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Dependency and Length as Processing Constraints on Word Order in Particle Constructions

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Abstract

Recent research has begun to investigate what factors influence word order preferences. Hawkins' has proposed a theory of performance constraints (Hawkins, 1994, 2001), which drives languages to choose word orders that minimize processing demands. Experimental production studies as well as corpus studies have been conducted to test this theory. In this study we examine ordering preferences in verb particle constructions in a comprehension task. Verb particle constructions include a verb (e.g., *throw*) and a particle (e.g., *out*, *up*, *on*) that can either be produced adjacently as in *'he threw out the garbage*' or separately as in '*he threw the garbage out*.' Verb particle constructions also vary in the degree to which the verb depends on its particle for its meaning. For example, '*chew out'* versus '*finish up'* (Gries, 1999). To determine dependency, we conducted a similarity survey (how similar is '*look'* to '*look up*') and a masked priming task (similar verb/verb particle pairs primed, while dissimilar pairs did not). We then tested sentences varying in dependency, adjacency, and length of NP on reading times in a self-paced reading task. Results indicate that it is more difficult to process shifted sentences with long intervening noun phrases and this is especially true when the verb and particle are highly dependent. Thus, word order preferences in particle constructions are affected by processing constraints such as adjacency, dependency, and NP length. These findings support Hawkins' (1994, 2001) notion that word order is determined by performance factors.

Dependency and Length as Processing Constraints on Word Order in Particle Constructions

The necessity for word order stems from the nature of language. Language is produced or comprehended one word at a time, thus we are required to make order choices in the use of language. There are infinite ways in which one can order the words used to communicate, but it is useful to limit ordering options, especially when order reflects meaning or reference in language.

Each language can choose its own way to set word order. However, there are three major ordering classifications languages fall into; those with the heads of the sentence typically falling to the left, those with heads to the right, and those that are a mixture of these (Hawkins, 1983). English is a left-headed language, Japanese is right-headed, and Chinese demonstrates a mixture. Although English, Japanese, and many other languages have relatively fixed word order, there are some structures that allow a choice. English speakers have an ordering choice in sentences with two prepositional phrases, for example, ‘I went to the game with my sister’ or ‘I went with my sister to the game.” In dative sentences there is the choice to say ‘Give the ball to the boy’ or ‘Give the boy the ball.’ A final example can be demonstrated in sentences with verb particles, ‘Mary looked up the number’ versus ‘Mary looked the number up.’

Given the nature of languages today, with varying syntactic orders and grammars, it is logical to ask why and how these languages have chosen to fix their language in the manner they have. What are the reasons underlying the fixed structure? Are there some heritage-based influences or processing tendencies that have helped to form grammars? Another question to ask about language is what influences the way language is produced in individuals today. For example, if a speaker is given an order option (as in the previous examples from English) what underlies the choice that is made?

There are two major ways in which these questions are answered. One answer is that of a Universal Grammar proposed by Chomsky that states that the grammars that determine word order are ultimately innate (Hawkins, 1994). He believes that humans have a built-in ability to structure language and this innate grammar is the influence on which languages order and grammaticalize their words. Another theory, proposed by Hawkins (1994), is centered on language performance, such that the processing and use of language shapes the grammar of a language as a whole based on the actions of individual users. Hawkins's theory accounts for fixed differences between languages as they exist today and for the individual differences people show in the use of language. This proposal will focus on testing the performance theory to see if the predictions it makes are borne out in behavioral data. The results will add to our understanding of the underlying mechanisms that cause language differences in grammar and word order.

Performance Theory

Hawkins's theory describes how the grammar of a language responds to processing (Hawkins, 1994, 1998, 2000). He believes that language users work to minimize the processing necessary to understand or formulate a given utterance. This aspect of performance offers insight into why certain languages have fixed word order in a particular way. The grammar of a particular language usually reflects a desire to decrease the amount of processing necessary for production and comprehension (Hawkins, 1994).

Hawkins (1994) has laid out a much more detailed analysis of the mechanisms underlying processing minimization. He believes that processing is made easier when all of the constituents (S, NP, VP, PP, etc) of a sentence are recognized as early in the sentence as possible. Different ordering of sentences involves changes in recognition time; therefore one order may allow earlier constituent recognition than another order. Therefore a sentence such as ‘I lent the book about whales in the Atlantic Ocean *to Jim’* requires more processing and constituent recognition time than “I lent *to Jim* the book about whales in the Atlantic Ocean.’ The first sentence requires that one process ten words in order to reach the beginning of the final constituent (‘to’ of the PP) while the second only requires four words be processed before reaching the final constituent (‘the’ of the NP).

In this paper we focus on a particular English construction, verb particles, that allow for variable word orders. Verb particle constructions include items such as ‘look up’ or ‘throw out.’ These are structures in which the verb (run, think, look) depends (more or less) on the particle (e.g., up, out, in, down, etc.) for its meaning. Furthermore, the direct object (DO) of the sentence can either be positioned adjacent to the verb as in ‘John looked the number’ (DO-Adjacent). The particle can also be adjacent to the verb with the DO following as in ‘John looked up the number’ (Particle-Adjacent).

Previous investigations of word order choice

As Hawkins demonstrates, word ordering has many underlying influences that determine how an individual speaker will choose to order an utterance. There are several other studies that have taken this performance-processing theory and tested aspects of it. Stallings, MacDonald, and O’Seaghdha (1998) investigate the effects of NP length, the 'shifting disposition' of verbs, and the animacy of the noun in a PP. Arnold, Wasow, Losongco, and Ginstrom (2000) study the effect of grammatical complexity (heaviness) of the DO and newness (status in discourse) of the DO. Finally, Lohse, Hawkins, and Wasow (2003) investigate the effect of minimizing domains (as in Hawkins's EIC theory) on verb particle ordering.

In the Stallings et al. (1998) study, the effect of length, verb type, and animacy were explored in a production task. This study used the optional ordering structure found when both a PP and NP follow a subject and verb head. Therefore two sentences can be formulated, 'Mary described to Jane the content of the lecture material' or Mary described the content of the lecture material to Jane.' This study focused on the tendency to observe heavy NP-shift (placing the NP at the end of the sentence) when the NP is long.

The production experiment conducted by Stallings et al. (1998) allowed participants to choose the order in which they would produce and utterance (they would have to press a button to tell which order (S-V-NP-PP) or (S-V-PP-NP) they were going to say). When they had chosen a formulation they were instructed to produce the utterance. This study was interested in which order was chosen, how long it took to choose an order, and how long it took to produce the sentence when the order was formulated). They found that there was an effect for length when ordering choice was concerned. Participants shifted a long NP to the end of a sentence four times more than a short NP. Also, ordering decision times were significantly longer when the NP was long. Finally voice initiation times showed significantly longer times for long NP's. This experiment demonstrates that the length of the NP and the nature (and experience of adjacency) of a verb effects sentence ordering. They also affect how long it takes someone to process the order of their production as well as how long it takes to put plans of varying complexities into action.

The study by Arnold et al. (2000) studies heaviness and newness of NPs in corpus studies and experimentally. The corpus study observed instances of order alternative dative structures and those of heavy-NP shift (described earlier). The data was analyzed and coded for dative utterances that contain a NP and PP (V-NP-PP) ('I gave the box of cookies to Mary') or two NP's following the verb (V-NP-NP) ('I gave Mary the box of cookies'). Heavy-NP shift utterances were coded as nonshifted (V-NP-PP) and shifted (V-PP-NP). The heaviness (number of words) and newness (new, given, or inferable) of the information were also recorded.

Arnold et al. (2000) found that the V-NP-NP dative clause was used when information was heavier and newer, thus signaling that this ordering is preferred when more processing is involved. This is also a sentence in which the more complex NP is sentence final. The same information was found for heavy-NP shift structures. When the information contained in the NP was heavy and new the NP was shifted to the sentence final position, thus assuming this information is harder to process. The same influence of heaviness and newness was found in the experimental production study by Arnold et al. (2000).

Arnold et al. (2000) offer insight into why heaviness and newness affect word order. They propose that heavy and new NP's are more difficult to process. Given the nature of the way a speaker formulates an utterance (eliciting a concept of the message, formulating the utterance by choosing words and assigning phonological rules to them, and producing the sentence) it follows that heavy phrases need more words assigned to them, thus that stage will take longer and new information may require additional processing to determine which words are appropriate to describe the new concept. Therefore it may be beneficial to the speaker to delay the production of such phrases in order to give additional processing time.

An article by Lohse, Hawkins, and Wasow (2003) demonstrates how the theory of Minimize Domains (presented by Hawkins) affects the ordering of verb particle sentences. This principle states that orders that create smaller domains will be preferred. This principle is related to the Early Immediate Constituent principle described above that minimizes the string of relevant constituents, in this case the relevant constituents are the verb, the particle, and the first word of the DO.

Lohse et al. (2003) make several predictions about the effects of variables on word order preferences. The first prediction is that the length of the NP will affect the adjacency of the verb and particle. Based on corpus analysis, Lohse et al. have shown that as the number of words in the NP increases past two words the number of split orderings diminishes. This shows that length of the NP does affect the order in which verb particles occur.

This study then turns to the variable of dependency. Lohse et al. (2003) first investigate the dependency between the verb and particle. They distinguish the ability of both the verb and the particle to be processed independently. Therefore, a verb may retain its meaning without its particle (e.g., ‘finish up’ versus ‘finish’) or the verb may require the particle for meaning (e.g., ‘chew out’ versus ‘chew’).

Lohse et al. (2003) found in a corpus study that dependency of the verb and particle (on each other for meaning) affects their adjacency. They found that dependent particles occur very infrequently in the nonadjacent (e.g., ‘The teacher will *chew* the students *out*.’) form due to their dependency on the verb for meaning. This study provides evidence that domain minimization influences word order in verb particles due to constraints that influence dependent verb particles to occur together, thus shifting the NP to the end of the sentence.

Objective of the Proposed Research

This research examines verb particles as a means to understand the relationship between processing and word order in a comprehension task. As seen in previous research it has been hypothesized and confirmed in corpus based and experimental production studies that the length of the object noun phrase and the nature of the verb particle construction affect how people order sentences. While linguists have provided descriptive studies of the word order possibilities with verb particles (Gries, 2002 & Lohse et al., 2003), few experimental comprehension investigations with verb particles been conducted. Therefore, I will examine the effect of verb particle dependency and adjacency, as well as NP length, on processing via self-paced reading of sentences which include these variables.

I will examine dependency at three levels; high (chew out), medium (look up) and low (finish up). ‘Chew out’ depends greatly on ‘out’ for its meaning, ‘look up’ depends slightly on ‘up’ to establish the correct meaning, while ‘finish up’ does not get much of its meaning from ‘up’. I will also examine the effect of short noun phrases (I threw *the garbage* out) versus long noun phrases (I threw *the garbage that I bagged last night* out) on sentence processing. Finally the adjacency of the verb and particle will be manipulated to determine the effect of ordering in particle constructions (e.g., '*finish u*p the homework' (particle-adjacent) versus '*finish* the homework *up*' (DO-adjacent)).

Response times in a masked priming experiment should increase when a verb particle is dependent (the verb stem meaning differs from the verb particle meaning). Sentence reading times should increase as verb particle dependency increases, as NP length increases, and when the NP intervenes between the verb and particle (DO-adjacent). Main effects should occur for all three variables and interactions should be seen between dependency, length, and adjacency, with the longest reading times occurring when the sentence contains a dependent verb particle, a long NP, and in the DO-adjacent form.

Method

Preliminary Data Collection:

Verb Particle Dependency Ratings

Verb particle dependency ratings were needed to determine which verb particles are highly dependent for meaning and which are not. This was determined through a survey of the similarity between the verb particle (e.g., 'look up') and its stem verb (look.')

Participants

128 Lehigh University undergraduates (60 men and 68 women) participated for course credit. They were all native speakers of English.

Materials

A survey that contained 209 verb particle/verb pairs was used. The similarities of the verb stem (throw) and verb particle (throw out) were rated on a scale of 1 (very dissimilar) to 9 (very similar).

Procedure

Participants rated the verb particle/verb similarity on a scale of 1-9. Those that were rated as most similar in meaning will be used as the independent verb particles (*finish*/*finish up*) and those that are rated as most dissimilar will be used as the dependent verb particles (*chew*/*chew out*) in sentence formation (for the self paced reading task).

Experimental Tasks:

Masked Priming of Verb Particles

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 particles (matched for frequency of occurrence and separated into three equal groups; 26 high similarity, 26 middle similarity, and 26 low similarity, as judged in the similarity survey) and 156 filler items were used in a masked priming experiment. The target was either related to the prime (look out-look) or unrelated (scale up-look). The stimuli were presented on a computer screen with PsyScope and the participants used a button box to indicate their decisions.

Procedure

Participants were presented with an asterisk (1000msec) to orient their view on the computer screen. They then saw a mask (e.g., %#@!&^$) for 500msec, followed by the prime (30msec) and then the target (200msec). They were asked to make a lexical decision to the target item. They were asked to press a green button if the target displayed was a real word of English and a red button if it was not.

Self-Paced Reading Task

Participants

141 Lehigh University undergraduates (75 women and 66 men) participated for course credit. All were native English speakers.

Materials

Each participant read 78 sentences of interest and 78 filler sentences presented on a computer screen using PsyScope. The target sentences were created from the 78 verb particles used in the masked priming experiment. Six sentences conditions were created for each verb particle for a total of 468 sentences (short NP/particle-adjacent (PA), short NP/DO-adjacent (DA), mid NP/PA, mid NP/DA, long NP/PA, and long NP/DA). These sentences were sorted into six lists (each included approximately 13 sentences from each sentence condition and these sentences were presented in random order). Each list contained only one sentence form for each verb particle; therefore a single participant did not receive more than one sentence containing the same verb particle.

Procedure

Participants read each sentence at their own pace by pressing a button to receive each successive word. Participants only viewed one word at a time; each button press cleared the preceding word when it revealed the next word). Content questions were asked after most sentences to ensure diligent reading. Reading times for each button press were recorded.

Results

Masked Priming of Verb Particles

The masked priming data was analyzed in a 2 x 3 (Prime Type (Relatedness) x Prime-Target Similarity) ANOVA with the dependent variable being decision time. Results showed a main effect of Prime Type, $F(2, 50) = 13.3$, $p < .001$. The results did not show a main effect for Prime-Target similarity, $F(2, 50) = 0.3$, $p < .76$ or a significant interaction between Prime Type and Prime-Target Similarity, $F(4, 100) = 1.5$, $p < .21$. Planned comparisons revealed facilitation for targets following related primes in the Mid Similarity and High Similarity conditions, but not for the Low Similarity items (see Table 1). Therefore, more similar items showed a priming effect due to their semantic relatedness. Items that were not similar did not show a priming effect because they were not semantically related.

Self-Paced Reading Task

The self-paced reading data was analyzed in a 2 x 3 x 3 (Adjacency x NP Length x Dependency) ANOVA with the dependent variable being average reading time. Results indicate main effects of Adjacency (see Figure 1): $F(1, 140) = 21.5$, $p<.001$, with shifted sentences taking longer to read; NP Length (see Figure 2): $F(2, 280) = 18.9$, $p<.001$, with reading times increasing as the length of the NP increases; Dependency (see Figure 3): $F(2, 280) = 24.0$, $p<.001$, showing reading times increasing as the verb becomes more dependent on the particle for its meaning. Interactions of Adjacency by

NP Length (see Figure 4): $F(2, 280) = 13.1$, $p<.001$, with slowest reading times for long NPs, but only when shifted. Interaction of Adjacency by Dependency (see Figure 5): $F(2, 280) = 24.2$, $p<.001$, with slowest reading times for high dependency items (*chew out*), but only if shifted. Interactions of NP Length by Dependency (see Figure 6): $F(4, 560) = 6.4$, $p<.001$, showing that reading times get increasingly longer as the verb becomes more dependent on its particle for meaning, but only for the shortest and longest NPs

Discussion

Verb Particle Dependency Ratings

Results from the survey showed that subjects are sensitive to the degree of similarity between verb particle/verb pairs (e.g., *throw-up/throw*). Moreover, the similarity ratings corresponded to the notion of dependency developed by linguists (Gries, 2002; Lohse et al., 2003), with pairs considered not to be dependent on linguistic grounds being rated very similar (e.g., *clear off/clear*), and those that depend on the particle for meaning (e.g., *throw-up/throw)* rated as very dissimilar.

Masked Priming of Verb Particles

Dependency was reflected in the masked priming task, where more similar items (*finish up/finish; look up/look*) produced greater priming than less similar, high dependency pairs (*chew out/chew*). This suggests that the semantic relatedness (similarity of meaning) for low and middle dependency verb particles creates semantic priming. The lexical decision time is faster when the prime is semantically related to the target. However, when the prime is not semantically related to the target (as seen in highly dependent verb particles) decision times are not faster and thus the dissimilar pairs do not prime each other.

Self-Paced Reading Task

There were main effects of NP Length, Verb-particle Dependency, and Adjacency, with longer reading times for longer sentences, more dependent verb particle pairs, and shifted sentences, where a noun phrase intervened between the verb and particle. This shows that it takes longer (and thus may require more processing) to read sentences with long NP's, dependent verb particles, and non-adjacent verb particles even when these variables are not interacting.

The interactions between Adjacency and Dependency show slower reading times for shifted, high dependency sentences (*The teacher chewed the students out*). This suggests that it is harder to process sentences that contain non-adjacent and highly dependent verb particles. 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.)* This demonstrates that it is harder to process and read sentences when a long NP intervenes between the verb and particle.

Finally, there was a Length by Dependency interaction, with reading times *increasing* as dependency increases, for both short and long sentences, but not medium length sentences. This effect may reflect the influence of competing forces on processing efficiency. For high dependency verb particles, putting the verb next to the particle helps process the verb. But shifting the particle allows the comprehender to build an NP structure earlier, making shifted structures more efficient, especially if the particle does not influence the verb meaning very much. For sentences with short intervening NPs, keeping the particle and verb together does not greatly reduce the recognition domain for the NP. Thus, the short NPs are showing effects of dependency. With longer NPs, shifted structures will be very difficult regardless of dependency, thus having a long intervening NP Length strongly affects processing even for low dependency items. The long NPs are therefore showing effects of Adjacency because the non-adjacent sentences are hard to comprehend regardless of the dependency of the verb particle. With NPs of medium length, both Dependency and Adjacency have effects, but in opposite directions, effectively canceling each other out, thus resulting in the wash-out effect that can be more easily viewed in Figure 6.

Results from the three tasks presented here indicate that word order preferences in particle constructions are affected by processing constraints such as adjacency, dependency, and NP length in a comprehension task. This experiment demonstrates that processing constraints have an effect on how people comprehend sentences with varying order and complexity. These findings support Hawkins' (1994, 2001) notion that word order is determined by performance factors.

References

Arnold, J.E., Wasow, T., Losongco, A., & Ginstrom, R. (2000). Heaviness vs. newness: The effects of structural complexity and discourse status on constituent ordering. *Language*, 76(1), 28-53.

Gries, S. (1999). Particle movement: A cognitive and functional approach. *Cognitive linguistics*, 10(2), 105-145.

Gries, S. (2002). The influence of processing on syntactic variation: Particle placement in English. In: Dehe, N., Lackendoff, R., McIntyre, A., & Urban, S. (eds.), *Verb-Particle explorations*, 269-288. Berlin: Mouton de Gruyter.

Hawkins, J.A. (1983). *Word Order Universals*. San Diego: Academic Press.

Hawkins, J.A. (1994). *A performance theory of order and constituency*. Cambridge: Cambridge University Press.

Hawkins, J.A. (1998). Some issues in a performance theory of word order. In A. Siewierska (Ed.), *Constituent order in the languages of Europe*. Berlin: de Gruyter. 729-781.

Hawkins, J.A. (2000). The relative order of prepositional phrases in English: Going beyond manner-place-time. *Language variation and change*, 11, 231-266.

Hawkins, J.A. (2001). Why are categories adjacent? *Journal of linguistics*, 37, 1-34.

Lohse, B., Hawkins, J.A., & Wasow, T. *Domain minimization in English verb-particle constructions*. Unpublished manuscript, University of Southern California.

Stallings, L.M., MacDonald, M.C., & O'Seaghdha, P.G. (1998). Phrasal ordering constraints in sentence production: Phrase length and verb disposition in heavy-NP shift. *Journal of memory and language*, 39, 392-417.

Table 1

Response latencies (msec) for target words by prime types and similarity

	Prime-Target Similarity		
Prime Type	Low	Mid	High
Unrelated	550	553	557
Related	543	532	537
Unrelated-Related	7	21	20

Figure Captions

Figure 1. Mean reading times (msec) per word as a function of adjacency (shifted versus non-shifted sentences).

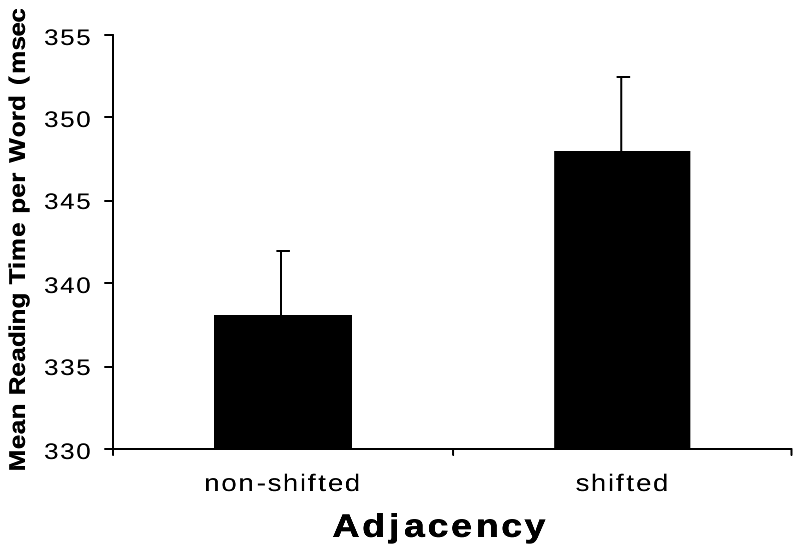
Figure 2. Mean reading times (msec) per word as a function of length (short, medium, and long sentences).

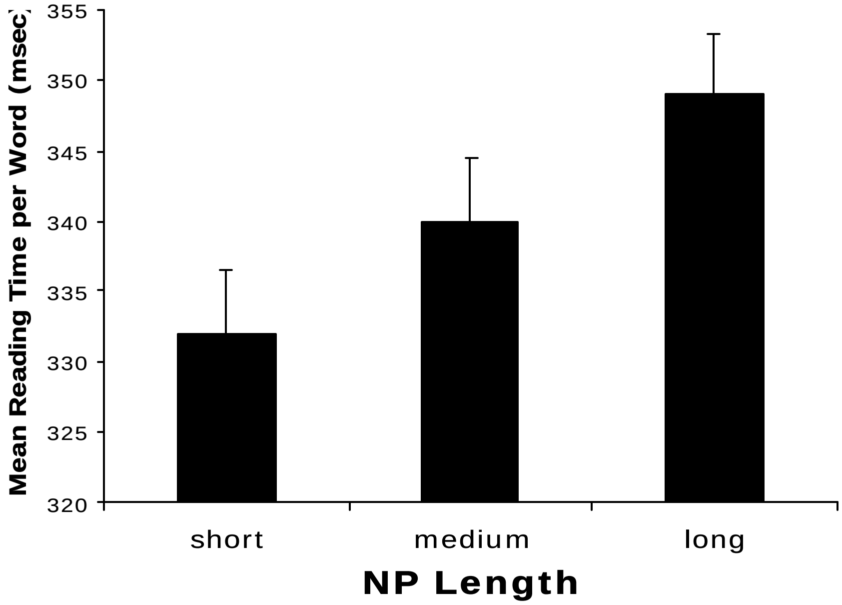
Figure 3. Mean reading times (msec) per word as a function of dependency (low, middle, and high sentences).

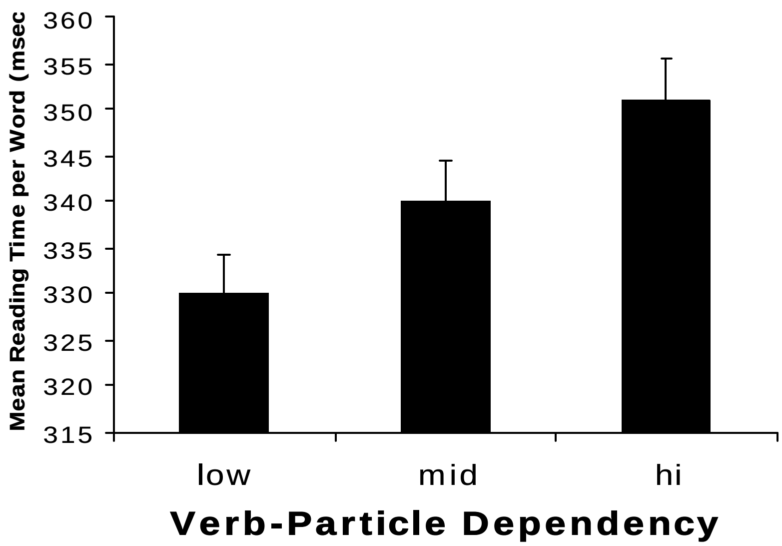
Figure 4. Mean reading times (msec) per word as a function of adjacency and length.

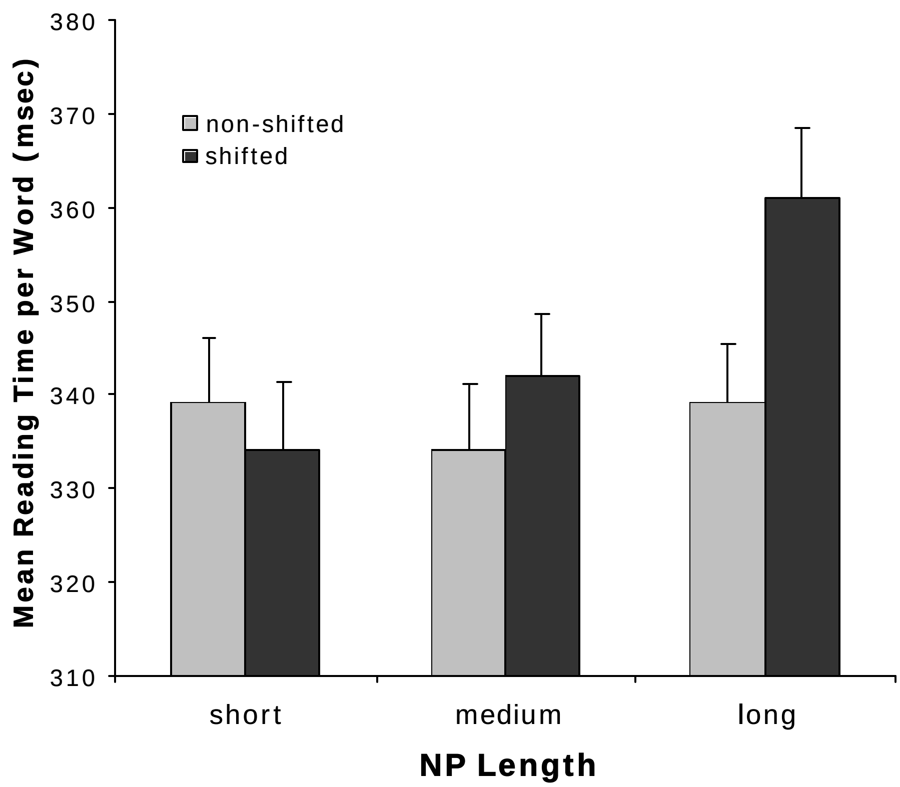
Figure 5. Mean reading times (msec) per word as a function of adjacency and dependency.

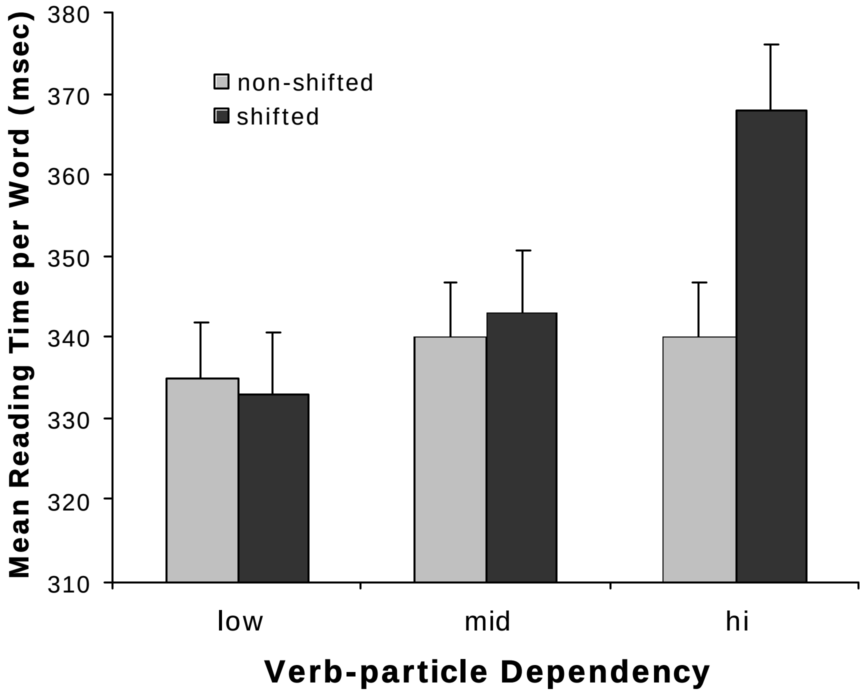
Figure 6. Mean reading times (msec) per word as a function of length and dependency.


Mean Reading Time per Word (msec
355
350
345
340
335
330
non-shifted
shifted
Adjacency

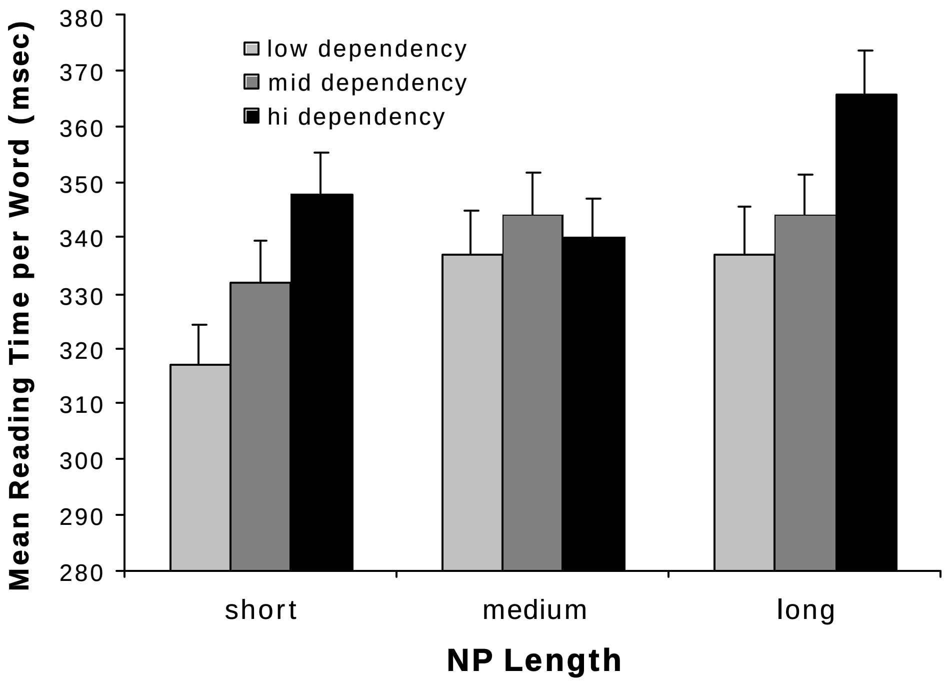

Mean Reading Time per Word (msec)
355
350
345
340
335
330
325
320
short
medium
long
NP Length


Mean Reading Time per Word (msec
360
355
350
345
340
335
330
325
320
315
low
mid
hi
Verb-Particle Dependency


380
370
360
350
340
330
320
310
Mean Reading Time per Word (msec)
non-shifted
shifted
short
medium
long
NP Length



Mean Reading Time per Word (msec)
380
370
360
350
340
330
320
310
non-shifted
shifted
low
mid
hi
Verb-particle Dependency


380
370
360
350
340
330
320
310
300
290
280
low dependency
mid dependency
hi dependency
Mean Reading Time per Word (msec)
short
medium
long
NP Length