

PROSODY AND AMBIGUOUS GERUND PHRASES  
Keith Johnson (1987)  
The Ohio State University

Natural language (as opposed to artificial languages) is filled with ambiguity. It arises at all levels of language; lexical, structural, semantic, and discourse levels all contain ambiguity. In fact, this pervasive ambiguity is one of the basic differences between natural and artificial languages. Thus, ambiguity has been of great interest to psycholinguists. If we can understand how people cope with ambiguity as they comprehend speech, we may move toward a more accurate characterization of what human language is, and how it is used.

There are at least two ways for hearers to process ambiguous phrases when they hear them. First, it may be the case that humans possess (among our other language processing abilities) an autonomous structural processor which takes as input lexical items (and possibly other aspects of the form of an utterance) and identifies constituents and computes the internal structural organization of the utterance. The chief characteristic of this hypothesis is that the syntactic structure of an utterance is computed without reference to its pragmatic or semantic content. In this view of things, all possible interpretations of an ambiguous phrase are computed and then passed on to a more contemplative component of the language processing system (i.e. a component with access to real world knowledge) which resolves the ambiguity.

On the other hand, hearers might compute the structure of an utterance more interactively. It may be that the processes which hearers use to assign structure to an incoming utterance are sensitive to factors such as prosodic and semantic context in addition to the grammatical properties of the words in the utterance. Ambiguous items (according to this approach) are often rendered functionally unambiguous by factors which interact to produce an expectation for one reading rather than the other. Thus, although a gerund phrase such as 'charming babies' is potentially ambiguous it may be rendered functionally unambiguous by the context in which it occurs. The claim here is that due to the information made available during structural processing only one structure is computed.

In one version of the autonomous structural processing hypothesis the information obtainable from prosody is taken to contribute to the work of the structural processor (I take this to be the view of Cairns (1984)). In the more extreme version of the autonomous structural processing hypothesis (Forster 1974, 1979) only lexical and grammatical information is used by the structural processor. Of course the interactive hypothesis allows for the influence of prosody in structural processing.

In this paper I will present the results of an experiment which relates to the resolution of ambiguity and the role of prosody in sentence processing. In two pretests I used a post-perceptual task to identify some factors involved in the interpretation of ambiguous gerund phrases. The main experiment uses an on-line task to test for the presence of those factors during the comprehension process.

Pretest 1

Cowart (1983) found that some of the gerund phrases in his experiment 3 showed an inherent bias. This was attributed to 'intrinsic properties of the item' which 'predisposed listeners to prefer is or are as a continuation' (p. 80). Upon a reading of his materials it seems intuitively correct to say that at least some of the ambiguous gerund phrases are biased toward one reading or the other. Thus 'frying eggs' seems to evoke a nominal reading (i.e. the act of cooking eggs a certain way) while 'starving children' seems to evoke an NP reading.

The purpose of the first pretest to be reported here was to identify for each of 40 ambiguous gerund phrases this inherent bias. In particular the experiment was designed to test the hypothesis that some syntactically ambiguous gerund phrases have a bias toward their NP reading while others are biased toward their nominal reading.

Subjects

Two groups of 16 undergraduates participated in the experiment. The subjects were native speakers of English.

Materials

Forty ambiguous gerund phrases and thirty unambiguous gerund phrases were presented to the two groups. (Examples of the unambiguous phrases are in table 1.) Of the thirty unambiguous phrases 15 could only be interpreted as nominal phrases and 15 could only be interpreted as noun phrases. The ambiguous phrases were taken from Cowart (1983) and are listed in table 2.

Table 1

Unambiguous Gerund Phrases	
NP	Nom
gleaming lights	composing sonatas
sagging bridges	listing faults
Subcategorization	Selectional
Restriction	Restriction
Intransitive verbs:	Usually verbs that
to gleam, to sag	require animate or
	human subjects.

Procedure

The materials were randomized and typed in a list with 'is/are' following each gerund phrase ('is/are' was counterbalanced with 'are/is'). The subjects were instructed to circle the verb which in their opinion is the best/most natural continuation of the gerund phrase. Subjects received instructions and wrote their responses while in a classroom situation. In this experiment as in the two to follow responses to the unambiguous filler items were used to establish a criterion level. If a subject answered correctly fewer than 66% of either type of unambiguous phrase his/her data were not included in the study.

Results

For each ambiguous gerund phrase the percent 'is' responses was calculated. The scores ranged from 100% to 0%. These values were then statistically compared with 50% using simple t tests (p = .01). From this analysis the phrases were divided into three groups (table 2). Items labeled 'no bias' were not significantly different from 50%, while items labeled 'biased toward the NP reading' showed a preference for 'are' as a continuation, and items labeled 'biased toward the Nominal reading' were more often followed by 'is'.

Table 2  
The Inherent Bias of 40 Ambiguous Gerund Phrases

Biased toward the NP reading	No bias	Biased toward the Nom reading
starving children	bathing elephants	hunting eagles
rhythmic words	nursing infants	breeding pigeons
melting glaciers	growing flowers	riding horses
cutting boards	jangling keys	cooking apples
harrying people	folding chairs	frying eggs
ringing bells	amusing people	losing games
moving pictures	boiling vegetables	drying clothes
nagging adolescents	battling lions	breaking glasses
clanking chains	enrolling students	playing cards
spinning tops	burning trees	flying kites
	visiting relatives	shaking hands
	packing cases	
	moving cars	
	training athletes	
	jostling shoppers	
	landing planes	
	racing cars	
	sailing ships	
	inviting suggestions	

Discussion

Inherent bias may be the result of the influence of real world knowledge in the selection of a best continuation. For instance, 'starving children' may be biased toward an NP reading because the subjects in the study would never actually starve children. Or it may be that the real world knowledge involved has more to do with the words in the phrases. Subjects may be influenced by the relative frequency of a particular reading or by the relative transitivity of the verb used in the construction (notice that unambiguous NP gerunds are formed with intransitive verbs).

Whatever the explanation for inherent bias, notice that we are dealing with a phenomenon which does not fall into the range of the abilities normally assumed for an autonomous structural processor, namely processing which is sensitive to real world knowledge of some sort.

Pretest 2

The second pretest was devised to test two hypotheses. The first was that unambiguous control items (NP and Nominal gerund phrases) occur with characteristic rhythmic patterns. The second hypothesis was that if there is a characteristic stress pattern associated with the unambiguous items of each type, that stress pattern is capable of changing the subject's judgment as to the most natural continuation of an ambiguous gerund phrase. If stress is used in this way we would have to say that prosody can be used to disambiguate ambiguous gerund phrases.

Subjects

Four groups of undergraduate linguistics students participated in this study. The sizes of the groups were as follows: group 1 - 14, group 2 - 19, group 3 - 18, and group 4 - 18. All subjects were native speakers of American English and none reported any hearing problems.

Materials

A native speaker of American English who was unaware of the nature of the study read sentences containing the 40 ambiguous and 30 unambiguous phrases used in the first pretest. The gerund phrases were embedded in disambiguating contexts (see Table 3).

After recording the items in sentence contexts they were spliced out of those contexts and placed at five second intervals on two test tapes. In the first of the two tapes the NP readings of the first 20 items and the nominal readings of the last 20 were recorded with the 30 unambiguous items as fillers. The second tape had the opposite readings for the ambiguous items and the order was randomized. Answer sheets were provided on which subjects were asked to indicate either (1) the location of the single most stressed syllable in the gerund phrases (groups 1 & 2), or (2) the most natural continuation of the phrase ('is' or 'are') (groups 3 & 4).

Table 3  
Disambiguating Contexts

<u>NP Reading</u>	subordinate	main
if	they .....	VERBING NOUNS are ...
when		
since		
etc.		
Example:	As they soar gracefully above the field, flying kites are often inspiring.	
<u>Nom Reading</u>	subordinate	main
if	it .....	VERBING NOUNS is ...
when		
since		
etc.		
Example:	If it is done near power lines, flying kites is dangerous.	

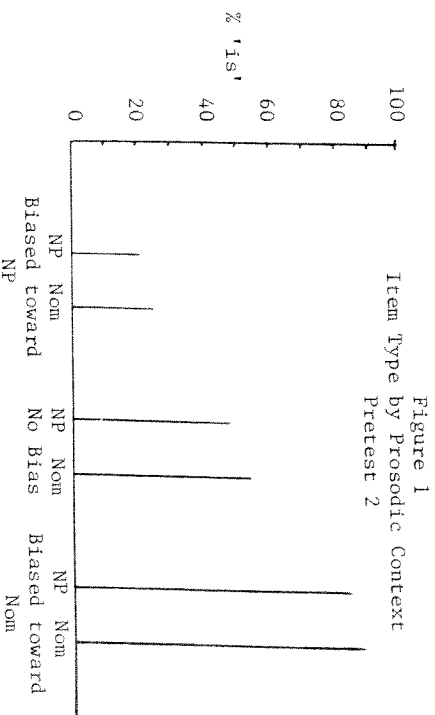
Procedure  
Each tape was played to two groups of subjects in a classroom listening situation. The tape player was a high quality portable stereo player. Volume was adjusted to the satisfaction of the subjects. For each tape one group marked the most stressed syllable in the phrase and one group indicated the most natural continuation.

Results  
In the perceived stress portion of this experiment it was found that the unambiguous nominal gerund phrases were perceived to have second word stress, while the unambiguous NP gerund phrases did not seem to occur with a characteristic stress pattern. This is a mixed result. We had hypothesized earlier that unambiguous items occur with characteristic rhythmic patterns. This hypothesis was not fully supported. Rather, it seems to be the case that the unambiguous nominal gerund phrases did occur with a characteristic stress pattern (second word stress), while subjects didn't seem to notice a consistent pattern in the placement of stress on unambiguous NP gerund phrases.

The reason that the nominal phrases appeared with a characteristic stress pattern while the NP phrases did not is that the gerund phrases were presented to subjects in isolation. Because stress can only be determined relative to a surrounding context the items which began with a stressed word had virtually no context with which to compare the 'stressed' syllable, this led the listeners to differ in their ability to hear first or second word stress.

An analysis of variance was conducted on the results of the 'most natural continuation' portion of this experiment. There was

one between subjects variable (materials groups, 2) and two within subjects variables (item type, 3; and context prosody, 2). Item type was determined by the classification presented in table 2. It should be pointed out that the materials for this experiment and the one to follow were constructed before the results of the first pretest were known, thus the data analysis was complicated by unequal n's. Unweighted cell means were used in the F tests. Figure 1 presents the results of this portion of pretest 2. As the figure indicates, the percent 'is' responses for items



inherently biased toward a nominal reading was much greater than the percent 'is' responses for items in the neutral group, and likewise the items biased toward an NP reading had a still lower percentage of 'is' responses. The variation due to type was very significant ( $F = 197.7$ ). It is also noticeable from this figure that the percent 'is' responses for the items which were read in a nominal context was slightly higher than for those items which were read in an NP context. The effect of the prosody, however, proved to be only marginally significant ( $F = 3.015$ ,  $p < .1$ ).

Tables 4 and 5 also illustrate the effectiveness of nominal prosody. Table 4 is a list of all of the ambiguous items in the experiment which were judged by subjects to have second word stress (significantly more than 50% of the subjects heard second word stress on these items). Of these twelve items ten (83%) were either already biased toward the nominal reading or shifted toward it (bias was computed in the same way that it was in the first pretest). Only one item did not change categories when accented on the second word (starving children) and this one was, in the inherent bias test, the most strongly biased item in the group. The other item shifted away from the nominal reading. I have no explanation at this time for this result.

Table 5 contains information for first word stress which is analogous to that in table 4. This analysis was done to test the possibility that first word stress (even though not present in unambiguous items) might be a cue for an NP reading. The results indicate that more items were unaffected by first word stress

Table 4  
Items with Stress on the Second Word

Item	Shift Toward		Already		Shift Toward		No Change
	NOM		NOM		NP		
Flying kites			x				
drying clothes			x				
riding horses				x			
racing cars		x					
cooking apples				x			
breeding pigeons					x		
visiting relatives (NOM)	x						
moving pictures	x						
meling glaciers		x					
starving children					x		
sailing ships						x	
visiting relatives (NP)	x						
Totals	5	5	10	5	1	1	
			10 (83%)				1 (8%)

(47%) than shifted toward (or remained at) an NP reading (31%). Also, note that a sizeable proportion of the items (22%) shift in the wrong direction. These results indicate that first word stress was not a consistent cue of the NP reading, in the way that second word stress was a cue for the nominal reading.

Main Experiment

The results of the pretests indicate that in a post perceptual task subjects are sensitive to the inherent bias of ambiguous gerund phrases and to their prosodic structure. In this experiment I tested the hypothesis that these factors can influence subjects' responses in an on-line task.

The task used to test this hypothesis is called the next word naming task (see Cowart, 1983 for a discussion of the advantages of this task over other on-line tasks). In it subjects hear a phrase, then at its offset the next word in the phrase is presented on the screen of a computer terminal. Subjects are asked to read the word aloud as rapidly as possible. Their reaction time to the visually presented word is measured.

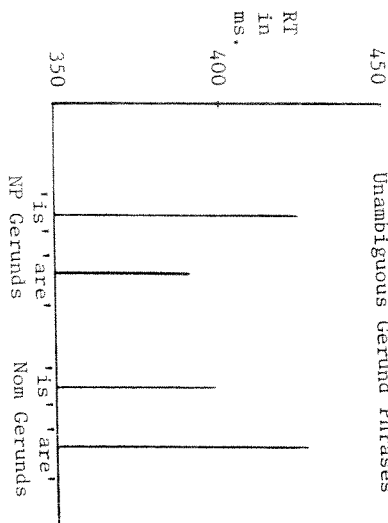
It is important to realize that this task is measuring the degree to which the word presented on the screen is compatible with the subject's expectations at that point. Thus, if subjects are presented with a word which is unexpected they will require more time to say it out loud than if the word on the screen fits their expectations. To illustrate this principle we turn to the unambiguous gerund phrases which were used as fillers in the

Table 5  
Items with Stress on the First Word

Item	Already		Shift Toward		Shift Toward		No Change
	NP		NP		NOM		
NP readings							
starving children		x					
rhyming words		x					
clanking chains			x				
spinning tops					x		
cutting boards					x		
amusing people				x			
packing cases				x			
playing cards				x			
landing planes					x		
battling lions						x	
hurrying people							x
jangling keys							x
bathing elephants							x
enrolling students							x
cooking apples				x			
nursing infants					x		
riding horses						x	
training athletes							x
frying eggs							x
breaking glasses							x
losing games							x
Nominal readings							
folding chairs				x			
rhyming words		x					
jostling shoppers						x	
moving cars							x
amusing people							x
training athletes							x
battling lions						x	
boiling vegetables							x
frying eggs							x
playing cards							x
shaking hands							x
Totals	4	6	10	6	7	15	
			10 (31%)				15 (47%)

experiment (figure 2). Notice that when NP gerund phrases were presented the reaction time for 'is' was longer than for 'are'. This indicates that the subjects were somewhat surprised by 'is' while 'are' fit their expectations and thus caused no delay in processing. Notice also that when Nominal gerund phrases were presented the reaction time for 'are' was longer than the reaction time for 'is'.

Figure 2  
Unambiguous Gerund Phrases



**Subjects**  
Twenty college students served as subjects for this experiment. They all had no previous experience in this paradigm, and none reported hearing loss. They were divided into 4 groups randomly.

**Materials**  
The same tape recordings that were used in the second pretest were used in this experiment. The experiment was run and data collected by a PDP 11-23 computer, using a Fortran program written by Wayne Cowart which I modified slightly.

**Procedure**  
Subjects were seated in a listening booth directly in front of a computer terminal and with a microphone approximately 6" from their lips. A set of instructions were recorded and played to the subjects. Subjects were given 10 practice items to familiarize them with the task. To insure active participation subjects were asked after each trial (via message on the terminal) whether the word they read aloud made a good continuation of the phrase. Answers to this question for the unambiguous filler items were used as a criterion for using a subject's data. Twenty-four subjects were run to get twenty sets of usable data.

**Results**  
An analysis of variance was computed for unweighted cell means. There was one between subjects variable (material groups, 4), and three within subjects variables (item type, 3; response word, 2; and prosodic context, 2). Less than 5% of the scores were estimated. Figure 3 shows the average reaction times for the two prosody conditions in each of the three inherent bias conditions. The prosody type labeled 'w' means that the word

presented on the terminal agreed with the prosodic context of the item presented auditorily. The prosody condition labeled 'a' means that the subjects were presented a word that did not match (was against) the prosodic context in which the phrase was originally recorded. The F value for the prosody main effect was 10.58 ( $p < .01$ ) indicating that the differences in reaction time due to prosody were significant. This indicates that the prosodic information available from these productions of ambiguous gerund phrases was available and being used within .33 of a second after their production. The prosodic pattern of the phrase set up an expectation as to whether 'is' or 'are' would be an appropriate continuation of the phrase.

Figure 3  
Type by Prosody

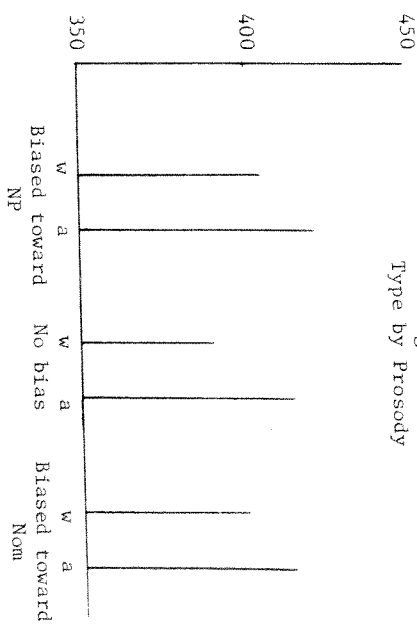


Figure 4 shows the average reaction times to 'is' and 'are' in each of the levels of bias. Notice in this figure that the items biased toward the NP reading and items biased toward the Nominal reading look like the unbiased filler items we presented in figure 2. The F value for this interaction was only marginally significant ( $p < .14$ ) and yet the value is striking enough (considering the number of estimated values) to warrant a claim that there is a tendency here.

**Discussion**

The results of this experiment indicate that prosodic context and inherent bias do influence subject's naming latencies in the next word naming task. This influence could only be present in the task if prosodic and semantic contextual

*Handwritten note:* A

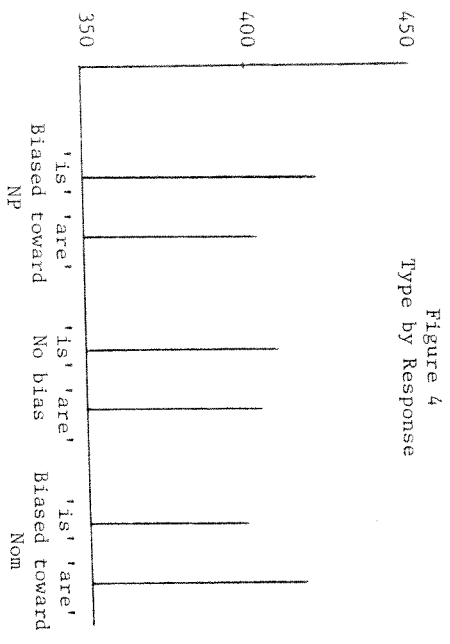


Figure 4  
Type by Response

information are being actively used by subjects to set up an expectation for the next word in the naming task. The fact that prosodic and semantic contextual information influence subjects in the next word naming task indicates that these two types of non-structural (i.e. non-syntactic) factors are involved in the resolution of ambiguity at the time that subjects are reacting to a stimulus word. (The indication is in fact that these factors are involved in setting up an expectation before the word appears on the screen.) From this we may conclude that the process of integrating contextual information with structural information has already begun when the stimulus word appears on the screen, and since the presentation of the word occurs at the offset of the gerund phrase (that is with no delay between phrase and test word) then it is probably the case that there is no point in the comprehension process at which contextual information is not being integrated with structural information.

REFERENCES

Cairns, H. 1984. Current issues in research in language comprehension. In R. Naremore (ed.). Recent Advances in Language Sciences. College Hill Press.

Cowart, W. 1983. Reference Relations and Syntactic Processing: Evidence of a Pronoun's Influence on a Syntactic Decision that Affects Word Naming. IJIC

Forster, K. 1976. Assessing the mental lexicon. In R. Wales and E. Walker (eds.) New Approaches to Language Mechanisms. Amsterdam: North-Holland.

Forster, K. 1976. Levels of processing and the structure of the language processor. In Cooper, W. and E. Walker (eds.) Sentence Processing: Psycholinguistic Studies Presented to Merrill Garrett. Hillsdale, NJ: Erlbaum.

Lehiste, I. 1973. Phonetic disambiguation of syntactic ambiguity. Glossa 7, 107-121.

Lehiste, I., J. Olive, L. Streeter. 1976. Role of duration in disambiguating syntactically ambiguous sentences. J. Acoust. Soc. Am. 60, 1199-1202.

Tyler, L. and W. Marslen-Wilson. 1977. The on line effects of semantic context on syntactic processing. JVLVB 16, 683-692.