

## Evidence for phonological constraints on nuclear accent placement\*

JAMES GERMAN

JANET PIERREHUMBERT

STEFAN KAUFMANN

*Northwestern University*

*Northwestern University*

*Northwestern University*

**1. INTRODUCTION.** The distribution of pitch accents in speech is a topic of long-standing importance because it reflects the relationships among different levels of representation: phonology, syntax, semantics, and information structure. The broad tendency for accents to be located on new information is a classic observation, but formalizing the principles that govern accent placement in all cases has proven to be a difficult challenge. In this discussion note, we use experimental data to explore in depth the accent patterns on constructions with stranded prepositions. We extend the model of Schwarzschild 1999 to account for our findings.

Function words are prosodically weaker than content words and do not ordinarily carry accents. However, Ladd (1980) notes an interesting class of exceptions. These are cases in which a preposition has been stranded at the end of an infinitival clause in which all other words are given. Ladd's dialogue (1) provides an example.

(1) A: Why don't you have some French toast?

B: There's nothing to make French toast OUT of.

In 1B, the noun *French toast* is the default location for the nuclear pitch accent by virtue of being prosodically stronger than its neighbors. However, the prosodic prominence of the noun is weak because of its recent mention in the discourse, and the nuclear accent appears on the preposition.

Our study concerns a closely related but more tractable set of examples such as 2, in which contextual effects are more carefully controlled.

(2) A: Are the children playing their game?

B: Paul took down the tent that they play their game in.

In 1, the accentability of the verb *make* is equivocal, as it is newly mentioned, but it is also a light verb which might be implied by the first clause. In our examples, the verb in the rejoinder is always given. We are concerned here only with the placement of the nuclear accent, in view of experimental results by Welby (2003) indicating that prenuclear accents are far less relevant to focus structure.

The two primary reference points for our theoretical analysis are Selkirk 1984, 1995 and Schwarzschild 1999. These proposals were developed against a backdrop of efforts to relate pitch accents to syntactic structure and information status that date back to Chomsky 1970. Liberman and Prince (1977), Ladd (1980), Pierrehumbert (1980), and Halle and Vergnaud (1987) all use autosegmental-metrical theory to handle the placement of accents in the default case where the sentence is entirely new. They also provide for shift of the accent to other locations, determined by the structure of the prosodic tree, in many of the more obvious cases of discourse givenness.

Selkirk (1984, 1995) advances beyond the works just cited by developing an explicit account of how focus structure propagates through syntactic trees. With certain simpli-

\* Work on this project was partially supported by a grant from the James S. McDonnell Foundation.

fyng assumptions, she predicts that the preposition is the only acceptable locus for a pitch accent in contexts like 2B. A closely related proposal is developed by Rochemont (1986, 1998).

The very significant contribution of Schwarzschild (1999) is a technical formulation of GIVENNESS. He proposes that accent placement is predictable for any sentence if the set of entailments of the discourse context is known. Based on those entailments, a rigorous semantic definition identifies syntactic constituents that bear a given relation to the discourse context. He uses optimality theory (Prince & Smolensky 1993, 2003) to formalize the relationship of givenness to accent placement. For any distribution of given and nongiven constituents in a syntactic tree, a set of hierarchically ranked, violable constraints determines how many accents are necessary and where they should occur. The account handles a number of cases that were problematic for Selkirk (1984, 1995), notably the case in which a nuclear accent is produced even if the entire intonational phrase is given. It makes explicit predictions about the placement of pitch accents in contexts like 2B, where a preposition is the only new information in its prosodic domain. Specifically, it predicts that an accent will occur on the preposition in such cases, since no other pattern satisfies the constraint hierarchy as well.

Schwarzschild (1999) and Selkirk (1984, 1995) do not discuss phonological constraints on prosodic structure as a possible contributor to nuclear-accent placement. In this discussion note, we present the results of a study that show that prosodic factors do compete with discourse-level factors in determining accent placement. In particular, we show, *contra* Schwarzschild (1999) and Selkirk (1984, 1995), that in contexts similar to 2B, speakers prefer to accent the direct object and tend to avoid placing accents on prepositions even when these constitute the only new information in their clause. Our results support Ladd (1980) in suggesting that prepositions are intrinsically weak, and that any account of accent placement must take into consideration the inherent prosodic prominence of particular word classes. We show that the proposal in Schwarzschild 1999 adequately accounts for our data only if it is amended to reflect the weak prosodic status of prepositions.

In our study, speakers most often placed the nuclear accent on the direct object in contexts like 2B, though they opted to accent the preposition at a rate substantially higher than zero. Building on Schwarzschild's optimality-theoretic treatment of accent placement, we propose that accent placement is best accounted for by a stochastic constraint-based grammar along the lines of proposals made by Anttila (1997) and Boersma (1997). This amended version of Schwarzschild 1999 can account for a wide range of data including our own experimental results if it is assimilated to these stochastic models.

**2. THEORETICAL BACKGROUND.** Since our study focuses on the treatment of accent placement in Selkirk 1984, 1995 and Schwarzschild 1999, we first provide a summary of each theory individually. This sets the stage for our explanation in §3.2 of what each theory predicts for our experimental contexts.

**2.1. SELKIRK 1984, 1995.** Selkirk relates the locations of accents to the discourse status of individual syntactic nodes. Following Jackendoff 1972, syntactic features called F-markers are assigned to nodes that are NEW, while GIVEN nodes remain unmarked unless they signal a contrastive meaning. A set of rules determines the number and locations of accents by constraining the way that F-markers are allowed to project from accented words to other nodes. These rules are shown in 3 and 4.

- (3) BASIC FOCUS RULE: An accented word is F-marked.
- (4) FOCUS PROJECTION:
- F-marking of the head of a phrase licenses F-marking of the phrase.
  - F-marking of the internal argument of a head licenses the F-marking of the head.
  - F-marking of the antecedent of a trace left by NP or WH-movement licenses the F-marking of the trace.

To see how the rules apply, suppose that the sentence in 5 is entirely new and has the pattern of F-marking shown.<sup>1</sup>

- (5) [[Judy]<sub>F</sub> [adopted<sub>F</sub> a parrot<sub>F</sub>]<sub>F</sub>]<sub>Foc</sub>

The rules in 4 license F-marking to project from the direct object to the verb and from the verb to the VP node. There is nothing that licenses F-marking to project to the direct object FROM any other node, however, so the only way F-marking can occur on the direct object in 5 is if it is accented. Selkirk (1984, 1995) assumes that the subject must be accented if it is F-marked.

Selkirk (1984, 1995) also predicts accent placement in specialized discourse contexts. Suppose, for example, that the sentence in 5 occurs in the context of the dialogue in 6.

- (6) A: Parrots are amazing animals.  
B: Judy adopted a parrot.

Since parrots have just been mentioned, we assume that the direct object in 6B is given, and since it is not contrastive in this context, that it does not receive F-marking. The rest of the sentence is new, so F-marking is now assigned as in 7.

- (7) [[Judy]<sub>F</sub> [adopted<sub>F</sub> a parrot]<sub>F</sub>]<sub>Foc</sub>

Since accenting obligatorily generates F-marking, and the direct object must remain unmarked, then it must also remain unaccented. F-marking cannot project to the verb and VP from the internal argument as before, so only an accent on the verb can license F-marking on those nodes. Thus, 6B is predicted to have the accent pattern in 8B, with *Ju* and *dop* accented.

- (8) A: Parrots are amazing animals.  
B: Judy *ADOPTED* a parrot.

As the above examples show, Selkirk (1984, 1995) captures a wide range of examples in which the discourse status of individual nodes is easy to determine and does so without appealing to the prosodic grammar. The theory is not able to predict accent placement directly from facts about the discourse context, however, since the relationship of the context to the discourse status of words and phrases is not formalized in any way.

**2.2. SCHWARZSCHILD 1999.** Like Selkirk (1984, 1995), Schwarzschild (1999) mediates the relationship between accent placement and the discourse status of syntactic nodes through the assignment of F-markers. The proposal differs from Selkirk's in two fundamental ways, however. First, Schwarzschild formalizes the notion of discourse status so that it may be determined directly from the entailments of the context. This is achieved through the definition in 9 (Schwarzschild 1999:151).

<sup>1</sup> For Selkirk (1984, 1995) and others, an F-marked node that is not immediately dominated by another F-marked node is said to be FOC-marked. Thus, the sentence node in 4 is taken to be F-marked because it is new and FOC-marked because it is undominated by any F-marked node.

- (9) GIVEN: An utterance U counts as given iff it has a salient antecedent A and
- a. if U is type e, then A and U corefer;
  - b. otherwise: modulo  $\exists$ -type-shifting, A entails the existential F-closure of U.

The notion of utterance (U) here is assumed to be any syntactic constituent. Inconveniently, most syntactic constituents correspond to propositional fragments which cannot possibly be entailed by anything.  $\exists$ -type-shifting is a way of transforming syntactic constituents into full propositions so that it is possible to check whether they are entailed by the context. The operation applies to any constituent by existentially closing its unfilled arguments. For example, the result of applying  $\exists$ -type-shifting to the VP in 10a is 10b.

- (10) a. [hums a happy tune]<sub>VP</sub>  
 b.  $\exists x[x \text{ hums a happy tune}]$

Existential F-closure in 9b refers to an operation that applies to constituents that have already undergone  $\exists$ -type-shifting. For any phrase U, it looks for the highest F-marked node contained in U and replaces it with an existentially closed variable. So, for example, if the object in 11a is F-marked as shown, then the existential F-closure of 11a is the proposition in 11b.

- (11) a.  $\exists x[x \text{ hums } [a \text{ happy}_F \text{ tune}_F]]_F$   
 b.  $\exists Y \exists x[x \text{ hums } Y]$

With these definitions, it is possible to determine the discourse status of any node knowing only the entailments of the discourse context. For example, if the VP in 12a is a salient antecedent for the VP in 12b, then the latter counts as given. This is because 13a, the  $\exists$ -type-shifted version of 12a, entails 13b, the  $\exists$ -type-shifted and existentially F-closed version of 12b.

- (12) a. Sean [hums a happy tune]  
 b. Angie [hums [Chopin's *Funeral march*]<sub>F</sub>]  
 (13) a.  $\exists x[x \text{ hums a happy tune}]$   
 b.  $\exists Y \exists x[x \text{ hums } Y]$

Schwarzschild's proposal also differs from Selkirk's in assuming an optimality-theoretic grammar (Prince & Smolensky 1993, 2003) in which accent placement is governed by a set of violable, hierarchically ranked constraints. In particular, the set of constraints in 14 relates the discourse status of individual syntactic nodes (according to 9) to the pattern of F-marking, and the pattern of F-marking to the locations of accents.

- (14) a. GIVENness: A constituent that is not F-marked is given.  
 b. FOC: A FOC-marked phrase contains an accent.  
 c. AVOIDF: Do not F-mark.  
 d. HEADARG: A head is less prominent than its internal argument.

As in all optimality-theoretic grammars, the constraints are organized into a hierarchy of relative priority. Outputs are selected from among candidates based on how well they satisfy the constraints, where candidates are checked first against higher constraints and against lower-ranked constraints only if there is a tie between two or more candidates. The ranking Schwarzschild proposes is given in 15.

- (15) GIVENness, FOC  $\gg$  AVOIDF  $\gg$  HEADARG

Relying crucially on the definition of givenness in 9, then, 14a constrains the distribution of F-marking. On the surface, it is a statement about how non-F-marked nodes must be interpreted. In particular, it means that a lack of F-marking on a particular

constituent indicates that there is an antecedent in the discourse that (i) is sufficiently salient and (ii) entails the  $\exists$ -type-shifted, existential F-closure of that constituent. By contraposition, however, it also requires nodes that are not given to be F-marked.

Whereas GIVENness relates discourse status to F-marking, Foc relates F-marking to accent placement. As in Selkirk's theory, a FOC-marked node for Schwarzschild is just an F-marked node that is not immediately dominated by another F-marked node. Thus, Foc, in requiring that FOC-marked phrases contain an accent, relates the number of accents to the pattern of F-marking and specifies a domain in which accents must occur.

AVOIDF simply states that candidates with less F-marking are preferable to those with more F-marking. In the absence of higher-ranked constraints, such as GIVENness, that require F-marking on certain constituents, the result of AVOIDF would always be the total absence of F-marking. Importantly, AVOIDF also has the effect of limiting the number of accents. After all, Foc does not limit the number of accents in a FOC-phrase; it merely requires that there be at least one. Since Schwarzschild (1999) assumes that all accented words are F-marked, any accent on a node that is not already F-marked (e.g. according to the requirements of GIVENness) incurs additional violations of AVOIDF. In this way, AVOIDF indirectly limits the number of accents by limiting the number of F-markers that are allowed. In general, therefore, pitch accents are not predicted to occur on given items except in cases where Foc cannot be satisfied otherwise, as in the case of all given FOC-phrases. Schwarzschild (1999) gives the example in 16.<sup>2</sup>

- (16) {[the rising of the TIDES] depends upon [the MOON being full], and}  
 [the MOON<sub>F</sub> being full]<sub>FOC</sub> depends upon [the position of the SUN<sub>F</sub>]<sub>FOC</sub>

Schwarzschild stipulates that the second occurrence of the NP *the moon being full* is FOC-marked because it has undergone a shift from object position to subject position. Accordingly, the only way FOC can be satisfied is if some element inside the NP is accented. Since everything inside the NP is given, satisfying FOC necessarily involves accenting a word that is given.

The lowest-ranked constraint, HEADARG, encodes the head-argument asymmetry into the grammar directly. Its effect is to narrow down accent placement when higher-ranked constraints do not distinguish between available loci, in particular, when more than one element in a FOC-phrase is new, or, as in 16, all elements in a FOC-phrase are given.

The above summary shows how Schwarzschild (1999) captures the same facts about accent placement that Selkirk (1984, 1995) does without requiring that the discourse status of words and phrases be known. Instead, it is able to make explicit predictions about the locations of accents in a sentence for any context whose entailments are known.

**3. EXPERIMENT.** In this section we describe an experiment in which subjects were asked to provide naturalistic productions of sentences occurring in the context of carefully controlled dialogues like that in 2. In this way, we were able to test specific

<sup>2</sup> It should be noted that there are more available renditions than the one in 16. In cases of hyperarticulation, for example, a speaker may choose to accent more than one word in each NP giving rise to patterns like (i), where bracketing indicates the boundaries of FOC-phrases.

(i) [The MOON] [being FULL] [DEPENDS] [upon the POSITION] [of the SUN]

Such examples of facultative phrasing necessarily involve additional violations of AVOIDF. We assume here that AVOIDF undergoes reranking in order to allow for the added intonational structure. This does much of the work of Pierrehumbert 1993, in which iMin, or the specified minimal intermediate phrase, ranges over prosodic categories from the foot to the intermediate phrase at the phrasal grid level.

predictions of the above theories regarding the relationship of discourse context to the locations of nuclear accents.

**3.1. MATERIALS.** The sentences we tested each contained an embedded relative clause (either finite or nonfinite) in which the VP consisted of the following sequence of elements: a verb, a direct object NP, and a preposition that is stranded by relative clause extraction of its argument. An example is given in 17.

(17) Paul took down the tent that they play their game in.

The pattern of given and new elements in such sentences can be altered by manipulating the discourse context that precedes them. Without appealing too closely to any particular theory or definition, it is apparent that when 17 occurs in the context of 18, nothing in the embedded VP of the embedded clause counts as given.

(18) A: Why are the children upset?

B: Paul took down the tent that they play their game in.  
new

When 17 occurs in 19, by contrast, everything in the VP besides the preposition counts as given, while the preposition remains new.

(19) A: Are the children playing their game?

B: Paul took down the tent that they play their game in.  
given new

By transcribing the locations of accents in speaker productions of such sentences, it is possible to test predictions about the relationship between the discourse status of specific elements and the location of pitch accents.

The set of materials used in the experiment consisted of thirty SCENARIOS, where each scenario consisted of three dialogues corresponding to each of three conditions. One condition corresponded to the BROAD-FOCUS context and resembled 18 in terms of the pattern of given and new in the rejoinder. A second condition, corresponding to the NARROW-FOCUS context, involved dialogues like 19. A third condition, shown in 20, involved dialogues similar to those in the narrow-focus context, but with a pronoun rather than a full NP in the place of the direct object.<sup>3</sup>

(20) A: Are the children playing their game?

B: Paul took down the tent that they play it in.

Each subject was presented with one of three ITEM SETS, which were balanced across the three conditions. The three dialogues from each scenario were divided among the three item sets, so that each subject was presented with ten items in the broad-focus condition, ten items in the narrow-focus condition, and ten items in the condition involving narrow focus with pronoun substitution, though subjects never encountered more than one item from the same scenario.

All three item sets included the same twenty BASELINE ITEMS. Like the target items, these involved dialogues in which the initial sentence was designed to induce given

<sup>3</sup> This third condition addresses a concern expressed to us by Mary Beckman (p.c.), namely, that a repetition of a full NP that is given is highly unnatural, and speakers may not provide natural productions as a result. The predictions, it turns out, are the same whether the direct object is a pronoun or a full NP, since it is given in either case. Pronouns are even less likely than prepositions to carry accents, so it is merely the case that the accent is predicted not to fall there independent of the theoretical predictions. An accent on the verb, however, is still an open possibility and would provide evidence against the hypothesis being tested.

status in some part of the rejoinder. The mention of *pyramid* in 21A, for example, causes its second occurrence in 21B to count as given, with *Az* accented.<sup>4</sup>

(21) A: The casino was designed to look like an Egyptian pyramid.

B: It looks a lot like an Aztec pyramid from ⟨this⟩ angle.

Unlike the target items, however, the baseline items did not involve sentence-final prepositions or any other contextual factors likely to interfere with deaccenting of the given item. Rather, they were constructed so that even standard intuitions predict, as 21B indicates, that the accent shifts away from the given item.

Because our baseline examples involve straightforward predictions, they can be used to gauge the tendency of individual subjects to attend to the context when giving their responses. In contexts like 21, for example, attentive subjects will react as if they interpret *pyramid* as given and shift the accent onto *Aztec*. Subjects who are not attending to the context will react as if they attribute broad focus to the response and place an accent on the given item as in 22.

(22) B: It looks a lot like an Aztec PYRAMID from ⟨this⟩ angle.

Consequently, the frequency with which a subject uses an unshifted accent pattern on the baseline items provides an estimate of the likelihood that he or she will fail to attend to the context. That is, it estimates the rate at which a default reading is used in a nondefault context. More importantly, it indicates whether any default-type responses on narrow-focus items are actually attributable to a narrow-focus interpretation, or whether subjects are giving that response in error. For example, if the proportion of default-type responses on narrow-focus items is similar to the proportion of baseline errors, then these are most likely attributable to speaker error. If, however, the proportion of such responses is significantly different from the baseline items, then that difference can be attributed to real speaker preferences and it informs our test of the theoretical predictions.

In addition to thirty target items and twenty baseline items, each of the three item sets contained the same ten FILLER items. These items also consisted of speaker dialogues, but involved no material in the context that was intended to induce givenness or stress shift in the response and no relative clauses with stranded prepositions.

The three item sets were pseudo-randomized with regard to item type (test, baseline, filler) and condition (broad focus, narrow focus, narrow focus with pronoun substitution).

**3.2. PREDICTIONS.** Selkirk (1984, 1995) and Schwarzschild (1999) make similar predictions about accent placement in the contexts used in our experiment. In the narrow-focus context, Selkirk (1984, 1995) predicts that an accent will occur on the preposition if one occurs at all in the VP. The theory does not allow noncontrastive given items to be accented or F-marked, so the lower VP cannot acquire F-marking from the direct object or the verb. Since adjuncts do not project F-marking, the higher VP must also remain unmarked. According to Selkirk, therefore, the only way of assigning F-marking to the VP in 19B is as shown in 23.

(23) play their game [[in]<sub>F</sub> t]<sub>FOC</sub>

The rules of F-projection state that F-marking must originate from a pitch-accented word and may project from internal arguments to heads and from heads to phrases. They also state, however, that F-marking may project onto a trace from its antecedent.

<sup>4</sup> Here and throughout, angled brackets indicate optional pitch accents.

There are therefore two ways of deriving the focus structure in 23. Either (i) a pitch accent generates F-marking directly on the preposition, which then projects onto the phrasal node as shown in Figure 1, or (ii) the trace inherits F-marking from its antecedent (the nominal head of the relative clause), which then projects onto the preposition and from there to the phrasal node as shown in Figure 2.

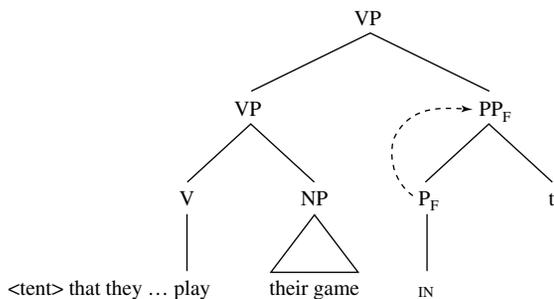


FIGURE 1. F-marking originates with accented preposition.

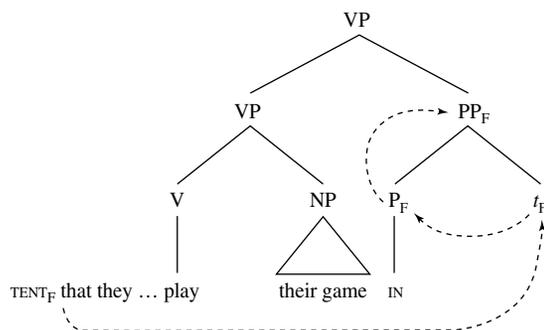


FIGURE 2. F-marking originates with trace antecedent.

In the first case, a pitch accent is required on the preposition, since F-marking can never reach the preposition or PP otherwise. In the second case, no pitch accent is required, though having one on the preposition is not ruled out. Although accents generate F-marking obligatorily, nothing rules out the presence of an accent on a word that acquires F-marking via projection from some other node. What both situations have in common is that a pitch accent is not predicted to occur outside of the PP. Placing one on the preposition is at worst redundant, but not forbidden, as in the case of Figure 2. Placing one on the NP or verb, however, creates F-marking on a given constituent, which is not allowed by the theory unless it is also assumed to be contrastive.

Schwarzschild (1999) similarly predicts that the preposition is the only appropriate accent locus in the narrow-focus context and that having one there is obligatory. To see why, it is first necessary to check which nodes within the VP are given according to the definition in 9, repeated here as 24.

- (24) GIVEN: An utterance *U* counts as given iff it has a salient antecedent *A* and
- if *U* is type *e*, then *A* and *U* corefer;
  - otherwise: modulo  $\exists$ -type-shifting, *A* entails the existential F-closure of *U*.

The context we are interested in is repeated in 25.

(25) A: Are the children playing their game?

B: Paul took down the tent that they play their game in.

Since GIVENness is not dominated by any other constraints, knowing which nodes require F-marking follows straightforwardly from their discourse status. Starting with the innermost node, part (a) of the definition in 24 states that the NP *their game* in 25B is given and does not require F-marking since it is coreferential with *their game* in 25A. To check whether the verb *play* is given, it is necessary to check whether its  $\exists$ -type-shifted, existentially F-closed counterpart is entailed by 25A. First, applying the  $\exists$ -type-shifting operation to 26a, we get 26b.

(26) a. [play]

b.  $\exists x\exists y[x \text{ play } y]$

Recall that existential F-closure replaces the highest F-marked node within the node being checked with an existentially closed variable. Since there are no F-marked nodes contained within 26b, the operation leaves it unchanged. Finally, we check whether 25A entails 26b, and since it does, we establish that the verb counts as given and does not require F-marking.<sup>5</sup> The lower VP node consisting of [play their game] is also given. Applying  $\exists$ -type-shifting to 27a we get 27b.

(27) a. [play their game]

b.  $\exists x[x \text{ play their game}]$

Again, existential F-closure does not alter 27b, since neither the verb nor the NP is F-marked. Since 25A entails 27b (see n. 5), the embedded VP also counts as given and therefore does not require F-marking. Although Schwarzschild (1999) does not explicitly define  $\exists$ -type-shifting for adjuncts, checking the given status of the preposition and the prepositional phrase [in *t*] is straightforward. Neither node has a salient antecedent since there is no PP in 25A, so they cannot be given. Both nodes must therefore be F-marked. The example in 28 shows the pattern of F-marking that has been established so far for the embedded VP in 25B.

(28) [play their game<sub>VP</sub>] [in<sub>F</sub> *t* PP]<sub>F</sub>

Notice that since the prepositional phrase contains a trace, merely applying existential closure to the subject argument of 28 would result in a nonpropositional fragment. In order to deal with this problem, we could follow the convention Schwarzschild proposes for applying existential closure to interrogatives, which in this case yields 29.

(29)  $\exists x[\text{play their game}_{VP}] [\text{in}_F x \text{ PP}]_F$

The details of the trace turn out to be unimportant, however, since the application of existential F-closure replaces the entire PP with a variable. The example in 30 shows the result of applying both  $\exists$ -type-shifting and existential F-closure to 29.

(30)  $\exists x\exists P[x \text{ play their game } P]$ ; where P is a properties of events

<sup>5</sup> Strictly speaking, since 25A is a question, it does not entail any propositions under standard semantic assumptions. Saying that it entails 26b is merely a shorthand for saying that the  $\exists$ -type-shifted form of the antecedent in 25a,  $\exists x\exists y[x \text{ is playing } y]$ , entails 26b. Similarly for the VP node. Example 25A 'entails' 27b because the antecedent,  $\exists x[x \text{ are playing their game}]$ , entails 27b. See Schwarzschild 1999:147–51 for a discussion of entailment by antecedents.

Checking whether 30 is entailed by its antecedent in 25A is not as straightforward as it is for other nodes. The question depends crucially on whether the entailment of the  $\exists$ -type-shifted, existential F-closure of a simple event implies the entailment of that event with some unspecified property applied to it. In other words, is it reasonable to assume that when a context entails that something happened, that it also entails that it happened in *SOME* manner, in *SOME* location, at *SOME* point in time, and so forth? Intuitively, this does not seem right, especially since the criterion of salience would require that the existence of such a property be indicated in the context. The two alternatives do not ultimately give rise to different predictions about accent placement. Nevertheless, we cover them separately in our explication of what the theory predicts.

Under the assumption that properties of events are NOT automatically entailed, 30 is not entailed by 25A. As a result, the higher VP node does not count as given, and GIVENness requires it to be F-marked, as shown in 31.

(31) [play their game [in<sub>F</sub> t]<sub>F</sub>]<sub>F</sub>

The IP node has no unfilled arguments, so to check whether it is given, we simply apply existential F-closure. Since the expression  $\exists P'$  [they P'] (where P' is a property of individuals) is entailed by (25A), the IP is given and remains unmarked. This in turn means that the higher VP node is FOC-marked, since it is not immediately dominated by another F-marked node. This situation is shown in 32.

(32) [play their game [in<sub>F</sub> t]<sub>F</sub>]<sub>FOC</sub>

Thus far, we have established that the pattern of F-marking in 32 satisfies GIVENness. The next step is to determine how accents can be assigned in a way that satisfies the other constraints. FOC states that a FOC-phrase (in this case is the higher VP node) must contain a pitch accent. Since FOC is inviolable in the context of this hierarchy, AVOIDF and HEADARG are left to select the location of the accent within the higher VP. The tableau in 33 shows a comparison of some of the candidates.<sup>6</sup>

(33) Narrow focus: VP is a FOC-phrase.

	[play their game [in t]] <sup>7</sup>	GIVENness	FOC	AVOIDF	HEADARG
a.	[play their game [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>		*!	***	
b.	[ <sup>es</sup> play their game [IN <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			***	*
c.	[play their GAME <sub>F</sub> [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			****!	
d.	[PLAY <sub>F</sub> their game [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			****!	*

Since GIVENness requires that the preposition be F-marked in any candidate structure, placing an accent there incurs no further violations of AVOIDF. Placing an accent on a

<sup>6</sup> A full comparison would involve an unnecessarily large number of candidates. Since GIVENness is undominated, any candidate with less F-marking than 32 will fatally violate that constraint. We therefore compare only the subset of candidates that satisfy GIVENness. Candidates that involve more than one accented item have also been omitted. It suffices to show that any accent outside of the PP fatally violates AVOIDF, so candidates with accents in addition to the one on the preposition or candidates with more than one accent outside the PP are eliminated along with 33c and 33d.

<sup>7</sup> We might think of the input here as being the syntactic representation of the VP (minus any F-marking) plus the set of all contextual entailments. Since this would be impossible to represent, a more descriptive representation of the input might include some sort of feature markup that tracks the discourse status of each node independently of F-marking, as in (i).

(i) [play<sup>G</sup> their game<sup>G</sup> [in t]]<sup>G</sup>

given item such as the NP or the verb, however, does incur additional violations. Since AVOIDF is the most highly ranked constraint after GIVENness and FOC, the candidate that incurs the fewest violations of AVOIDF is the optimal output. Under one set of assumptions, then, the theory predicts that a pitch accent will occur on the preposition and nowhere else within the VP.

The alternative assumption, namely that the existence of some property of an event is entailed whenever the event is entailed, also predicts that the preposition must be accented. Under that assumption, 30 is entailed by 25A, so the higher VP is given and remains unmarked. Since the PP is not immediately dominated by another F-marked node in that case, it is FOC-marked in addition to being F-marked, as 34 shows.

(34) play their game  $[[in]_F t]_{FOC}$

Now FOC requires that a pitch accent occur within the PP. Since the preposition is the only phonologically realized element in the PP, the accent must fall there. As before, an accent anywhere else is forbidden, since it would incur an additional, and fatal, violation of AVOIDF. Regardless, therefore, of what assumption is made about the entailment of adjuncts, Schwarzschild (1999) predicts that a pitch accent must occur on the preposition and nowhere else in the VP.

For the broad-focus context in which the VP is entirely new, both Selkirk (1984, 1995) and Schwarzschild predict that an accent on the direct object is obligatory. For Selkirk, there are two reasons why this is so: (i) only the direct object can project its F-marking to all other nodes within the VP (verb, lower VP, higher VP), and (ii) the direct object cannot be interpreted as F-marked unless it is accented. As in the narrow-focus context, F-marking on the preposition and the PP must be licensed either by the presence of an accent on the preposition or by the presence of F-marking on the trace. An accent on the preposition is therefore either obligatory or optional depending on the status of the trace, but it is not prohibited. An accent on the verb is also not prohibited, since nothing prevents accents on items that are already F-marked.

For Schwarzschild (1999), the direct object must receive an accent because FOC requires one within the higher VP, and HEADARG favors arguments over heads.<sup>8</sup> Nothing in the VP has a salient antecedent, so GIVENness requires every node to be F-marked. Since the IP is given (i.e. ‘the children are upset’ entails  $\exists P'[\text{they } P']$ ), the higher VP is a FOC-phrase, and FOC therefore requires it to contain an accent. AVOIDF does not distinguish between locations in this case since all the relevant nodes are F-marked for independent reasons. An accent on either the preposition or the verb violates HEADARG, so the direct object is singled out as the obligatory accent locus. The tableau in 35 compares the candidates (as earlier, the comparison is limited; see n. 6 and 7 for discussion).

<sup>8</sup> We assume that an accent on the preposition results in an additional violation of HEADARG. As it is stated, HEADARG technically distinguishes between elements that are in a head-argument relation, and not just between any pairing of a head and an argument. It does not distinguish, therefore, between a preposition and an NP that is the argument of a verb. This does not matter when comparing candidates, however. But according to one theory of NP extraction, the prepositions in our examples do have arguments in spite of the fact that these do not get spelled out. Thus, while accenting the preposition over the direct object does not constitute a violation of HEADARG as it applies to some relation between those two elements, it does constitute a violation of the constraint as it applies to the preposition and its internal argument, namely, the trace.

## (35) Broad focus: PP is a FOC-phrase.

	[play their game [in t]]	GIVENness	FOC	AVOIDF	HEADARG
a.	[play <sub>F</sub> their <sub>F</sub> game <sub>F</sub> [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>		*!	*****	
b.	[play <sub>F</sub> their <sub>F</sub> game <sub>F</sub> [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			*****	*!
c.	<sup>ES</sup> [play <sub>F</sub> their <sub>F</sub> game <sub>F</sub> [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			*****	
d.	[PLAY <sub>F</sub> their <sub>F</sub> game <sub>F</sub> [in <sub>F</sub> t] <sub>F</sub> ] <sub>FOC</sub>			*****	*!

In contrast to Selkirk, accents in addition to the one on the direct object are ruled out since they necessarily involve fatal violations of HEADARG.

To summarize, Schwarzschild (1999) and Selkirk (1984, 1995) both predict for the two narrow-focus contexts that an accent will occur at most on the preposition. Schwarzschild additionally predicts that an accent there is obligatory. In the broad-focus context, both theories predict an obligatory accent on the direct object. Tables 1 and 2 provide a summary of these predictions. Parentheses indicate optionality.

	VERB	NP	PREPOSITION
BROAD FOCUS	(accent)	accent	accent
NARROW FOCUS	no accent	no accent	accent
NF-PRONOUN	no accent	no accent	accent

TABLE 1. Summary of Schwarzschild's predicted accent loci.

	VERB	NP	PREPOSITION
BROAD FOCUS	(accent)	accent	(accent)
NARROW FOCUS	no accent	no accent	(accent)
NF-PRONOUN	no accent	no accent	(accent)

TABLE 2. Summary of Selkirk's predicted accent loci.

Assuming for the moment that the preferred pattern in the broad-focus context is as predicted, then if the percentage of responses in the narrow-focus condition with a nuclear accent on the direct object is similar to the percentage of error responses on the baseline items, then responses with a nuclear accent on the direct object may be viewed as errors. If, however, the proportion of such responses is significantly greater than the proportion of baseline errors, there is good evidence that the predictions of both theories are inconsistent with speaker judgments. In short, the predictions we want to test are the following.

(36) BROAD FOCUS: The direct object always receives a nuclear accent.

(37) NARROW FOCUS: Given items (verb, direct object) do not receive a nuclear accent at a rate higher than baseline error.

**3.3. SUBJECTS.** Twenty-four Northwestern University undergraduate students participated in the experiment for course credit. All were native, first-language speakers of English.

**3.4. PROCEDURES.** Prior to the experiment, all of the prompts ('Speaker A' sentences) were prerecorded by a female native speaker of English. These recordings were produced in a sound-attenuated booth, digitized at 22 kHz, and burned onto an audio CD as individual tracks.

During the experiment, subjects sat in the same sound-attenuated booth, which contained a CD player connected to an audio speaker. Subjects were given control

over playback of the CD which contained recordings of the prompts. They were also given a script of the dialogues in the item set assigned to them. They were instructed to listen to each prompt and then provide a rendition of the corresponding rejoinder ('Speaker B' sentence) in a conversational manner using the wording shown on the script.

Responses were recorded and digitized at 22 kHz using ProTools audio software. All coding was conducted by one of the authors and involved a combination of coder assessment of relative prominence and visual inspection of the pitch track using Praat 4.0. Test items were coded according to which syntactic unit in the sequence [V NP P] received a nuclear pitch accent. Baseline items were coded for whether the given item was appropriately deaccented.

To summarize, twenty-four Northwestern University undergraduates were each presented with a total of sixty dialogues (thirty test items, twenty baseline items, ten filler items). The subjects were provided with a script of each dialogue and presented with a prerecorded audio stimulus corresponding to Speaker A's contribution to each dialogue. The subjects then responded out loud, thereby providing their own assessment of the most natural reading for Speaker B's contribution.

**3.5. RESULTS.** Overall, the results show that nuclear accents are more likely to occur on either the NP or the verb than on the preposition, even when the preposition is the only new element. In the broad-focus context the accent fell almost exclusively on the NP. In the narrow-focus context, the accent was somewhat more likely to occur on the preposition (32%), but the NP was still highly preferred (64%). In the narrow-focus context involving pronoun substitution, the preferred accent locus was the verb (77%), and the accent fell on the preposition only 15% of the time. These results are summarized graphically in Figure 3.

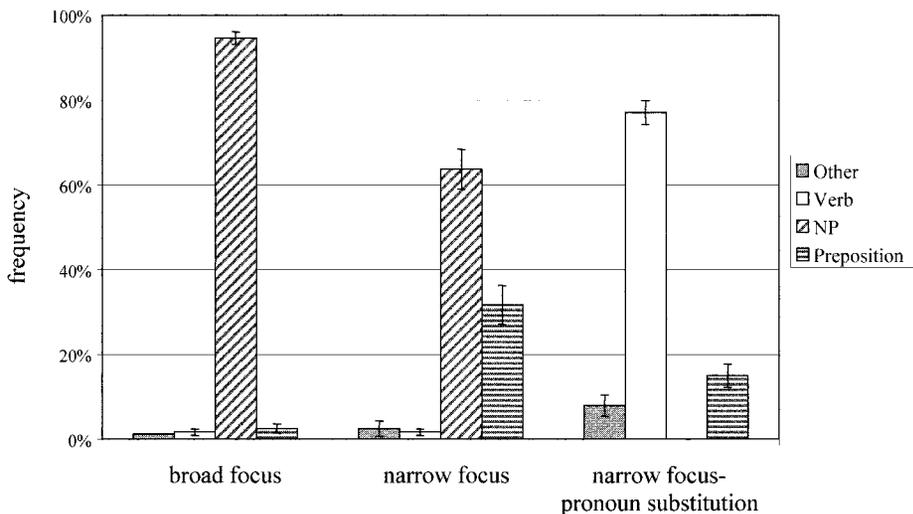


FIGURE 3. Mean frequency of nuclear pitch accent at each locus by condition.

Three of the baseline items could not be used for reasons related to coding. The mean score across subjects on the seventeen remaining baseline items was  $91 \pm 1.5\%$ . Eight subjects scored 100%, while twelve scored 90% or higher. The lowest score was

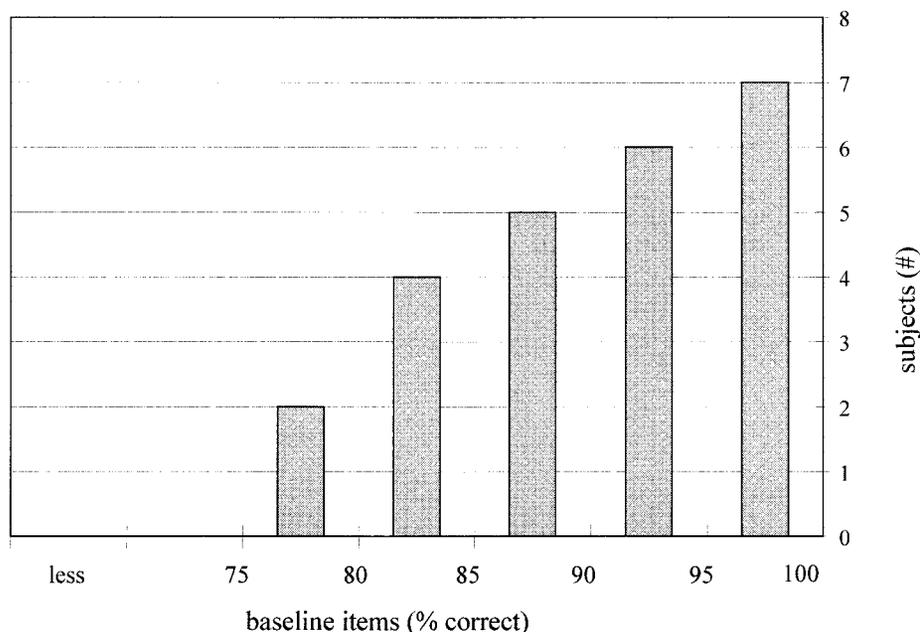


FIGURE 4. Distribution of subject performance on baseline items.

76% (two subjects). Figure 4 shows the distribution of subject performance on baseline items. Since the baseline items provided a measure of the expected error rate on narrow-focus items, a by-subjects ANOVA was used to compare the proportion of baseline errors to the proportion of items in each of the two narrow-focus conditions in which a given item received a nuclear accent. In each case, the means were found to differ significantly ( $p < 0.0001$ ).

Pooling across items, a paired  $t$ -test revealed a significant main effect of broad versus narrow focus on the proportion of NPs receiving nuclear accents ( $t = 6.510$ ,  $p < 0.001$ ). The same comparison was also significant for the proportion of prepositions receiving nuclear accents ( $t = 4.733$ ,  $p < 0.001$ ). Since pronouns did not carry accents in our experiment, a comparison of broad focus versus narrow focus with pronoun substitution needs to involve only the proportions associated with prepositions. The comparison was found to be highly significant ( $t = 4.733$ ,  $p < 0.001$ ).

A by-items analysis revealed a similar pattern of differences among means. Broad versus narrow focus was found to be a significant main effect for the proportion of NPs receiving nuclear accents ( $t = 6.161$ ,  $p < 0.001$ ), as well as for a comparison of the proportions of prepositions receiving a nuclear accent ( $t = 6.161$ ,  $p < 0.001$ ). There was also a significant main effect of broad focus versus narrow focus with pronoun substitution for a comparison of nuclear accented prepositions ( $t = 2.390$ ,  $p < 0.024$ ).

To summarize, subjects were more likely to place an accent on the preposition if the rest of the VP was given than if it was not given, but overall, accenting the NP (in the narrow-focus condition) or the verb (in the narrow-focus condition with pronoun substitution) was preferred to accenting the preposition.

**3.6. DISCUSSION.** The result that speakers prefer to accent nouns and verbs rather than prepositions even when the nouns and verbs are given and the prepositions are

not is contrary to the predictions of Schwarzschild (1999) and Selkirk (1984, 1995). Both predict that accents will not occur on given items outside the PP. In Selkirk's theory, accents obligatorily generate F-marking, and F-marking is stipulated to be disallowed on nodes that are given but not contrastive. Accenting such an item, therefore, is straightforwardly prohibited. There is no obvious way to modify Selkirk's theory to accommodate our results.

Schwarzschild's theory is more readily adapted, because the accenting of noncontrastive given items is allowed in certain instances. The fact that it occurs in our results, then, while inconsistent with the theory as it stands, does not imply a rejection of any of its major premises. In fact, as we showed in 33 in §3.5, the difference between an accent on the preposition and one on the NP in the narrow-focus context amounts to a difference of one violation of AVOIDF. Accounting for cases where the theory seems to overgenerate is merely a matter of augmenting the constraint set, a valid move if the proposed additional constraint is independently justifiable.

Our proposal incorporates insights from Ladd (1980) and Altenberg (1987) and integrates them into Schwarzschild's more modern formalism. Ladd proposes that word classes are inherently more or less accentable. Altenberg's corpus study reveals differential accentuation rates for words by class, and a particularly low rate for prepositions as a category. Across twelve grammatical categories, eight of which were functional categories, prepositions received a prominent pitch movement in less than 5% of all tokens and were only more likely than determiners and relative pronouns to do so. Even when they occurred in what Altenberg calls 'focal territory' at the right edge of a tone unit, prepositions were more likely to be postnuclear (63%) than to carry a nuclear accent themselves (37%). For determiners, comparable figures were 92% for postnuclear position and 18% for nuclear position, and for nonlexical verbs the figures were 27% for postnuclear position and 73% for nuclear position.

Accordingly, we can incorporate the resistance of prepositions to accents as 38.<sup>9</sup>

(38) \*ACC<sub>PREP</sub>: Do not accent a preposition.

In our study, speakers generally preferred to accent given items rather than prepositions. The resulting output inexplicably incurs an extra violation of AVOIDF. In the augmented constraint set, \*ACC<sub>PREP</sub> must thus dominate it in the hierarchy, which is shown in 39.

(39) GIVEN<sub>ness</sub>, FOC, \*ACC<sub>PREP</sub> >> AVOIDF >> HEAD<sub>ARG</sub>

We now turn to the fact that in the pooled data, speakers produced more than one output per target type. In fact, while they were most likely to accent the NP or the verb in the two narrow-focus conditions, they nevertheless opted to accent the preposition in approximately 23% of all narrow-focus trials. In contrast to the baseline condition, only one speaker produced a particular pattern uniformly (by accenting the given noun 100% of the time). Since items were not repeated during the experiment, it is possible in principle that subtle syntactic differences among the outcomes were responsible for the variable results. Given the tightly controlled nature of the materials, however, it

<sup>9</sup> The fact that this constraint is formulated so as to generalize to a particular grammatical class raises the important question of whether it may belong to a class of constraints of the form \*ACC<sub>X</sub>, for all grammatical classes X. An interaction between constraints of this type would provide a very general account for the apparent head-argument asymmetry. For example, if AVOIDF >> \*ACC<sub>VERB</sub> >> \*ACC<sub>NOUN</sub>, it would reflect the fact that nominal arguments of verbs receive an accent in the broad-focus case, but the accent shifts to the verb if the noun is given.

appears more likely that the grammar itself generates the variable outcomes observed for almost every speaker.

As Anttila (1997) already notes, variable outcomes can be generated by variable constraint ranking. The constraint ranking is fixed by random selection on each individual trial. In the present case, the two rankings which must be supported are ones in which \*AccPREP outranks AVOIDF, as in 39, and one in which AVOIDF outranks \*AccPREP, as in 40.

(40) GIVENness, FOC  $\gg$  AVOIDF  $\gg$  HEADARG, \*AccPREP

Boersma (1997) and Boersma and Hayes (2001) extend Anttila's original insight by allowing constraints to occupy positions along a continuum or scale of constraint STRICTNESS. In general, constraints that occupy higher positions on the scale outrank those that occupy lower positions. On any given evaluation of the candidate set, however, the value of each constraint is determined stochastically, that is, according to its position on the strictness scale plus or minus noise in the rankings. Specifically, the constraints are associated with Gaussian distributions representing the likelihood of taking on values in their range. Since constraints are not fixed, the relative ranking of those that are close to one another may vary on repeated evaluations. A constraint with a mode that is higher on the scale will generally outrank one with a lower mode. With some nonzero probability corresponding to the degree to which their distributions overlap, however, the opposite orientation will obtain. The result is that outputs will also be evaluated variably.

In our proposal, the variability among outputs is accounted for by the possibility of two distinct orientations of \*AccPREP and AVOIDF, where \*AccPREP outranks AVOIDF with a higher probability than the reverse. Such a possibility is offered by a model in which the distribution associated with \*AccPREP has a mode slightly higher on the scale than that of AVOIDF, but the tails of the distributions overlap significantly. Figure 5 illustrates this relationship schematically.

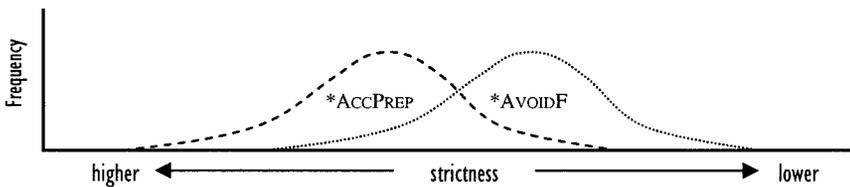


FIGURE 5. Strictness distributions of constraints that are close may overlap.

On a given evaluation of the candidate set, if the strictness value for \*AccPREP is to the right of that for AVOIDF, as shown in Figure 6, then the accent will occur on the NP or the verb.

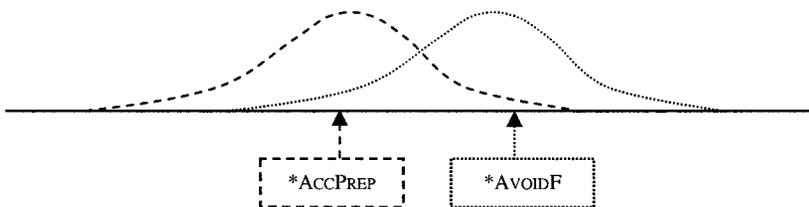


FIGURE 6. \*AccPREP  $\gg$  AVOIDF: Accent falls on given NP or verb.

But if the sampled strictness of AVOIDF happens to be higher than that of \*ACCREP, as shown in Figure 7, then the accent will fall on the preposition.

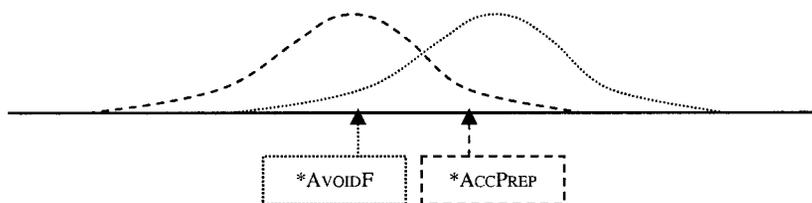


FIGURE 7. \*AVOIDF >> ACCREP: Accent falls on preposition.

The fact that subjects in our study produced accents on NPs or verbs in approximately 71% of all narrow-focus tokens suggests a model in which \*ACCREP always has a .71 probability of having a higher strictness value than AVOIDF on any evaluation. Modeling the grammar in this way not only allows us to account for why certain patterns are preferred in our results, but it also reflects the optionality we found there.

Assigning a probability of .71 to \*ACCREP reflects the behavior of an average speaker and thus does not necessarily reflect any particular speakers' grammar. In fact, the GRADUAL LEARNING ALGORITHM is designed to be a model of how speakers learn rankings through experience. There will be little between-speaker variation with regard to constraints that are applied uniformly by the adult population that the child is exposed to. For constraints whose rankings vary stochastically, however, differences of experience are predicted to give rise to differences in output frequencies. The model can therefore account for why some speakers accented given items in as many as 100% of trials and some did so in as few as 40% of all trials.

**4. CONCLUSION.** In conclusion, our results clearly show that both Selkirk (1984, 1995) and Schwarzschild (1999) make incorrect predictions about accent placement in the context we studied. Selkirk 1984, 1995, we suggest, cannot be easily reconciled with our results. We instead propose to amend Schwarzschild 1999 in light of evidence that prepositions are relatively poor carriers of pitch accents. With the addition of one new constraint, Schwarzschild's approach can account for the preferred patterns found in our data. By assimilating it to other constraint-based stochastic models, we have shown that the theory can also explain the high degree of intra-speaker variability revealed by our study.

#### REFERENCES

- ALTENBERG, BENGT. 1987. *Prosodic patterns in spoken English*. (Studies in the correlation between prosody and grammar for text-to-speech conversion 76). Lund: Lund University Press.
- ANTTILA, ARTO. 1997. *Variation in Finnish phonology and morphology*. Stanford, CA: Stanford University dissertation.
- BOERSMA, PAUL. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences of the University of Amsterdam* 21.43–58.
- BOERSMA, PAUL, and BRUCE HAYES. 2001. Empirical tests of the gradual learning algorithm. *Linguistic Inquiry* 32.45–86.
- CHOMSKY, NOAM. 1970. Deep structure, surface structure and semantic interpretation. *Studies in general and oriental linguistics*, ed. by Roman Jakobson and Shigeo Kawamoto, 183–216. Tokyo: TEC Corporation for Language Research.
- HALLE, MORRIS, and JEAN ROGER VERGNAUD. 1987. Stress and the cycle. *Linguistic Inquiry* 18.45–84.

- JACKENDOFF, RAY. 1972. *Semantic interpretation in generative grammar*. Cambridge, MA: MIT Press.
- LADD, D. ROBERT. 1980. *The structure of intonational meaning: Evidence from English*. Bloomington: Indiana University Press.
- LIBERMAN, MARK, and ALAN PRINCE. 1977. On stress and linguistic rhythm. *Linguistic Inquiry* 8.249–336.
- PIERREHUMBERT, JANET. 1980. *The phonology and phonetics of English intonation*. Cambridge, MA: MIT dissertation.
- PIERREHUMBERT, JANET. 1993. Alignment and prosodic heads. Paper presented at the tenth Eastern States Conference on Linguistics, The Ohio State University, Columbus, OH.
- PRINCE, ALAN, and PAUL SMOLENSKY. 1993. Optimality theory: Constraint interaction in generative grammar. New Brunswick, NJ: Rutgers University, and Boulder, CO: University of Colorado, ms.
- PRINCE, ALAN, and PAUL SMOLENSKY. 2003. Optimality theory in phonology. *International encyclopedia of linguistics*, ed. by William John Frawley. Oxford: Oxford University Press.
- ROCHEMONT, MICHAEL S. 1986. *Focus in generative grammar*. Philadelphia: John Benjamins.
- ROCHEMONT, MICHAEL S. 1998. Phonological focus and structural focus. *Syntax and semantics: The limits of syntax*, ed. by Louise McNally and Peter W. Culicover, 337–63. San Diego: Academic Press.
- SCHWARZSCHILD, ROGER. 1999. GIVENness, AVOIDF and other constraints on the placement of accent. *Natural Language Semantics* 7.141–77.
- SELKIRK, ELISABETH O. 1984. *Phonology and syntax: The relation between sound and structure*. Cambridge, MA: MIT Press.
- SELKIRK, ELISABETH O. 1995. Sentence prosody: Intonation, stress, and phrasing. *The handbook of phonological theory*, ed. by John A. Goldsmith, 550–69. Cambridge, MA: Blackwell.
- WELBY, PAULINE. 2003. Effects of pitch accent position, type, and status on focus projection. *Language and Speech* 46.53–81.

Department of Linguistics  
Northwestern University  
2016 Sheridan Rd.  
Evanston, IL 60208-4090  
[j-german@northwestern.edu]  
[jbp@babel.ling.northwestern.edu]  
[kaufmann@northwestern.edu]

[Received 11 February 2005;  
accepted 20 May 2005]