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ABSTRACT

This study investigated two-month-old infants' memory for phonetic information using the high-amplitude-sucking procedure (HAS). Specifically, the study explored whether the availability of prosodic organization enhances infants' memory for the phonetic information they hear. After a baseline measure was obtained, infant sucking resulted in a sentence or a list being played. During this pre-shift phase, infants repeatedly heard either a single sentence or a list sequence. When infants habituated to this stimulus, the phase ended and was followed by a two-minute silent interval. During this time infants were shown colorful slides, and sucking did not produce a sentence or list sequence. At the end of this interval, infants heard either the same stimulus as in the pre-shift phase (control condition), one which differed by only one phoneme (one phonetic change condition), or one which differed by two phonemes (two phonetic change condition). Results revealed that infants who heard sentences (as opposed to lists) showed a significantly higher recovery of sucking in the post-shift phase, indicating that they were better remembering the phonetic information they heard prior to shift. Results demonstrated that prosody might serve as a first step for infants trying to acquire native language. (MM)

Does Sentential Prosody Improve Two-Month Olds' Memory for Speech ?

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One of the difficult tasks facing the prelinguistic infant is discovering the organization of his or her native language. Child language acquisition researchers have responded to this problem, by searching for potential cues in the speech signal which might help the infant to uncover underlying syntactic organization. Most recently, researchers have entertained the possibility that the prosody of speech directed to infants could provide these helpful cues to important grammatical units.

In order for "prosodic bootstrapping" of this sort to make sense, three conditions need to be satisfied. First, it must be clearly demonstrated that the acoustic correlates hypothesized to serve as cues for infants, are actually present in the speech signal. Research over the past decade or so has provided convincing evidence that such information does exist, at least for certain types of linguistic units (Fisher & Tokura, 1992; Cooper & Paccia-Cooper, 1980; Klatt, 1975, 1976; Scott, 1982; Lehiste, Olive, & Streeter, 1976; Cooper & Sorensen, 1977). Second, these prosodic cues must be ones that infants are able to detect on line when they are listening to fluent speech. Indeed, earlier research (Hirsh-Pasek et al., 1987;

Kemler Nelson, 1989; Jusczyk et al., 1992) has demonstrated that infants as young as 4 1/2 months old, are sensitive to the perceptual organization of fluent speech, that is, they preferred to listen to speech samples which were segmented to coincide with natural clausal and phrasal boundaries, than to those which were segmented in the middle of clauses or phrases.

However, while these studies show that there is some prosodic marking of syntactic units in speech to children, and more importantly, that young infants are indeed sensitive to such markings, the most interesting question of all has not yet been addressed. Specifically, can we find evidence that infants are not only sensitive to such prosodic markings, but are able to use such information to help organize the incoming speech input that they hear? In other words, can we find convincing evidence that infants are organizing the speech signal into units such as clauses or phrases using prosody as a grouping principle? It is these questions which get at the crucial issue of when the organization that is potentially available in the prosody begins to play a significant role in speech processing.

This issue is akin to one that the early psycholinguistic researchers faced when trying to demonstrate that certain linguistic units tended to be natural units for encoding and remembering information conveyed in the speech input. This early work demonstrated that adult listeners were better able to remember information from input that had a significant "linguistic" organization, as opposed to an arbitrary one (Epstein, 1961). Our research draws on this approach, in that we hypothesized that one

potential role of prosody during language acquisition might be to provide an organization which could be used in encoding and remembering speech information. Our study specifically asked the following question: Does the availability of prosodic organization enhance two-month-olds' memory for the phonetic information they hear? By comparing the memorability of the same information when it is packaged into a single prosodic unit, versus when it is not, we hoped to find out whether prosodic information available in the speech stream might actually serve an organizational function for linguistically naive infants at the earliest stages of language acquisition.

Half of the infants in our study heard stimuli that were produced as complete sentences; the other half heard the same sequences of words, but these were taken from long lists of unrelated words spoken in isolation. Specifically, creation of the stimuli involved having a person who was blind to the purposes of the experiment, read the sentences actually being used for the study in a list of 30 unrelated sentences, to control for the possibility of contrastive stress that might bias any results we obtained. Items for the list materials were prepared in an analogous fashion; that is, as randomly distributed items in a long list of isolated words. This random list represented various parts of speech to control for any possible "biasing" effects, such as pronouns, nouns, prepositions, conjunctions, etc.

Sequential order for the information being presented was the same in both sentence and list conditions. In other words, infants in either case received the same words, in the same sequence. In

addition, care was taken to ensure that the overall durations of the list sequences were equated to the comparable sentences. The only difference involved whether the information was spoken as a single prosodic unit (a sentence), or in isolation (as words in a list).

---Insert Figure 1 here---

Figure 1 shows the sentences used in both the single and double phonetic change conditions. List sequences consisted of the same words, in the same orders.

In addition to having stimuli which were either fluently spoken as sentences or artificially concatenated sequences, a further division was made such that sentences (and lists in the comparable list conditions) differed from each other by either one phonetic element, or two elements (what we called a "two phonetic change" condition, vs. a "one phonetic change" condition). Our original decision to further divide the conditions in this way, was in part due to the fact that experiments of this type have not previously been done, and therefore it was hard to know ahead of time how difficult the task would be.

The present study investigated two-month-olds' memory for phonetic information using the high-amplitude-sucking procedure. Part of the logic for using two-month-old infants in this study, is that previous research has demonstrated considerable success adopting the HAS procedure for investigating infants' memory for speech information.

The procedure went as follows: Infants were given a sterilized pacifier to suck on, and after a baseline measure was obtained, infant sucking produced a sentence (or a list, if the infant was randomly assigned to that condition). During this initial or "pre-shift" phase of the experiment, the infant repeatedly heard either a single sentence, or a list sequence. When the infant habituated to this stimulus by reducing her sucking rate below a specified criterion, the pre-shift phase ended and was followed by a two-minute silent interval, during which time the infant was shown a series of colorful slides. In this interval, sucking did not produce a sentence or list sequence. At the end of this interval, the post-shift phase began, in which infants heard either the same stimulus as in the pre-shift phase (Control condition), one which differed by only one phoneme (1 phonetic change condition), or one which differed by two phonemes (2 phonetic change condition).

---Insert Figure 2 here---

Let's consider some possible outcomes of this experiment:

If the prosodic hypothesis is correct, and infants are indeed using the prosodic relatedness of words in a sentence to help organize and encode them, we would expect infants to perform better in the sentence conditions than in the list conditions, as the units in the first case are organized into one prosodic whole.

On the other hand, one could easily make the contrary argument, that is, infants might actually perform better in the list conditions than in the sentence conditions, because the list conditions, unlike

the sentence conditions, do not contain coarticulatory information across the whole utterance. Thus the words from the list sequences are more easily segmented. Moreover one could argue that the units in the list condition better preserve the "quality" of phonetic information in the input the infant is hearing, and thus should be easier to encode and remember.

With these two possibilities raised, let's move to a discussion of the results and look at what actually happened.

---Insert Figure 3 here---

As the graph shows, there were two main effects:

First, as expected, there was a main effect for the type of material that the infant received [$F(1,66) = 14.97$, $p = 0.000$)]. In other words, infants who received the sentences as opposed to the lists showed a significantly higher recovery of sucking in the post-shift phase of the experiment, indicating that they were better remembering the phonetic information that they heard prior to shift.

Another interesting, and for us, surprising result, was that we also were able to demonstrate an effect related to the magnitude of phonetic change [$F(2,66) = 11.56$, $p = 0.000$)]. The interaction between materials and magnitude of phonetic change was not significant, $p > .20$. Not only did the infants in our study seem to be remembering phonetic information better when they received a string of words which were prosodically linked in a sentence, but it appears that the infants who were in the two-change condition were

performing better than those in the one-change condition. This was true regardless of whether the infants were in sentence or list conditions. That is, of the infants in the "list" conditions alone, those in the "2 change" condition outperformed those in the "1 change" condition. This magnitude effect is particularly interesting, in that our past experience with the HAS procedure has not shown it to be sensitive to the magnitude of differences in the stimuli.

The fact that the infants tested in the present study were only two-months of age has important as well as exciting implications for the future of language acquisition research. As mentioned at the outset, earlier studies which have examined the possible role of prosody in language learning have only demonstrated that infants are sensitive to the prosodic structure of utterances. Still, the youngest age tested in these studies was 4 1/2 months of age, which is quite a bit older than those tested in the present study.

The results are important because they extend earlier studies by showing that infants are more than merely sensitive to the prosodic character of the input. What is interesting about the present results, is that they demonstrate infants' abilities to "exploit" the available prosodic information, and actually use it to help organize and encode what they hear. This indicates that very early in language processing, the infant can utilize prosodic cues in the input to help group speech into relevant linguistic units, in this case, clauses.

Thus, the present study has demonstrated that prosody might serve as a "first" step for the linguistically naive infant trying to acquire his or her native language. Our results have demonstrated that prosody indeed acts as an organizing factor for the input the

infant hears, in that it helps the infant to keep items from the same linguistic unit together. In this sense, we could say that prosody is a kind of "perceptual glue"--it has psychological reality as a packager of information and facilitates the processing of linguistic information in memory.

The psychological reality of prosody as a parsing tool is a question that still needs considerable exploration. For instance, the present study pitted two "extremes" against one another. We looked at a sentential unit in which all items were prosodically linked, versus a list condition, where each item had its own prosodic envelope. In this second condition, the infants might have been treating the list items each as separate units, making it rather difficult to encode and remember the items being presented. Of course, there is a whole range of intermediate possibilities to be explored. One goal of further research might be to examine less extreme cases than those used in the present study, as well as employing new tasks which more directly address segmentation abilities.

Despite these unanswered questions, the present results clearly indicate that prosody is playing some role in how infants as young as two months of age, organize what they hear. We are currently investigating this issue further in our laboratory in order to understand the role prosody plays in language learning.

Fig. 1

Stimulus Pairs for Clause Memory Study with 2-month-olds

Single Phonetic Change Condition:

Preshift Stimulus

"The cat chased white mice"

Postshift Stimulus

"The cat raced white mice"

Double Phonetic Change Condition:

Preshift Stimulus

"The cat raced white mice"

Postshift Stimulus

"The rat chased white mice"

Fig. 2

Basic Design

		Experimental Condition		
		2 Phonetic Changes	1 Phonetic Change	Control
Type of Presentation	Sentence	rat chased vs cat raced	rat chased vs cat chased	rat chased vs rat chased
	List	rat chased vs cat raced	rat chased vs cat chased	rat chased vs rat chased

Fig 3

2-month-olds' Memory for Phonetic Information