The Professor Chewed the Students… Out: Effects of Dependency, Length, and Adjacency on Word Order Preferences in Sentences with Verb Particle Constructions

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Abstract

Recent research has begun to investigate the relationship between processing difficulty and preferred grammatical structures. In three studies, we examine verb-particle constructions, such as *look up*, which can occur in different grammatical orders. First, we measured speakers' sensitivity to the semantic similarity of verb-particle constructions (*look up*) and corresponding verbs (*look*). Results of a masked priming task demonstrated that participants are sensitive to this gradation in similarity (e.g., *chew out* vs. *finish up*), with only more similar items producing facilitation. Finally, participants read sentences in a self-paced reading task that varied on three dimensions: 1) dependency of the verb and particle for meaning (e.g., *chew* depends on *out* in *chew out*, but *finish* does not depend on *up* for its meaning; 2) adjacency (*look* the number *up* vs. *look up* the number); and 3) length of the direct object noun phrase. Reading times increased for more dependent verb-particle constructions, shifted sentences, and sentences with long intervening noun phrases. These findings support the proposal that performance factors affect word order preferences (Hawkins, 1994, 2004).

Introduction

Why do languages opt for the word orders that they do? Japanese places its verbs and other phrasal heads at the right ends of its constructions, while English generally places heads to the left. Although English uses relatively fixed word order, there are some structures that allow a choice. For example, one can say '*I went with John to the store*' or equally felicitously '*I went to the store with John.'*

Recent research has begun to investigate the factors that influence word order preferences within the grammars of particular languages as well as for individual speakers of a given language. Hawkins has proposed that performance constraints drive languages to choose word orders that minimize the processing demands on individual language users (Hawkins, 1994, 2004). Thus, processing is made easier when all of the constituents (S, NP, VP, PP, etc) of a sentence are recognized as early as possible. Different orderings of constituents involve changes in recognition time; therefore one order may allow earlier constituent recognition than another order. For example, the sentence 'I lent the book about whales in the Atlantic Ocean *to Jim*' requires a longer constituent recognition domain and thus is more difficult to process than 'I lent *to Jim* the book about whales in the Atlantic Ocean', since the first sentence requires processing ten words before reaching the final constituent ('to' of the PP) while the second only requires four words to be processed before reaching the final constituent ('the' of the NP).

Experimental studies testing ordering preferences have shown that the length of the direct object noun phrase (NP) affects word order preferences, with participants strongly preferring '*Mary explained to Sam the recently published theory of genetic inheritance'* over '*Mary explained the recently published theory of genetic inheritance to Sam'* (Stallings, MacDonald, & O'Seaghdha, 1998). Length effects have also been shown in English dative alternation constructions, where speakers are more likely to produce shifted structures if the NP is long (Wasow, 1997a).

In addition to studies of NP length effects on word order in English, data from cross-linguistic studies show that processing effects on word order are broadly applicable. Yamashita and Chang (2001) showed that long NP's may be preferred in early rather than sentence final position when the language is right-headed, as in Japanese. They found that when sentences offered ordering options, Japanese speakers chose to produce orders that fronted object NPs when the NP was long. These results are consistent with the idea that in Japanese, processing is minimized when all constituents occur to the right, therefore "long before short" ordering allows all constituents to be processed in the minimum amount of words.

Recent experimental studies have shown that in addition to NP length, other factors affect word order preferences, such as complexity and newness of the NP (Arnold, Wasow, Losongco, & Ginstrom, 2000). In addition, other theorists have emphasized the role of both integration and storage costs in processing difficulty and hence word order choice (Gibson, 2000; see also Lewis & Nakayama, 2002).

Verb particle constructions

Verb particle constructions are also interesting in terms of ordering preferences, since they include a verb (e.g., *look*) and a particle (e.g., *up*) that can either be produced adjacently as in *'he looked up the word'* or separately (with an intervening noun phrase) as in '*he looked the word up*'.

The placement of particles in sentences with verb-particle constructions has long been a subject of interest in the linguistic literature, with researchers describing several phonological, syntactic, semantic, pragmatic, and discourse factors that affect particle placement (e.g., van Dongern, 1919; Live, 1965; Bolinger, 1971; Gries, 1999, see also articles in Dehé, Jackendoff, McIntryre, & Urban. 2002, for a variety of methodological and theoretical approaches to understanding verb particles in English and other languages). For example, Bolinger (1971) discusses the impact of the particle on semantic interpretation when it is placed near the verb versus near the direct object. In addition to descriptive accounts, some scholars have offered more functional/processing based approaches to particle placement. For instance, Chen's account of discourse factors involves a functional explanation based on accessibility of the direct object concept in the ongoing discourse (Chen, 1986). Gries (1999, 2002) gives a recent overview of the possible variables that contribute to particle placement[1] and also offers a processing hypothesis, similar to Chen's, based on 'consciousness' of the elements in the sentence.

Processing account of particle placement

Lohse, Hawkins, and Wasow (2004) argue that the various factors determined to affect particle placement can be explained by a processing approach. They examined two factors that effect particle placement, namely length of the direct object NP, and dependency of the verb and particle. In a corpus study, they showed that as the number of words in the direct object NP increased, the number of split orderings diminished. Thus, the particle was more likely to be placed adjacent to the verb if the direct object NP was long.

Lohse et al. (2004) also investigated the effects of varying semantic dependency relationships between the verb and particle on placement of the particle in several corpora. Dependency in particle constructions concerns the extent to which a verb relies on its particle for the meaning of the complete construction. For example, *finish* does not rely on *up* for its interpretation in *finish up*, whereas *chew* depends strongly on the particle, *out*, in *chew out* for its semantic interpretation. Results from the corpus study showed that dependent particles are more likely to be placed adjacent to the verb. Thus, the sentence 'The teacher will *chew out* the students' is more common that "The teacher will *chew* the students *out*.' The corpora studies support a processing account of particle placement.

While previous studies have focused on word order preferences in language production and written corpora, the present study examines ordering choices in comprehension using verb particle constructions, testing interactions among the factors of adjacency, length of the direct object NP, and dependency between verb and particle.

[1] The factors Gries (1999, 2002) discusses include: 1) stress (of particle or direct object (DO)); 2) NP type (pronoun vs. complex nouns); 3) length of the DO; 4) determiner of the DO (definite versus indefinite); 5) complexity of the DO; 6) meaning of the VP (idiomatic versus spatial contribution); 7) animacy of the DO; 8) entrenchment of the DO; and, 9) production difficulty.

Measuring Dependency

Lohse et al. (2004) lay out a series of linguistic tests to determine the dependency relationship between a verb and its particle. The verb and particle can be mutually dependent or mutually independent, or one may depend on the other. For example, both the verb and particle meanings are modulated in the construction *chew out*, neither are particularly affected in *bring in*, the verb depends on the particle in *pull over*, and the particle depends on the verb in *call up*. While these descriptions of dependency relationships are clearly correlated with ordering preferences in corpus studies, it remains to be shown that they are reflected in linguistic performance. Thus, we tested participants' sensitivity to dependency relationships in both an off-line judgment task and an on-line priming task.

Semantic similarity Ratings

Previous studies have shown that participants are sensitive to semantic similarity variations among morphologically related word pairs. For example, *boldly* is judged more semantically similar to *bold* than *lately* is to *late* or *hardly* is to *hard* (Gonnerman, 1999). When a verb and/or particle are dependent on one another, the resultant meaning of the verb-particle construction is less similar to the verb alone; thus, *bring in* is more similar to *bring* than *chew out* is to *chew*. Therefore, we asked participants to provide semantic similarity ratings as a close approximation to the dependency relationships described by Lohse et al. (2004).

Participants 128 Lehigh University undergraduates participated for course credit. They were all monolingual speakers of American English.

Materials 209 verb particle/verb pairs were divided into 6 lists with 34 or 35 items each.

Procedure Participants were asked to rate the similarity in meaning of verb particle/verb pairs on a scale from 1 (very dissimilar) to 9 (very similar). The instructions included examples of highly similar as well as dissimilar pairs with corresponding ratings.

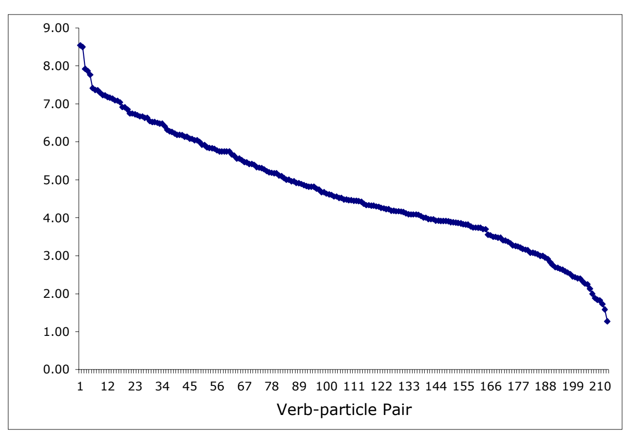

Figure 1. Mean semantic similarity ratings for 209 verb/verb particle pairs (e.g., *look up/look*).

Results and Discussion

Results from the survey showed that participants are sensitive to the degree of similarity between verb particle/verb pairs (see Figure 1 above). Moreover, the similarity ratings correspond to the categories of dependency developed by Lohse et al. (2004), with pairs considered dependent on linguistic grounds being rated as dissimilar (e.g., *throw-up/throw),* and independent pairs rated as more similar. (e.g., *clear off/clear*).

Masked Priming

Results from the ratings task showed that native English speakers are sensitive to gradations in similarity of meaning between verbs and verb-particle constructions. To test whether these judgments are reflected in on-line processing, we conducted a masked priming experiment. In the masked priming paradigm, primes are presented below conscious threshold such that participants are unaware of having seen the prime. We expect facilitation for highly similar pairs, (e.g., *clear off/clear*), which have a low dependency relationship, but no facilitation for dissimilar pairs (e.g., *chew out/chew*), which are highly dependent.

Participants 41 Lehigh University undergraduates (20 women and 21 men) participated for course credit. All were native speakers of English and did not participate in the similarity survey.

Materials 78 verb particle constructions were chosen from the set of 209 used in the ratings task above. They were separated into three equal groups: 26 low similarity; 26 middle similarity; and, 26 high similarity, matched for frequency. Items in the low condition had ratings less than 4 (*e.g*., *throw up/throw*). For the mid condition, ratings were equal to or greater than 4 and less than 6 (*e.g., look up/look*). For the high condition, ratings were greater then 6 (*e.g., finish up/finish*). Particles (*e.g., up*, *in*, *out*) were distributed across conditions, such that they appeared equally often in each condition. The verb and particle served as related prime (*e.g*., *cover up*), with the verb as target (e.g., *cover*). For each of the 78 related test primes (e.g., *cover up*) an unrelated control prime was selected to match in frequency and number of letters (*e.g., shut off*). Test and control primes did not overlap in meaning or orthography. The items were divided into two lists, one with the related test-target pair (*e.g*., *cover up/cover*), the other with the unrelated control-target pair (*e.g., shut off/cover*); each participant saw stimuli from only one list.

In addition, 78 real word prime-target filler items were added to each list, so that the overall proportion of related prime target pairs in the list was reduced. Finally, 156 non-word filler items were included, matched overall for frequency and reflecting the composition of the real-word items. Thus, half of the non-word pairs had verb-particle primes, divided equally into related (*e.g., keep up/keem*) and unrelated verb-particle pairs (*e.g., live down/bool*). The other half of the non-word pairs had one-word primes (e.g., *basil/grook*). Each list therefore consisted of 312 prime-target pairs, 39 of which were related verb-particle/verb pairs (*look up/look*).

Procedure Participants were tested individually in a quiet room with dim lighting. Lexical decisions were indicated by pressing a button on a button box. Rapid and accurate responses were encouraged. Psyscope (Cohen, MacWhinney, Flatt, & Provost, 1993) software was used to present stimuli and record responses. CRT monitors running at 85 HZ were used to display the stimuli. At the start of each trial a fixation point (an asterisk) was displayed for 1000 msec, followed by a mask (%#@!&^$) for 500 msec. The prime was then briefly presented for 35 msec and the target followed immediately, remaining on the screen for 200 msec. After the participant responded, a 500 msec delay occurred before the next trial began. Primes and targets were presented in white on a black background, with primes in lower case letters and targets in upper case.

Results and Discussion

Trials on which participants made errors were excluded from the latency analyses, as were outliers (responses greater than 2000 msec or less than 200). The decision latencies were entered into an analysis of variance with the factors Prime Type (related test or unrelated control) and Similarity (low, mid, and high). Results showed a main effect of Prime Type, $F(2, 50) = 13.3$, $p < .001$, but no main effect for Similarity, $F(2, 50) = 0.3$, $p < .76$, since there was facilitation in the high and mid similarity conditions, but not the low, as expected. There was no significant interaction: $F(4, 100) = 1.5$, $p < .21$. Planned comparisons revealed facilitation for targets following related primes in the mid and high Similarity conditions, but not for the low similarity items (see Table 1).

Table 1: Response latencies for target words by prime types and similarity

	Prime-Target Similarity		
Prime Type	Low	Mid	High
Unrelated (*cast off/throw*)	550	553	557
Related (*throw up/throw*)	543	532	537
Unrelated-Related	**7**	**21***	**20***

Thus, the factor of verb particle dependency described by Lohse et al. (2004) was indeed reflected in on-line processing of verb-particle constructions. Results from the masked priming task showed that more similar, less dependent, items (*finish up/finish; look up/look*) produced greater facilitation than less similar, high dependent pairs (*chew out/chew*)

Ordering Effects in Self-paced Reading

We have shown that speakers are sensitive to dependency relationships between verbs and particles in both off-line judgments and an on-line priming task. To address whether differences in processing of alternative word orders are, in fact, influenced by the nature of the dependency relationship, we conducted a self-paced reading task. We also looked at the factors of NP length and adjacency, which have been shown to affect ordering preferences in corpora and production studies (Lohse et al., 2004; Stallings et al., 1998; Yamashita & Chang, 2001).

Participants

141 Lehigh University undergraduates participated for course credit. All were monolingual English speakers.

Materials

The 78 low, mid, and high similarity verb-particle/verb pairs were the basis for our Dependency variable. We used the verb-particle constructions from pairs that were rated low in similarity (*e.g., chew out/chew*) as our high Dependency items. Mid Dependency constructions were taken from the mid Similarity set (e.g., *look* up/*look*), and low Dependency from the high Similarity set (e.g., *finish up/finish*).

We used three levels of the Length variable. Short direct object NPs included two words, medium NPs included five words, and long NPs included nine words.

The Adjacency variable had two levels: particles were either next to the verb in non-shifted constructions (*look up* the number) or were shifted (*look* the number *up*).

For each of the 78 verb-particle constructions, 6 sentences were created, reflecting the three length possibilities and two levels of adjacency (see Table 2 below for sample).

These sentences were divided into six lists, such that each list contained only one sentence form for each verb particle construction; therefore a single participant did not read more than one sentence containing the same verb and particle.

Table 2: Sample set of stimulus sentences for the verb *look up* (a mid-dependency item)

Length	Adjacency	Sample sentence
short	adjacent	The man will *look up* **the word**.
short	shifted	The man will *look* **the word** *up*.
medium	adjacent	The man will *look up* **the origin of the word**.
medium	shifted	The man will *look* **the origin of the word** *up*.
long	adjacent	The man will *look up* **the historical origin of the unusual and interesting word**.
long	shifted	The man will *look* **the historical origin of the unusual and interesting word** *up*.

Procedure

Sentences were presented one word at a time on a computer screen. Participants read at their own pace, pressing a button to replace the word they had just read with dashes and to display the next word of the sentence. After reading each sentence, participants answered a yes-no content question to ensure careful reading. Reading times for each button press were recorded.

Results and Discussion

Reading times for sentences where participants answered the yes-no question incorrectly were excluded from analysis. Mean reading times per word were calculated for each sentence. These values were then entered into an analysis of variance with the factors of particle Position (adjacent, shifted), NP Length (short, medium, long), and Dependency (low, mid, high). There were main effects of Position: F(1, 140) = 21.5, p<.001, with shifted sentences taking longer to read (347 msec) on average than adjacent ones (336 msec); NP Length: F(2, 280) = 18.9, p<.001, with reading times increasing as the length of the NP increases; and Dependency: F(2, 280) = 24.0, p<.001, with reading times increasing as the verb becomes more dependent on the particle for its meaning. Mean reading times are shown below for each condition (see Table 3).

Table 3: Mean reading times (msec) by Length (short, medium. long) and Dependency (low, mid, high) for sentences with Adjacent and Shifted particles.

	Dependency						
	Low		Mid		High		
Length	Adj	Shift	Adj	Shift	Adj	Shift	**Mean**
short	323	325	340	334	348	355	**337**
medium	330	350	334	358	327	355	**342**
long	344	325	337	352	343	373	**346**
Mean	**332**		**342**		**350**		

These main effects indicate that more processing is required, as reflected in increased reading times, for sentences with long direct object NP's, highly dependent verb-particle constructions, and shifted particles.

There was an interaction of Adjacency by NP Length: F(2, 280) = 13.1, p<.001, with slowest reading times for long NPs, but only in shifted sentences. There was also an interaction of Adjacency by Dependency: F(2, 280) = 24.2, p<.001, with slowest reading times for high dependency items (*chew out*), but, again, only in shifted sentences. Finally, there was an interaction of NP Length by Dependency : F(4, 560) = 6.4, p<.001, showing that reading times increased when sentences contained verb-particle constructions that were higher in Dependency. This effect was only seen for the short and long direct object NPs.

The interactions between Adjacency and Dependency showed slower reading times for shifted, high dependency sentences (*The teacher chewed the students out*). There was also an interaction between NP Length and Adjacency, with slower reading times for long NPs in shifted sentences (*The man will look the historical origin of the unusual and interesting word up.)* Thus, it is harder to read sentences when a long NP intervenes between the verb and particle.

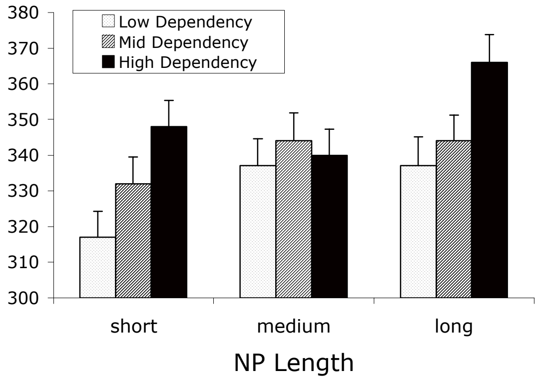

Figure 2. Mean reading times per word for sentences with short, medium, or long direct object NPs, and low, mid, or high Dependency verb-particle constructions.

A Length by Dependency interaction, with reading times *increasing* as Dependency increases, occurred for both short and long sentences, but not medium length sentences (see Figure 2). This pattern of effects may reflect the influence of competing forces on processing efficiency. For high Dependency verb-particle constructions, putting the verb next to the particle helps interpret the verb in the verb-particle construction. However, shifting the particle would allow the comprehender to build an NP structure earlier, making shifted structures more efficient for recognizing sentence constituents. Therefore, in sentences with short intervening NPs, keeping the particle and verb together does not greatly reduce the recognition domain for the NP. These sentences are thus highly sensitive to variations in Dependency. With longer NPs, shifted structures will be very difficult regardless of Dependency, so that having a long intervening NP strongly affects processing even for low dependency items. Thus, these sentences are highly sensitive to Adjacency. With NPs of medium length, both Dependency and Adjacency have effects, but in opposite directions, effectively canceling each other out.

To determine where the effects are occurring in each sentence type, we examined word-by-word reading times (see Figure 3 below).

We have included the graph for Short NPs only, in the interests of space. The patterns for the Medium and Long NPs are generally the same, except that the effect which is mainly apparent for High Dependency verb-particles in the Short NP condition is exaggerated in the Mid Dependency condition when the NP is long.

Of greatest interest, however, are the reading times for the particle itself in the different conditions. Figure 4 shows the difference between the mean particle reading times in shifted minus adjacent sentences. When the direct object NP is short, reading times for the particle are only slower in shifted sentences if the verb is highly dependent on the particle for its meaning. For long NPs, shifted particles are slower for Mid dependency constructions as well. When the verb is not dependent on the particle, readers are not slow to process the particle, even if the intervening NP is long. For the medium length NPs, the particle is slower when shifted for all three dependency conditions. It is unclear why the medium length NPs should yield a particle effect even for low dependency constructions.

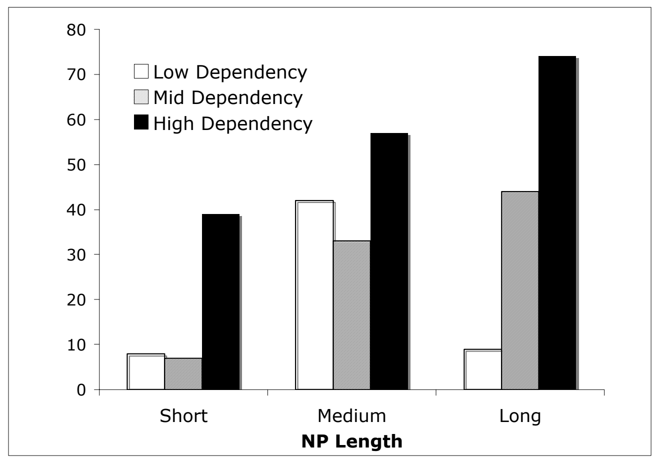

Figure 4. Difference in mean reading times for the particle when shifted minus adjacent in sentences with short, medium, or long direct object NPs, and low, mid, or high Dependency verb-particle constructions.

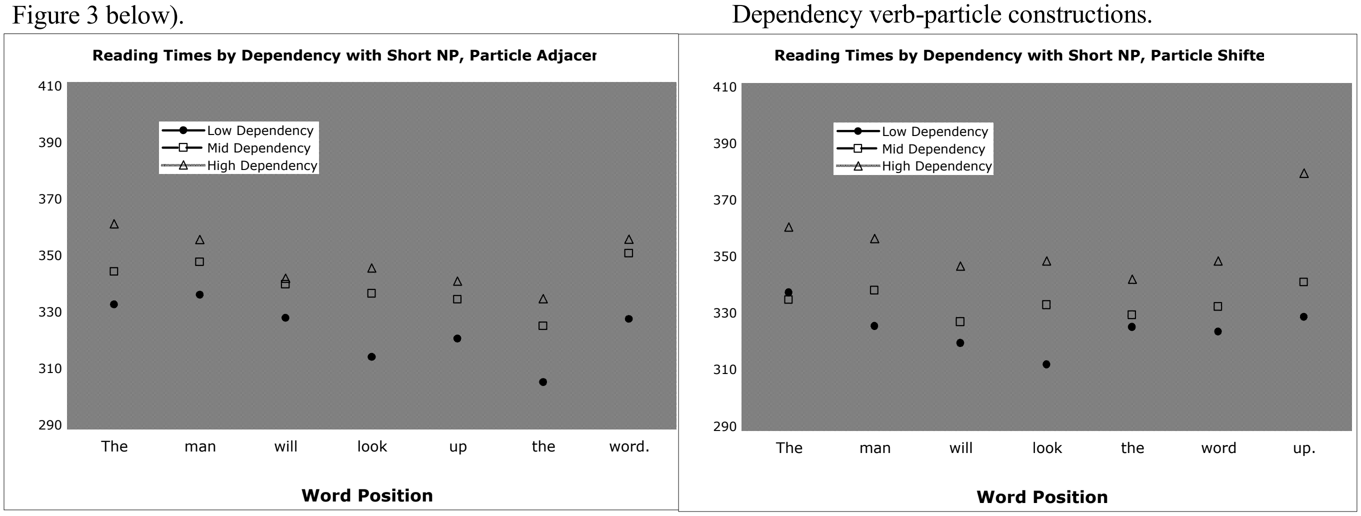

Figure 3. Mean word by word reading times for sentences with direct object NPs, with the particle adjacent to the verb (left) or shifted (right).

General Discussion

Results from the semantic similarity judgment task showed that speakers are sensitive to the degree of similarity between a verb-particle construction and the corresponding verb. Furthermore, this variation in similarity led to different priming results, with highly (*e.g., finish up/finish*) and moderately (*e.g., look up/look*) similar pairs producing significant facilitation, while low similarity pairs did not prime (*e.g., throw up/throw*). These findings suggest that the notion of dependency, given a detailed linguistic analysis by Lohse et al. (2004) and shown to affect word order in corpora, is also reflected in both offline ratings and on-line decision latencies.

In addition, the dependency relationships between verbs and particles were shown to affect reading times in a self-paced reading task, with increasing latencies as dependency increased. There was also a main effect of length of the direct object NP, with increasing reading latencies as NP length increased. This pattern is consistent with other experimental studies of length effects on ordering preferences (Arnold et al., 2000; Stallings et al., 1998; Yamashita & Chang, 2001). Finally, a main effect of adjacency showed that reading times increased when the NP intervened between the verb and particle. Taken together, the main effects provide strong support for processing influences on ordering in comprehension.

The pattern of interactions among dependency, NP length, and adjacency showed that reading times were generally most affected when two factors compounded the difficulty of a particular word order. For example, reading times were significantly longer for shifted sentences with high dependency verb-particle constructions, such as *'The teacher chewed the students out*' or shifted sentences with long intervening NPs, such as *'The man will look the historical origin of the word up*.'

The pattern of results from the three tasks presented here indicate that lexical factors, such as dependency in particle constructions, and syntactic constraints, such as adjacency, and NP length, affect reading times in a comprehension task. The findings are consistent with corpora and production studies of word order preference, but extend them to investigate the interactions of both lexical and syntactic factors. Importantly, these factors were shown to affect processing in a comprehension task, indicating that both speakers and hearers may be responding to similar constraints (cf. Wasow, 1997b; Stallings et al., 1998). The findings support Hawkins' (1994, 2004) notion that word order is influenced by performance factors.

Acknowledgments

This research was supported by NIH grant R01 MH55628-06 and an undergraduate research award to C. Hayes. We would also like to thank the undergraduates in the Language Acquisition and Processing Lab at Lehigh who helped with data collection.

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