18-month-olds' sensitivity to discontinuous dependencies over long verbs

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In order to comprehend sentences, infants must be able to determine relationships among elements in the sentence. One of the ways in which languages can mark these relationships is through relationships between morphemes, called here morphosyntactic dependency relationships. For example, English exhibits a number of dependency relations between morphemes, e.g., the relationships between subject and verb: *the child always run**s**; the child**ren** always run;* the relationships among verb forms: *the child **has** always walk**ed**; the child **is** always runn**ing***; or the relationships between determiners and nouns: **these** big green boat**s**; **this** big green boat.

Acquiring these relationships is a step crucial for learners to be able to structure and decode the language. At the same time, these relationships often appear on discontinuous constituents in the sentence requiring the language learner to access several non adjacent morphemes or words. In order to detect and decode these relationships, the learner must have sufficient processing capacity to access all of the elements involved in the relationship. If processing capacity is limited, this might interfere with the ability to understand or create these dependency relationships, especially if other constituents intervene.

Recent work by Santelmann and Jusczyk (1998) has suggested that while 18-month-old infants are able to detect relationships between morphemes, the processing ability to do so may be limited. Santelmann & Jusczyk compared infants' preference for grammatical passages with *is* and *-ing* as in: *The archeologist is digging for treasures* to ungrammatical passages with *can* and *-ing*, as in: *The archeologist can digging for treasures.* They found that these infants acquiring English showed a preference for the *is* and *-ing* passages, if the distance between the two morphemes was three syllables or less. However, if the distance between the two dependent morphemes was greater than 3 syllables, as in: *The archeologist is/can energetically digging for treasures*, then the infants no longer showed a preference for the grammatical passages. Santelmann and Jusczyk suggested that these results may stem from a narrow processing space in early infants.

However, while these studies characterized the processing space in terms of syllables, it is not clear that interference is directly related to the number of syllables intervening between the two parts of the dependency. Another possibility may that it is not simply distance, but the type of material intervening matters. In Santelmann and Jusczyk (1998) only adverbs were inserted between the critical elements of the syntactic dependency. It is possible that we may not find the same type of interference if we separate the dependent morphemes with a multi-syllable verb root rather than adverb+verb root.

The present studies were designed to examine whether 18-month-old infants were sensitive to the relationship between *is* and *–ing* over multisyllable verbs. However, one problem with using multisyllabic verbs to test this relationship is that multisyllabic verbs are relatively rare in spoken English, and are thus likely to be unfamiliar to very young

infants. It is possible that infants may not be able to detect the relationship over a number of long, unfamiliar verbs. Thus, these studies were designed to determine whether infants could detect the relationship between *is* and *–ing* over presumably unfamiliar, 3 syllable verb roots. Three-syllable verb roots were chosen because infants in Santelmann and Jusczyk (1998) were able to detect the relationship between *is* and *–ing* over a 3 syllable distance, when that distance was a single syllable verb root and a 2 syllable adverb.

Experiment 1

This experiment was similar to Experiment 1 in Santelmann & Jusczyk (1998), except that the passages contained 3 syllable verb roots, rather than single syllable verb roots. Infants were familiarized with two types of passages, natural passages with the dependency *is* and *–ing,* and unnatural ones with *can* and –ing.

Methods

Subjects

Twenty-four (11 female, 13 male) 18-month-old infants (mean age 548 days, range: 511-566 days) completed the study. An additional 10 infants participated but did not complete the testing (3 had average looking times less than 3 seconds, 2 cried, 1 fell asleep, 3 would not turn to lights and 1 equipment failure.) All infants were recruited from monolingual English-speaking homes in the greater Baltimore, MD area.

Stimuli

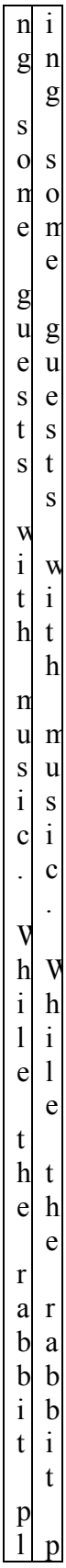
Eight sets of matched passages (16 total) with 6 sentences each were created. 2 of these matched sets (4 passages) were used as practice passages, and the remaining 6 matched passages (12 total) were used as test trials. In the "natural" set of passages, every sentence used the auxiliary verb is together with a 3 syllable main verb ending in *-ing* on the main verb. In the matched "unnatural" passages, each sentence contained the modal auxiliary *can* and the main verb ending with *-ing*, a combination which is ungrammatical in English. The natural and unnatural passages were exactly matched except for the substitution of *can* for *is* in the unnatural passages.

The sentences were constructed so that the dependency fell in different places in the sentence (early, mid or late), and the subject in each sentence was a full noun phrase in the third person singular (e.g., the rabbit), so that the auxiliary verb would always take the form *is*. The passages also included several other 3-4 syllable words so that the verbs were not the only long words in the passages. Examples of typical Natural and Unnatural passages are shown in Table 1 below.

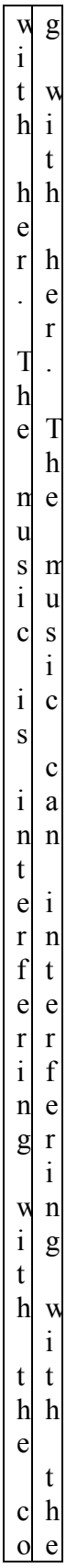
The stimuli were produced using synthetic speech (DECTalk model DTC01) so that both the natural and the unnatural passages would use the same prosody and stress on the morphemes under investigation. The stimuli were created with the voice "Beautiful Betty", with a fundamental frequency of 180 Hz.

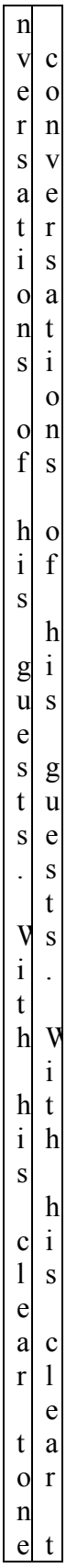
Table 1: Sample Stimuli Passages

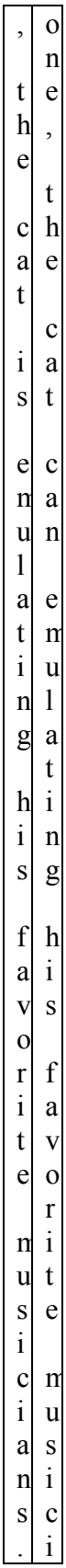
Natural Passages	Unnatural Passages
The tabby cat is entertaini	The tabby cat can entertain


ing some guests with music. While the rabbit p
ng some guests with music. While the rabbit pl

a y s t h e p i a n o , h i s g e n t l e t o n e i s h a r m o n i z i n g	l a y s t h e p i a n o , h i s g e n t l e t o n e c a n h a r m o n i z i n


with her. The music is interfering with the co
go with her. The music can interfering with the


conversations of his guests. With his clear tone


one, the cat can emulating his favorite musicians.

The rabbit thinks that the tune is hypnotizing	ans. The rabbit thinks that the tune can hypno

g	t
s	i
o	z
n	i
e	n
	g
o	s
f	o
	m
t	e
h	
e	o
i	f
r	
	t
f	h
r	e
i	i
e	r
n	
d	f
s	r
.	i
	e
S	n
h	d
e	s
	.
n	
o	S
t	h
i	e
c	
e	n
s	o
	t
t	i
h	c
a	e
t	s
t	t
h	h
e	a
	t

turtle is meandering around.	the turtle can meander around.

Design and Procedure

Infants were tested using a version of the Headturn Preference Procedure (HPP) (Kemler Nelson et al., 1995). The testing consisted of a single session. Each infant listened to 6 pairs of matched passages (12 total). Each experimental session began with four practice trials, two from each side. The practice trials were used only to get the infants comfortable with responding to the lights, and responses during the practice trials were not recorded or analyzed. The same four stimulus passages were used as practice trials for all participants, and had the same structure as the test trials. These practice trials were conducted using two sets of matched passages (four total): two "natural" passages, where the 6 sentences contained the auxiliary verb *is* together with the ending *ing*, and two matched "unnatural" passages, where the 6 sentences contained the modal auxiliary

can and the ending *ing*. The test phase began immediately following the 4 practice trials, and consisted of the presentation of the 12 passages.

Results

Mean listening times to the Natural and Unnatural passages were calculated for each of the 24 subjects. The mean listening times were averaged for the each type of passage. Across all subjects, the average listening times were 7.13 sec. (SD = 2.91 sec.) for the Natural passages and 7.68 sec. (SD = 3.16 sec.) for the Unnatural lists. There was a mean difference between the Suffixed and Control lists of -0.50 sec. A paired t-test indicated that this difference in average listening times was not statistically significant ($t(23) = -.810$, , $p = .503$).

Discussion

Unlike in previous studies, infants in the present investigation did not look significantly longer to the natural passages over the unnatural passages. One interpretation of these finding suggest that the nature of the intervening material (verb root vs. adverb) does play a role in infants' ability to detect the relationship, since the infants were not able to detect this relationship over 3 syllable verbs, even though they were able to detect the relationship over a single syllable verb + 2 syllable adverb in Santelmann and Jusczyk (1998). Another possibility is that the longer verbs were more unfamiliar to the infants, and that lexical familiarity played a role in the infants' ability to detect the relationship. A final possibility is that the prosody of the long verbs was considerably different than the prosodic contours of the passages with shorter verbs. This may have been exacerbated by the use of synthesized speech for these passages. It was extremely difficult to get DECTalk to produce natural sounding contours with the long verbs, and a number of visitors to the lab commented on the unusualness of the stimuli.

Thus, to guard against the possibility that the synthesized speech was a confounding variable in this study, the study was replicated using natural speech.

Experiment 2

This experiment was identical to Experiment 1, except that the stimuli were produced by a native speaker of English. The purpose of this study was to determine whether the naturalness of the speech had an effect on infants' ability to detect the relationship between *is* and *–ing* over long, unfamiliar verb roots.

Methods

Subjects

Twenty-four (8 female, 16 male) 18-month-old infants (mean age 556 days, range: 540-573 days) completed the study. An additional 7 infants participated but did not complete the testing due to fussiness. All infants were recruited from monolingual English-speaking homes in the greater Baltimore, MD area.

Stimuli

The stimuli in this study were exactly the same as in Experiment 1, except that for this experiment, the stimuli were produced by a female native speaker of English. She produced the stimuli in child directed speech and was careful not to stress any of the functor verbs in the sentences.

Design and Procedure

The Design and Procedure were identical to Experiment 1.

Results

Mean listening times to the Natural and Unnatural passages were calculated for each of the 24 subjects. The mean listening times were averaged for the each type of passage. Across all subjects, the average listening times were 8.98 sec. (SD = 2.94 sec.) for the Natural passages and 7.34 sec. (SD = 3.25 sec.) for the Unnatural lists. There was a mean difference between the Suffixed and Control lists of 1.65 sec. A paired t-test indicated that this difference in average listening times was statistically significant ($t(23) = 2.74$, $p = .01$).

These results suggest that 18-month-old infants are able to detect the relationship between *is* and *–ing* when the passages were produced with natural speech, but not with the synthesized speech. To provide further statistical confirmation of this observation, we performed a one-way ANOVA on the difference scores (avg. listening times for Natural passages - avg. listening times for Unnatural passages) from these two experiments. A significant effect was found for Study $F(1, 46) = 5.89$, $p < 0.01$). This strongly suggests that the type of stimuli (synthesized vs. natural) used in each study plays a role in infants' ability to process speech.

Discussion

These results suggest that 18-month-old infants are able to detect the relationship between *is* and *–ing*, even over long, presumably unfamiliar verb roots. These results suggest that it is not the verb roots themselves that are responsible for the lack of significant results in Experiment 1. Infants are able to detect the relationship between *is* and *–ing,* even when the lexical verbs intervening are unfamiliar to them. Because the infants were able to detect the relationship when the stimuli were produced in natural speech, this suggests that either naturalness of the stimuli or the prosodic contours may play a role in infants' ability to attend to these relationships.

Overall, this pair of experiments suggests that more work needs to be done in exploring infants' ability to detect morphosyntactic relationships. These studies suggest that the prosodic contour of the phrasing may play a role in infants' sensitivity to these relationships. In addition, these studies suggest that naturalness of the stimuli may also play a role not only in infants' listening preference, but their ability to extract information from the speech stream. If this result is replicated, then this has implications not only for the nature of the processing space, but also for experimental design in studies of infant speech perception.

References

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