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Names in frames: infants interpret words in sentence frames faster than words in isolation

Anne Fernald and **Nereyda Hurtado**
Department of Psychology, Stanford University, USA

Abstract

In child-directed speech (CDS), adults often use utterances with very few words; many include short, frequently used sentence frames, while others consist of a single word in isolation. Do such features of CDS provide perceptual advantages for the child? Based on descriptive analyses of parental speech, some researchers argue that isolated words should help infants in word recognition by facilitating segmentation, while others predict no advantage. To address this question directly, we used online measures of speech processing in a looking-while-listening procedure. In two experiments, 18-month-olds were presented with familiar object names in isolation and in a sentence frame. Infants were 120 ms slower to interpret target words in isolation than when the same words were preceded by a familiar carrier phrase, suggesting that the sentence frame facilitated word recognition. Familiar frames may enable the infant to 'listen ahead' more efficiently for the focused word at the end of the sentence.

Introduction

Speech addressed to young children is distinctively different from speech among adults in several respects. Prosodic features of child-directed speech (CDS) in English include exaggerated intonation and slower speech rate as compared to adult-directed speech (ADS) (Garnica, 1977; Stern, Spieker, Barnett & MacKain, 1983; Albin & Echols, 1996), modifications observed in parental speech in other European and non-Western languages as well (e.g. Fernald & Simon, 1984; Fernald, Taeschner, Dunn, Papousek, de Boysson-Bardies & Fukui, 1989; Greiser & Kuhl, 1989). Another unusual pattern in CDS is the use of utterances consisting of very few words (e.g. Broen, 1972; Snow, 1972; Fernald & Morikawa, 1993). Often these utterances include a short sentence frame used frequently in interaction with the child (Cameron-Faulkner, Lieven & Tomasello, 2003), and sometimes they consist of a single word spoken in isolation. Do such characteristic modifications in CDS provide perceptual advantages for the child? The idea that the special characteristics of CDS are well adapted to communication with a linguistic novice was first proposed by Ferguson (1977), who suggested that CDS served both 'affective' and 'clarification' functions. Although affective functions of speech to infants have been investigated in several studies (e.g. Fernald, 1989, 1992, 1993; Singh, Morgan & White, 2004; Werker & McLeod, 1989), the purported clarification functions of CDS have received much less attention (e.g. Fernald, McRoberts & Swingley, 2001; Thiessen, Hill & Saffran, 2005; Plunkett, in press). Here we ask how the context in which a word is heard influences infants' speed and accuracy in online word recognition.

Address for correspondence: Anne Fernald, Department of Psychology, Stanford University, Stanford CA 94305, USA; afernald@stanford.edu.

One feature of parental speech assumed to enhance intelligibility is the use of shorter utterances, of which a word in isolation could be regarded as the limiting case. Although one-word utterances occur in adult conversation in limited contexts such as greetings or in answer to a question, in CDS they may serve many functions (e.g. *See? Doggie!*). Studies in English (Aslin, Woodward, La Mendola & Bever, 1996; Brent & Siskind, 2001; Christiansen, Allen & Seidenberg, 1998), German (Fernald & Simon, 1984) and Japanese (Fernald & Morikawa, 1993) report that from 7 to 12% of all CDS utterances consist of isolated words. Peters (1983) hypothesized that hearing words in isolation would help the child specifically with the problem of segmentation. While the boundaries of words in continuous speech are potentially ambiguous, isolated words are bounded by silence and thus in principle should be easier to identify. Although more recent research on early speech perception shows that infants in the first year have formidable segmentation skills (e.g. Jusczyk & Aslin, 1995; Saffran, 2001), hearing words in isolation could still be beneficial.

The potential advantage of isolated words was explored further in two detailed analyses of parental speech. Aslin *et al*. (1996) asked mothers to teach words like *ear* and *wrist* to their 12-month-olds. When spoken in continuous speech (*That's your ear*), the onsets of these words are not acoustically demarcated, unlike words beginning with stop consonants that entail a brief closure at the onset (*That's your tongue*). Aslin *et al*. predicted that if mothers intuitively appreciated this segmentation problem, they would present words in isolation more often when the potential for ambiguity was high. Although 12% of the utterances in this sample consisted of single words, there was no effect of phonetic context, and some mothers did not use isolated words at all. The authors concluded that isolated words do not occur consistently enough to provide infants with cues to word boundaries essential for success in segmentation. Coming to a different conclusion, Brent and Siskind (2001) based their analysis on a longitudinal study of parents' interactions with infants from 9 to 15 months of age, in which 9% of CDS utterances consisted of words in isolation. These authors construed the glass as half-full rather than half-empty, arguing that hearing an unfamiliar word spoken on its own only a few times is sufficient to establish word boundaries, and thus even infrequent exposure to isolated words could be beneficial to the young language learner. Consistent with this hypothesis, Brent and Siskind found that of the 30–50 words first observed in children's own speech productions, 75% had been spoken by parents in single-word utterances several months previously. From these findings they concluded that exposure to isolated words may be important for vocabulary development in the early stages.

These studies of parental speech have generated debate about the potential processing advantage of words in isolation for the infant, leading to different predictions as to whether one-word utterances might facilitate early word recognition. If isolating a word makes acoustic boundaries easier to identify, as proposed by Peters (1983) and Brent and Siskind (2001), then infants should be more efficient in identifying an isolated word than a word embedded in continuous speech. This prediction is supported by Plunkett's (in press) recent finding that 17-month-olds benefited from presentation of words in isolation in a word recognition task. However, if Aslin *et al*. (1996) are right that infants' success in segmentation does not depend on hearing single-word utterances, we would not expect to find an advantage for isolated words in online sentence interpretation.

An alternative prediction that has not been widely considered in the developmental literature is that a familiar word heard in isolation might actually be *more difficult* for an infant to interpret than the same word presented in a sentence frame. This hypothesis is consistent with some of the earliest experimental studies of spoken word recognition by adults, showing that the predictability of the context in which a word is heard affects the intelligibility of the word. For example, Bruce (1958) showed that words are recognized

more reliably against background noise when presented in a coherent context than when presented on their own, and Lieberman (1963) found that adults can identify a familiar word in a sentence much faster than the same word in isolation. The prediction that words in sentence frames might be easier, rather than harder, for infants to process than words in isolation is also consistent with the finding that parents repeatedly use highly redundant frames in interaction with infants. In an extensive corpus analysis, Cameron-Faulkner *et al*. (2003) found that half of all CDS utterances started with one of 52 simple sentence frames, such as *Look at the __* and *Where's the __?* The pervasive use of such familiar frames may enable the child to anticipate the occurrence of the upcoming noun at the end of the sentence.

These competing hypotheses have emerged from descriptive analyses of parental speech. However, the questions they raise can only be resolved by assessing children's comprehension experimentally. Here we compare the responses of 18-month-old infants to the same words presented in isolation and in a familiar sentence frame, using online methods to capture the time course of word recognition. While most developmental studies of sentence interpretation have relied on offline measures to assess comprehension (e.g. Taylor & Gelman, 1988), or on summary measures of preferential looking (e.g. Golinkoff, Hirsh-Pasek, Cauley & Gordon, 1987; Meints, Plunkett & Harris, 1999), the eye-tracking methods used here provide continuous measures of speed and accuracy that enable more sensitive assessment of children's efficiency in interpreting the same word in different contexts (e.g. Fernald, Pinto, Swingley, Weinberg & McRoberts, 1998; Swingley & Aslin, 2002). If familiar words spoken in isolation are particularly easy to process, we would expect infants to be faster and more accurate in identifying an isolated target word than the same word presented in a sentence frame. If there is no advantage either way, performance should be equally good in both conditions. However, if infants are able to make use of sentence context in word recognition at the very early stages of language learning, we would expect faster, more reliable responses to target words presented in a familiar sentence frame than to target words in isolation.

Experiment 1

Method

Participants—Participants were 24 18-month-olds (12 M, 12 F) recruited through a university hospital, all typically developing infants from families in which English was the primary language in the home.

Stimuli—The speech stimuli included six target nouns (*baby, doggie, car, book, ball, shoe*), reported by parents as understood by all participants. Target words were presented twice in each of two conditions. On sentence-frame trials, the target noun was preceded by the carrier phrase *Look at the __*, followed after 800 ms by one of three attentional frames to add variation (e.g. *Look at the doggie! Can you find it?*). On isolated-noun trials the target noun was presented on its own, also followed by an attentional frame (e.g. *Doggie! Do you like it?*). To create the speech stimuli, a female native speaker of English recorded multiple tokens of each object name in each context in CDS prosody, matching the duration of target nouns across tokens and conditions as closely as possible. Waveforms were measured and edited using Peak™ LE 2.62 sound analysis software. Tokens for the final stimulus set were chosen based on prosodic comparability. Mean duration of target nouns was 552 ms (range: 549–554 ms) in the sentence-frame condition and 553 ms (range: 538–560 ms) in the isolated-noun condition. Mean duration of the carrier phrase in the sentence-frame condition was 572 ms (range: 542–587 ms).

Visual stimuli were colorful digitized pictures of objects named by the six target nouns, with four tokens per type. Pictures were presented on a grey background in yoked pairs (baby-doggie, car-book, shoe-ball), matched for visual salience within each pair.

Apparatus and procedure—The 'looking-while-listening' procedure (Fernald, Perfors & Marchman, 2006) was conducted in a sound-treated room with a three-sided testing booth. The child sat on the parent's lap facing two 15-inch computer monitors mounted side-by-side in the back panel. A curtain behind the child's head obstructed the parent's view of the monitors. Speech stimuli were delivered at 75 dB (SPL) through loudspeakers below the monitors. Infants' eye movements were recorded by a video camera connected to the computer in an adjacent control room.

On each trial, infants looked at a pair of objects while listening to speech naming one of the objects. Each picture served as both target and distractor, with side of target picture counterbalanced across trials. Pictures appeared for 2s prior to sound onset, followed by the 3.2-s speech stimulus and a 1-s silent period. Both screens were blank for a 1-s intertrial interval. The 24 test trials were structured in four blocks, each with six isolated-noun or six sentence-frame trials, with each target word presented once per block. Eight filler trials were interspersed among the test trials to maintain interest. Participants were randomly assigned to one of four stimulus orders.

Coding eye movements—The video record of each session was marked with a 33-ms digital time-code, with visual cues indicating picture and sound onset on each trial. Highly trained observers blind to stimuli and trial type coded infants' gaze patterns offline frame by frame, noting on each frame whether the child was fixating the left or right picture, between pictures, or away from both. Data on the time course of eye movements were coordinated with the speech waveform using custom software to calculate duration of fixations and shifts in gaze between images. Two observers conducted reliability checks by independently coding eight trials with at least two shifts in gaze for 25% of the participants. Observers agreed within a single frame on 98% of the trials.

Measures of efficiency in online word recognition

Reaction time (RT): Mean response latency to shift to the correct referent was calculated for each child in each condition. This analysis was based on those trials where the child started out on the distractor and shifted to the target picture within 367–1800 ms from target word onset, a time window based on previous analyses of shift distributions for 18- to 21-month-olds (Fernald, Swingley & Pinto, 2001). Shifts prior to 367 ms were excluded because they occurred before the child had time to process sufficient acoustic input and mobilize an eye movement (Haith, Wentworth & Canfield, 1993).

Accuracy: Accuracy was operationalized as fixation time to the target picture as a proportion of total time spent on either target or distractor picture, averaged over the 367–1800-ms window from target word onset across all trials for each child in each condition.

Results

In Experiment 1 we asked whether infants would be faster and more accurate in identifying the appropriate referent in response to an object name spoken in isolation or in a multiword utterance. Figure 1 gives an overview of the time course of orienting to the target picture, averaged across infants for each 33-ms interval, showing changes in the proportion of trials on which infants fixated the correct referent on isolated-noun and sentence-frame trials. Initially at chance in both conditions, children began to orient to the target image as the target word unfolded. Note that the curve marked with circles rises more rapidly and reaches

a higher level than the curve marked with diamonds, indicating that infants responded more quickly and accurately overall to target words in sentence frames than to target words in isolation.

A comparison of mean RTs in the two conditions confirmed that infants were significantly faster to respond to target words presented in a short, familiar sentence frame (M = 906 ms, SD = 170 ms) than to the same words in isolation (M = 1034 ms, SD = 172 ms), F (1, 19) = 11.5, $p < .003$, $\eta_p^2 = .37$. Although mean accuracy scores were reliably above chance (.50) in both the sentence-frame condition, t (23) = 7.067, $p < .001$, and the isolated-noun condition, t (23) = 2.804, $p < .01$, infants were significantly more accurate in identifying the correct referent when the target word was presented in continuous speech (M = .66, SD = .10) than when it occurred in isolation (M = .56, SD = .10), F (1, 23) = 14.0, $p < .001$, $\eta_p^2 = .38$. Thus in the first experiment, we found that isolated words were interpreted less rapidly and reliably than the same words at the end of a carrier phrase.

Experiment 2

One explanation for infants' greater efficiency in interpreting a familiar noun preceded by a sentence frame is that the continuity of the frame facilitated anticipation of the object name. However, it could be that it was simply the presence of the attentional word *Look* at the beginning of the frame that elicited attention, serving as a prompt for the upcoming target noun independent of any intervening words in the sentence. To explore this alternative explanation, the imperative *Look* was presented before the target noun at a constant interval of 250 ms on isolated-noun trials in Experiment 2. Thus the overall duration of the imperative-plus-target-noun stimuli in the isolated-noun condition (e.g. *Look. Doggie!*) in Experiment 2 matched the duration of the multiword stimuli in the sentence-frame condition (e.g. *Look at the doggie!*) in Experiment 1. If it was the occurrence of an attentional cue immediately before the target noun that accounted for the speed of infants' response on sentence-frame trials, then in Experiment 2 they should respond just as efficiently to isolated target words preceded by an imperative as they did to target words in a sentence frame beginning with the same imperative.

Method

Participants—Participants were 24 18-month-olds from the population described in Experiment 1.

Stimuli—The same visual and auditory stimuli were used as in the previous experiment, with one important modification: In the isolated-noun condition, the target word was preceded by the imperative *Look* also spoken in isolation. The same speaker who produced the stimuli for Experiment 1 recorded the imperative with prosody appropriate for a one-word utterance, matching the duration of the first word in the sentence-frame stimuli. By separating the imperative and isolated target noun by 250 ms, the overall durations of stimuli on isolated-noun (M = 3267 ms) and sentence-frame trials (M = 3192 ms) were closely matched.

Apparatus, procedure and dependent measures—As described in Experiment 1.

Results

As shown in Figure 2, infants' gaze patterns in Experiment 2 were very similar overall to those shown in Figure 1. As in the previous experiment, infants were significantly faster to respond to target words in continuous speech (M = 861 ms, SD = 230 ms) than to target words in isolation (M = 1015 ms, SD = 185 ms), F (1, 19) = 7.6, $p < .02$, $\eta_p^2 = .29$, even

when the isolated noun was preceded by the imperative *Look*. Mean accuracy scores were reliably above chance (.50) in both sentence-frame, t (23) = 4.774, $p < .0001$, and isolated-noun conditions, t (23) = 3.096, $p < .01$. However, as in Experiment 1, infants were significantly more accurate on sentence-frame trials (M = .63, SD = .13) than on isolated-noun trials (M = .57, SD = .11), F (1, 23) = 5.65, $p < .05$, $\eta_p^2 = .20$.

Discussion

The observation that caretakers speaking to infants often use utterances consisting of a single word has led to debate about potential benefits of such simplified language input. One hypothesis is that words in isolation should be advantageous for the young listener because they are easier to segment. The results presented here use online measures of spoken language understanding to address this question directly. In Experiment 1, we found no benefit from hearing a familiar target word in a single-word utterance. In fact, 18-month-old infants were significantly *slower* to identify the referent of a well-known word spoken in isolation than when the same word was heard at the end of a short sentence, suggesting that target word interpretation was facilitated by the carrier phrase on sentence-frame trials. However, before considering this explanation we examined an alternative hypothesis. Because target words in the sentence-frame condition were always preceded by *Look at the __*, the continuity of the frame was confounded with the presence of an initial attentional word. The imperative *Look* preceding the target word may have served to elicit attention and also to provide a temporal cue that the object name was about to occur, regardless of the intervening functor words. But when this confound was eliminated by including the same imperative on both trial types in Experiment 2, there was no improvement in the isolated-noun condition. Infants were still slower and less accurate in identifying the referent of a target word spoken as a one-word utterance than when the same word was presented in a multiword sentence.

Why would infants respond more slowly to a familiar word in isolation? As Peters (1983) and others have suggested, a word preceded and followed by silence should in principle be easier to identify as a unit than the same word in continuous speech, because the boundaries of an isolated word are unambiguous. However, an obvious drawback of hearing a word in isolation is that it appears without warning. Consistent with research on word recognition by adults (e.g. Bruce, 1958; Lieberman, 1963), infants also appear to benefit from the predictability that results from hearing the target noun in the context of a familiar carrier frame. In fact, such short, simple frames are used repeatedly in everyday speech to infants, in combination with different content words (Cameron-Faulkner *et al*., 2003). Familiar frames may enable the child to anticipate the occurrence of the upcoming target noun, a processing advantage that could account for our finding that infants' mean RT was more than 120 ms faster in response to target words in sentence frames than to isolated words.

In arguing that 18-month-olds took advantage of the carrier frame to track the unfolding sentence and anticipate the focused word, we are not saying that the frame merely served as a prompt. A robust phenomenon in perceptual research is that signal detection is faster when a prompt precedes the stimulus. However, our second experiment showed that infants were not relying only on the temporal predictability of the carrier frame relative to the target word to expedite interpretation. In Experiment 2, isolated words were preceded by a single attentional word, separated from the target word by a silent interval of 250 ms. If on sentence-frame trials, the child needed only to attend to the onset of the sentence, then the imperative *Look* should have been just as effective as a prompt as *Look at the __*, enabling a quick response to the isolated word that followed. Yet responses to isolated words preceded by *Look* in Experiment 2 were no faster than on trials without a prompt in Experiment 1,

suggesting that infants were at some level making use of all the words in the sentence frame to anticipate the target word.

Several sources of information in the preceding carrier frame could increase the predictability of the target word. In adult speech processing, the prosodic contour of the sentence indicates that the final focused word is yet to come (Grosjean & Hirt, 1996), a cue that infants also make use of in online understanding (Thorpe & Fernald, in press). Co-articulation of the functor word *the* with the first consonant of the noun is another potentially informative cue to the upcoming target word. It could also be critical that the target words in the continuous-speech stimuli used here came at the end of the sentence. This type of sentence structure is common in speech to children, where focused words occur more frequently in utterance-final than in medial position (Fernald & Mazzie, 1991). It is noteworthy that our results are quite different from those of Plunkett (in press), who found that 17-month-olds were relatively more successful at identifying familiar words in citation form than in medial position in fluent speech. Procedural differences may account for this discrepancy in results, since the Plunkett study did not use real-time measures of response speed. However, a more likely explanation is that medial target words are particularly challenging for infants at this age and are identified more slowly and less reliably than target words in final position (see Fernald *et al.*, 2001).

In addition to phonological cues and word position, infants can also rely on their increasing familiarity with particular sequences of functor and content words. By 11 months, infants are attentive to prosodic and segmental features of functor words in fluent speech (Shafer, Shucard, Shucard & Gerken, 1998), and by 18 months they can distinguish passages in which functors are in typical or atypical positions in the sentence (Santelmann & Jusczyk, 1998). Moreover, word recognition by infants at this age is affected by the grammaticality of the preceding determiner (Gerken & McIntosh, 1993). A recent study using online methods found that 18-month-olds could easily identify object names in grammatical carrier frames such as *Where's the* __ and *Show me the* __, but were less reliable in identifying target words when the determiner *the* was replaced by a nonce determiner (Zangl & Fernald, under review). Since *the* is followed by a noun more than 90% of the time in CDS (Thorpe & Fernald, in press), it provides a reliable distributional cue for the young language learner, especially in the larger context of a familiar sentence frame (e.g. Mintz, 2003). Consistent with these findings, infants in the present study were quick to identify target nouns preceded by a continuous carrier phrase that enabled them to anticipate when the upcoming target word would occur, but found it harder to identify isolated nouns that came out of the blue.

Recent research on early speech perception reveals infants' phenomenal aptitude for exploiting distributional cues to identify structural units in the stream of sound (e.g. Gomez, 1999; Saffran, 2001). Using nonce syllables and miniature artificial languages as stimuli, these studies show how very young language learners use recurrent sequences of sounds as predictive cues in listening to speech. Thus it should not be surprising that in natural language as well, 18-month-olds can take advantage of the flow of familiar words to anticipate the object name, presumably using a combination of prosodic and distributional information to monitor the unfolding sentence as adults are able to do (Grosjean & Hirt, 1996). Although the focus in this study was on infants' recognition of well-known object names, it could still be the case that unfamiliar words present a more formidable segmentation problem, as Brent and Siskind (2001) have argued. Thus hearing a novel word in isolation might help the child to link it to a referent in the first place, a question we are exploring in ongoing research. But a striking implication of this study is that by concentrating so intently on the potential perceptual benefits of using isolated words in speech to children, an odd practice indeed by standards of adult conversation, we have underestimated another odd parental habit that appears to be even more advantageous for the

young learner: the use of short, simple, repetitive carrier frames leading up to a familiar noun. Cameron-Faulkner *et al*. (2003) argue that such frequent frames play a role in the gradual induction of grammatical form class. But before this can happen, frequent frames may serve a more basic and immediate function, helping the infant to 'listen ahead' more efficiently for the focused word at the end of the sentence.

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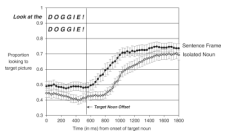

Figure 1.

The time course of children's looking to the correct referent in the Isolated Noun and Sentence Frame conditions in Experiment 1. Curves show changes over time in the mean proportion looking to the correct referent as the target word unfolds, measured (in ms) from noun onset; error bars represent SEs.

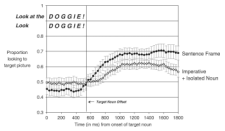

Figure 2.

The time course of children's looking to the correct referent in the Imperative + Isolated Noun and Sentence Frame conditions in Experiment 2. Curves show changes over time in the mean proportion looking to the correct referent as the target word unfolds, measured (in ms) from noun onset; error bars represent SEs.