a significant proportion of children's earliest vocabularies consist of words that they have heard in isolation?
4. Does exposure to isolated instances of a word predict later knowledge of that word, above and beyond total frequency of exposure?

If the answer to all four questions is "yes", that would suggest that children may benefit from the presence of isolated words during the first year of word learning.

2. Method

2.1. Subjects

Thirteen English-speaking mothers with first-born infants under 9 months old were recruited by advertising in *Baltimore's Child*, a free newspaper distributed in and around Baltimore, Maryland. Three mothers who missed four or more recording sessions each were dropped from the study. Of the remaining ten mothers, two were eliminated due to consistent recording difficulties attributable to experimenter

error. The remaining eight were selected for transcription and further study. Three of the infants were male and five were female.

2.2. Procedure

Each mother–infant pair was visited at home approximately every 2 weeks while the infant was between 9 and 15 months old, for a total of 14 recording sessions. The mother was fitted with a fanny pack containing a portable digital audio tape (DAT) recorder. A lavaliere microphone was affixed to the mother's clothes approximately 8 inches below her mouth. Each session lasted 90–120 min, during which the mother and infant were alone in their home. The mother was asked to go about her normal business, with the exception of avoiding radio, television, recorded music, and long telephone conversations.

Partway through the study it was decided to administer the MacArthur Communicative Development Inventory (CDI, Fenson et al., 1993) at 3-month intervals. All eight subjects were surveyed at 18 months (child form), seven of those were surveyed at 15 months (infant form), and six of those seven were surveyed at 12 months (infant form).

2.3. Transcription and tabulation

The middle 75 min were transcribed from three to four sessions recorded for each infant when the infant was under 12 months old ("early transcripts") and from one to two sessions for each infant when the infant was over 14 months old ("late transcripts"). The early transcripts were used only to assess maternal speech to infants, whereas the late transcripts were used only to assess the infants' productive vocabulary. The beginning and end of each session were avoided out of concern that the arrival and departure of the experimenter could have led to self-conscious speech. Generally, the data for infants under 12 months were taken from sessions 2–4, except when those sessions had poor acoustic quality, terminated prematurely due to equipment failure, or contained extended periods of adult-to-adult speech. The beginning and end of each transcribed utterance were manually time-aligned with computerized sound files, allowing for temporal analysis.[1]

The early transcripts were analyzed to determine the frequency and diversity of isolated words in maternal speech. Isolated words were counted only if they were separated from all other maternal speech by at least 300 ms (see Fernald et al., 1989). If two utterances were not separated by at least 300 ms, they were counted as part of the same utterance, regardless of how they were transcribed. Two transcribers independently annotated utterance boundaries in 10% of the early-transcript recordings. The two transcribers agreed 93% of the time on whether an inter-utterance interval exceeded the 300 ms minimum for isolated words. In addition, we reran all the analyses described below with a minimum separation of 450 ms. The pattern of

[1] Recordings and transcripts from this corpus – the only extensive, time-aligned corpus of child-directed speech and the only extensive corpus focusing on speech to infants – are being made available at *http://lsrg.cs.wustl.edu.*

results was the same as that obtained with the 300 ms minimum separation. Thus, the results are not sensitive to the exact placement of utterance boundaries.

All 86 words that occurred in isolation (using the 300 ms criterion) but failed to occur in combination with other words in the corpus were excluded from the isolated-word count, as were 55 other special cases that do not combine normally into phrases (e.g. "yes", "no", "byebye", "hmm"; see Appendix A for a complete list).

3. Results

3.1. Frequency and reliability of isolated words

The first question we asked was how frequent isolated words are. To investigate this question, we analyzed three early transcripts per child. In order to separate the frequency of isolated words from the overall number of utterances produced by each mother, we used only the first 600 maternal utterances from each transcript, approximately the smallest number of maternal utterances in any transcript. On average, 9.0% of the maternal utterances consisted of isolated words. There was no statistically significant difference between subjects in the rate at which they use isolated words (one-way ANOVA with subject as a random factor: $F(7, 16) = 2.1$,

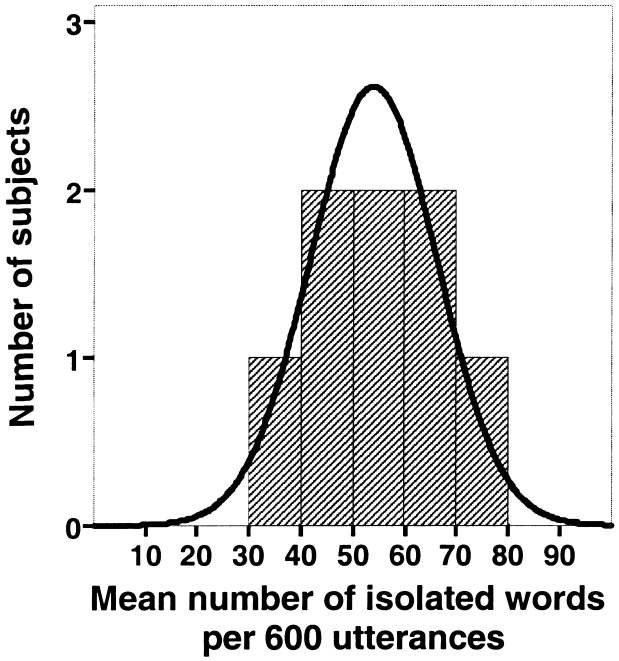

Fig. 1. Histogram of the mean number of instances of isolated words produced by eight subjects. Each mean is computed from the first 600 maternal utterances of each of three early transcripts per child. A normal curve with the same mean and standard deviation as the sample is superimposed on the experimental data.

Table 1
Total number of isolated word types heard by each child and the number and percentage of those that the child heard repeated within 30 s[a]

Subject	Isolated types	Repeated types	% Repeated
1	47	12	25.5
2	66	22	33.3
3	54	11	20.4
4	76	16	21.0
5	64	15	23.4
6	63	23	36.5
7	70	21	30.0
8	65	18	27.7
Average	63.1	17.2	27.2

[a] Counts are based on a sample of 1800 utterances per child obtained by combining the first 600 utterances from each of three early transcripts.

$P = 0.11$). Further, the distribution of isolated-word production rates across mothers showed no departure from normality (Fig. 1, Shapiro–Wilk $P = 0.967$). Thus, it appears that single-word utterances are a regular occurrence (at least several times per hour of interaction) in the experience of almost every infant.[2]

3.2. Diversity and repetition of isolated words

The second question we asked was how diverse the isolated words are. To investigate this question, we analyzed a sample of 1800 utterances per child obtained by combining the first 600 utterances from each of three early transcripts. On average, each child heard a total of 63.1 distinct isolated word types, of which 17.2 (27.2%) occurred two or more times within 30 s. Table 1 shows a breakdown of these results by subject. This finding suggests that mothers tend to use a variety of word types in isolation and tend to repeat a number of those word types in close temporal proximity.

3.3. Proportion of early vocabulary heard in isolation

The third question we asked was what proportion of children's earliest vocabularies was previously heard in isolation. To address this question, we analyzed all utterances in all of the early transcripts for each child. These were compared to three measures of the child's vocabulary: the first available CDI survey taken at or after 12 months ("early CDI"), the first available CDI survey taken at or after 15 months ("late CDI"), and the child's productions taken from the late transcripts ("productions"). The data used from the CDI forms were the words that mothers indicated their children produced. One child who was 15 months old when his vocabulary was

[2] Since our data showed no departure from normality, we estimated the parameters of a normal population model from the data. The results showed that only about one in 10 000 mothers drawn from the same population would use fewer than eight isolated words per 600 infant-directed utterances. Every mother produced at least 600 such utterances in each of the 75 min transcripts.

first surveyed knew only onomatopoeia and social routines, both of which are excluded from our isolated-word count. Since it was not possible to compute a percentage using the 15-month survey (the denominator would have been zero) the 18-month survey was used instead.

The results of these analyses are shown in Table 2. On average, 40.4% of the words produced by each child as of the early CDI, 27.1% of the words produced as of the late CDI, and 43.9% of the recorded productions were spoken to that child in isolation in the early transcripts. Note that the sessions from which the early transcripts were made all occurred before the early CDI was administered. Since the early transcripts represented at most 5 h of interaction for each child, we estimated the effect of more maternal speech by pooling the transcribed speech of all eight mothers. On average, 82.3% of the words produced by each child as of the early CDI, 74.3% of the words produced as of the late CDI, and 76.9% of the recorded productions were spoken by at least one of the mothers in isolation in their combined early transcripts. This is still likely to be an underestimate of the average percentage of vocabulary heard in isolation, since 40 h is only a small fraction of the total speech addressed to each child prior to vocabulary assessment.

3.4. Predictive power of exposure to isolated words for subsequent vocabulary

The final question we asked was whether exposure to a word in isolation predicts later knowledge of that word. As a preliminary visualization, we plotted the proportion of children who produced each word, according to the early CDI, as a function of how often their mothers said that word in isolation in three early transcripts (Fig. 2). This plot suggests that exposure to a word in isolation may indeed predict later productive knowledge of that word. We therefore used logistic regression to quantify the relationship between frequency of exposure to a word in isolation and subsequent production of that word. The dependent variable was whether the word was in the child's productive vocabulary at the time of vocabulary assessment. All vocabulary assessments were preformed subsequent to all recording sessions used to assess maternal speech. As in the previous analysis, we used three separate measures of the child's productive vocabulary: the early CDI, the late CDI, and the recorded productions. For each measure, the logistic regression included only words that were in the vocabulary of at least one child, according to that measure. The predictor variables were (a) the frequency with which that child's mother spoke that word in isolation and (b) the total frequency with which that child's mother spoke that word, whether in isolation or not. The second variable made it possible to measure the value of isolated frequency for predicting later production while controlling for effects of total frequency.

The results showed that, although the total frequency with which a particular child heard a particular word was not a significant predictor of whether that child would produce that word, the frequency with which the child heard the word in isolation was. This was true both when the early CDI was used to assess vocabulary (total frequency: $P = 0.511$, $R = 0.000$; isolated frequency: $P = 0.034$, $R = 0.062$) and when the late CDI was used to assess vocabulary (total frequency: $P = 0.856$, $R = 0.000$; isolated

Table 2
Proportion of vocabularies previously heard in isolation, according to three measures of vocabulary: early CDI, late CDI, and productions in late transcripts[a]

Subject	Early CDI					Late CDI					Productions				
	Used	Heard		Pooled		Used	Heard		Pooled		Used	Heard		Pooled	
		No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
1	10	6	60.0	10	100.0	174	20	11.5	96	55.2	44	10	22.7	29	65.9
2	11	5	45.5	9	81.8	47	18	38.3	34	72.3	14	7	50.0	9	64.3
3	18	4	22.2	15	83.3	18	4	22.2	16	88.9	1	1	100.0	1	100.0
4	26	9	34.6	20	76.9	87	20	23.0	59	67.8	9	3	33.3	7	77.8
5	30	11	36.7	18	60.0	71	19	26.8	43	60.6	8	4	50.0	7	87.5
6	23	7	30.4	16	69.6	23	7	30.4	16	69.6	10	2	20.0	7	70.0
7	6	4	66.7	6	100.0	16	6	37.5	15	93.8	2	1	50.0	2	100.0
8	22	6	27.3	19	86.4	22	6	27.3	19	86.4	4	1	25.0	2	50.0
Average	18.3	6.5	40.4	14.1	82.3	57.3	12.5	27.1	37.3	74.3	11.5	3.6	43.9	8.0	76.9

[a] The same survey was used in the early and late assessments for subjects 3, 6, and 8.

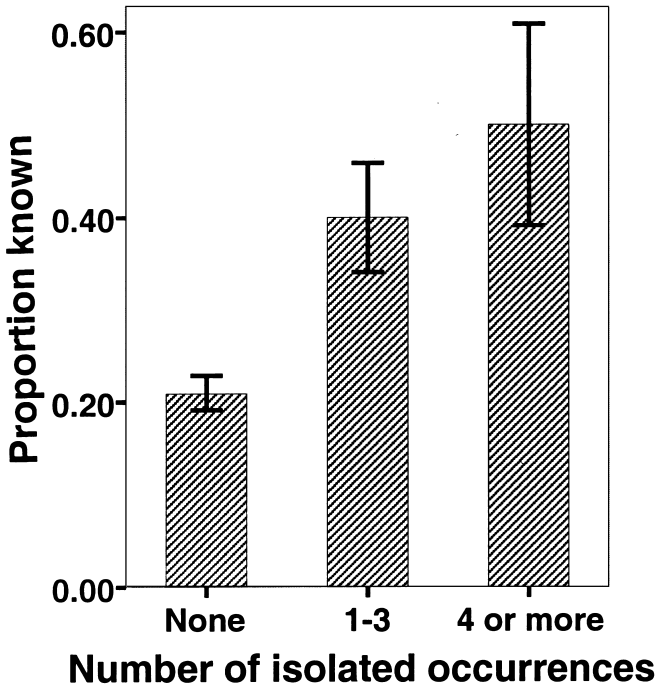

Fig. 2. The proportion of children who produced each word, according to the early CDI, as a function of how often their mothers said that word in isolation in three early transcripts per subject.

frequency: $P = 0.002, R = 0.065$). When the child's recorded productions in the final session (at 15 months) were used to assess vocabulary, the pattern of results was the same: the frequency with which a mother uttered a given word in isolation was a significant predictor of whether the child would produce that word in the final session ($P = 0.016$, $R = 0.086$), whereas the total frequency with which a mother uttered a given word was not a significant predictor at all ($P = 0.181$, $R = 0.000$).

According to the logistic model based on the early CDI, the odds that a child would learn a word increase by about 12% each time the word is heard in isolation; for the late CDI and the productions, the corresponding estimates are 9% and 8%.[3]

[3] The late CDIs and the late productions dated from at least 3 months after the transcripts used to assess the mothers' speech. Nonetheless, it seemed prudent to be sure that the results of the logistic regression could not be accounted for by the mothers' repetitions of words they thought their children produced. Thus, an additional logistic regression was carried out on the words that mothers reported their children understood but did not produce. The early CDIs were used, and the set of words included was the same as in the previous study using the early CDIs. The pattern of results was the same as in the other analyses: the frequency with which a mother uttered a word in isolation was a significant predictor of whether she would later report that her child understood but did not produce that word ($P = 0.025$, $R = 0.064$), whereas the total frequency with which a mother uttered a word was not a significant predictor ($P = 0.312$, $R = 0.000$). This suggests that the previous results cannot be accounted for by mothers' repetitions of words they thought their children produced.

4. Discussion

The data and analyses described above provide positive answers to the four empirical questions posed in Section 1. First, isolated words are a regular occurrence in the experience of almost every infant in the population from which this sample was drawn. Second, the isolated words to which infants are exposed comprise a variety of distinct word types, a number of which are repeated in close temporal proximity. Third, a substantial proportion of the first 30–50 words produced are words typically spoken in isolation by mothers to their infants before they are used by the infants. Finally, the frequency with which a given mother speaks a given word in isolation is a statistically significant predictor of whether her child will be able to use that word at a later date. However, the total frequency with which she speaks a word is not a statistically significant predictor of her child's later word use.

The finding that about 9% of infant-direct utterances are isolated words is consistent with several previous analyses of single subjects (Siskind, 1996; van de Weijer, 1998). However, the finding that isolated word use is reliable across mothers is not consistent with an earlier study (Aslin et al., 1996). This difference may result from differences in the experimental methods. First, the current study analyzed spontaneous speech produced in the home, whereas the earlier study analyzed speech produced in the lab in response to a specific task. Second, the current study analyzed a much larger sample per subject. Third, the current study analyzed all isolated words produced by the mother, whereas the previous study focused on words related to the task.

A number of previous studies have measured the potential of maternal speech to influence children's later knowledge. Studies focusing on syntax have found a very limited influence of maternal speech on children's later productions (e.g. Newport, Gleitman, & Gleitman, 1977). In the domain of word learning, Huttenlocher, Haight, Bryk, Seltzer, and Lyons (1991) found that the amount a mother speaks to her child is correlated with the child's rate of vocabulary growth at 16–24 months. However, the current study is the first to focus on isolated words. The results are consistent with the findings of Huttenlocher et al. (1991), and suggest that the greater number of isolated words resulting from greater total maternal speech may have been the mechanism of influence. Our results are also consistent with recent findings that suggest possible routes of influence but do not measure that influence directly. For example, cross-linguistic studies have shown that infant-directed speech is slower, higher pitched, and exhibits a wider, more sing-song pitch range (Fernald et al., 1989) and clearer vowels (Kuhl et al., 1997; Ratner, 1984) than adult-directed speech. Further, infants prefer listening to infant-directed over adult-directed speech (Cooper & Aslin, 1990; Fernald & Kuhl, 1987; Werker, Pegg, & McLeod, 1994).

The findings reported above are based on an English-speaking population. Ultimately, it will be important to extend these results to other languages and cultures. Nonetheless, there are several reasons to be optimistic that the phenomena reported here are characteristic of caretaker–child interaction in general. First, a number of other qualitative properties of child-directed speech have been found in several languages (e.g. Fernald et al., 1989; Kuhl et al., 1997). Second, our finding regarding

the frequency of isolated words in infant-direct speech is consistent with results reported for a Dutch–German bilingual household (van de Weijer, 1998). Third, although naming objects for children is rarer in some cultures than it is in America (e.g. Fernald & Morikawa, 1993; Gopnik & Choi, 1995), naming does not account for a preponderance of the isolated words in our sample; many are utterances such as "come", "go", "now", and "up". These utterances serve mundane communicative functions that are likely to exist in any culture. Finally, it appears that even in agglutinative languages like Finnish and Inuktitut, child-directed speech contains many words in citation form (Inuktitut: S. Allen, pers. commun.; Crago & Allen, 1998; Finnish: A. Vainikka, pers. commun.). If child-directed speech were like adult-directed speech in these languages, children might hear each inflected form of a word very rarely.

This study supports a model in which young children typically acquire a small, initial vocabulary from exposure to isolated words. This does not imply that exposure to isolated words is essential for native-language acquisition, any more than the beneficial effects of mother's milk imply that consuming mother's milk is essential for healthy development. Indeed, laboratory studies of infant speech segmentation suggest that isolated words are probably not essential. Nonetheless, the abundance of isolated words in infant-directed speech may help explain why so many children develop language so rapidly. Once children have acquired a small initial vocabulary, they could use that vocabulary to segment novel words out of multi-word utterances by recognizing adjacent familiar words. Such mechanisms have been proposed (Peters, 1983; Pinker, 1984) and have been formalized and shown to be effective via computer simulation (Brent, 1999; Brent & Cartwright, 1996). Until now, however, empirical evidence that the word-learning environment supports such a mechanism has been lacking.

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Appendix A. Words excluded from the isolated-word count

The following words were excluded from all isolated-word counts because they occurred in isolation but not in combination with other words: ahh ahhah alrightie Anne-'s Atlanta baby + boo back + twist backward beam blah Bodeen bodine Boni boo booby boop carefully choco + monster cootchykoo dirt Donald + Duck ew

forward glove-s gravity ha hah haha heehee hippity hiya ho hop hoppity hots hunhunh hunmmm jeez lordy Louie Maggie + mooskie Maggie + mooskie + moo mega + block-s Mickey + Mouse Milky mmhm momma muscle + man na nuhuh officially oohs oop operator ouchie Pappy patty Peter + pan piggy + piggy pinky pointer pst roadblock Sabatino Sam + Sam shh softball Sports + Connection sudsy sweets tada tippytoe toast tsk twinkle ugh uhhuh wazat wazis whaddya whoo whoops whoopsadaisy woah woo yep.

The following words were excluded from all isolated-word counts because they do not fit into familiar open and functional syntactic categories: aah ahem aw brr bye byebye giddyup good + bye goodness gotcha hello hey hi hmm huh mkay mmm mmm-s neato no nope o@l-s oh okay okeydokey ooh oops oopsadaisy oopsie oopsie-s ow oy peekaboo please poopie sh tada uh uhoh uhuh um well whee whoa whoopie wow yay yea yeah yes yuck yucky-s yum yummy yumyum.

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