Disambiguating NN combinations with left/right stress

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Abstract

An interesting subclass of Noun-noun combinations in English can take two meanings depending on whether the first or second word is stressed in speech. A BRICK factory is one that makes bricks, whereas a brick FACTORY is one made of brick. An explanation is offered in terms of a bias for nouns from particular ontological categories to trigger particular semantic interpretations for a combination, together with the proposal that the unstressed noun provides the relation to be used. The explanation is tested in three empirical studies.

Keywords: NN combination, concepts, compounds, meaning, ambiguity, stress

Introduction

Noun-noun compounds are found in many languages. They are the result of placing two nouns together in order to create a compound noun phrase with a new meaning (Gleitman & Gleitman, 1970; Levi, 1978). The first noun—the modifier—serves to specialise the meaning of the second noun—the head. To take the example of *cheese knife*, the head noun *knife* determines the kind of thing involved—a cheese knife is a knife—while the modifier *cheese* specifies that it is designed for use with cheese.[1]

Looking at noun-noun compounds in English it is possible to differentiate those that are constructed on the fly to meet the communicative needs of a given moment from those that long ago entered the lexicon. A good example of the former is Downing's (1977) famous *apple-juice seat* to indicate the seat at a table at which the person drinking apple-juice should sit, whereas examples of the latter are *toothpaste* or *lunch box*. As they enter the lexicon, compounds in English may be lexicalized as single orthographic words (e.g., *snowman*), or optionally hyphenated (e.g., *pigeon-hole*), while others have two-word spellings (e.g., *taxi driver*). Lexicalization involves a number of changes in the status of a phrase. In particular, lexicalized compounds are also more likely to lack semantic transparency, and hence to appear in dictionaries. The meaning of such non-transparent phrases must be acquired through hearing them in context, rather than being computable from the individual meanings alone. Examples like *beer garden*, *water glass*, or *wine lake* cannot be easily understood without appeal to knowledge external to the meaning of the two individual words.

In addition to the many lexicalized compounds in English, it is also possible to create new forms which can be readily understood. People have little trouble understanding new expressions like *camel field*, or *student gardener*, even though they may not have come across these combinations before. An explanation for this productivity was suggested by Gagné and Shoben (1997) in their CARIN model of Noun-Noun (NN) combinations. Earlier, Levi (1978) had proposed that the majority of compounds employ one of about 12 semantic relations, such as USE, LOCATION, MATERIAL COMPOSITION or CAUSE. Gagné and Shoben suggested that each noun in a person's vocabulary may be associated in memory with the relations that it most commonly enters into, as either a modifier or a head. Thus for example *mountain* as a modifier would normally indicate a location as in *mountain goat*, or *mountain village*. On the other hand *magazine* as a head would normally use an informational "about" relation as in *train magazine* or *psychology magazine*. When the two are put together to form *mountain magazine*, a search is instigated to find a plausible meaning. Since a magazine about mountains strikes most people as more plausible than a magazine in the mountains, in this case the head noun ends up dictating the preferred meaning of the phrase.

In the search for a plausible meaning, two equally plausible meanings can sometimes arise, each based on one of the two nouns and their preferred semantic relations, so that the compound is ambiguous. Kamp and Partee (1995) cite the example of a *brick factory*, which can either mean a factory that makes bricks or a factory that is made of brick. They also point out that the stress pattern employed when speaking the phrase can disambiguate its meaning. Thus one can compare (1) and (2):

(1) a *BRICK factory* = a factory that makes bricks
(2) a *brick FACTORY* = a factory made of brick.

The account offered by Kamp and Partee is that the ambiguity relates to the use of two distinct syntactic forms. They suggest, following Bloomfield, (1933: 228) and Chomsky and Halle's (1968: 15-18) Compound Rule, that left stress is a general signal in English that the phrase is a compound, meaning that its semantics will depend on local

[1] While familiar compounds like *cheese knife* have a conventional meaning, given a sufficiently rich context, they can take on an indefinite number of alternative meanings—such as a knife made of cheese, or the knife given as a trophy to the prize winning cheese maker. We are concerned here with the default meaning that first comes to mind in the absence of such a context.

context and the argument structure of the head noun. Note how *BEER garden*, *WATER glass*, and *WINE lake* all take left stress patterns, indicating this compound structure. On the other hand, right stress typically indicates a simpler modifier+head noun phrase. For example a *black BIRD* is a bird that is black, in contrast to the left-stressed, lexicalized, compound *BLACKbird*, which in British English refers to the common species of garden bird, *Turdus merula*.

The meaning of the compound phrase *BRICK factory* requires an understanding that the concept of *factory* takes an argument of the kind of thing made in it, with the modifier noun placed into this slot, as in (3).

(3) FACTORY (makes X)
X = {jam, brick, car, clothing,..}

On the other hand *brick FACTORY* is interpreted by treating the noun "brick" as a modifier meaning "made of brick". This account is not entirely satisfactory, since the question of when a NN combination is a "true" compound is hard to make on purely semantic grounds. For example why should the meaning of "factory" not also have an argument equivalent to [made of] in which the noun "brick" could be placed? The occurrence of left stress in compounds is also not as clear or reliable as one might hope (see Bell & Plag, 2010). While most single orthographic compounds do take left stress (e.g. *SUNflower, TOOTHpaste, ICEcream*) other highly familiar forms written as two-word phrases take right stress (*plum JAM, pumpkin PIE).* Nor is it that a given semantic relation such as MADE OF seen in these last two examples is consistently right stressed. Thus in British Received Pronunciation *cake* (unlike *pie)* is typically left stressed (*GINGER cake, CHOCOLATE cake*). It is unclear why the ingredients of jams and pies should be syntactically adjectival while the ingredients of cake should require an argument structure (a point noted by Lees, 1962: 120). Given these difficulties, in this paper we will refer to all NN combinations simply as compounds.

A large corpus-based analysis by Plag (2006) using a variety of models found the assignment of stress in spoken English to be largely unpredictable. The best means of prediction was by using analogy with other similar compounds (e.g. *OIL painting, FINGER painting, ACTION painting)*, suggesting a role for similarity-based generalisation in the assignment of stress (Plag, 2010). Further work by Plag and colleagues has identified evidence for a semantic basis, and for families of semantically similar compounds taking the same stress (Plag et al. 2008). Bell & Plag (2010) also reported that relative informativeness can direct stress on to the more informative of the two nouns.

The placement of stress in speech generally is clearly a very complex phenomenon (for a review see Cutler et al. 1997). There has been relatively little research on prosody in the psychological literature in relation to the interpretation of compounds. A study by Lynott and Connell (2010) manipulated spoken stress for an arbitrary set of novel NN compounds, and found that dual emphasis differentially speeded the generation of property interpretations (e.g. a *zebra mussel* as a striped mussel). However they reported no effects of stress on the frequency with which different interpretations were generated, even though many of the compounds had more than one interpretation.

In this paper we focus on one particular use of stress in the context of the interpretation of compounds. Specifically, we ask how ambiguous compounds such as *brick factory* are disambiguated with the help of stress. Why should left versus right stress direct interpretation in two different directions? Our proposal is that stress indicates which of the two nouns provides the semantic relation for interpretation of the phrase. In particular we propose that it is the *unstressed* noun that determines the relation.

Recall the example of *brick factory*. The claim is that *brick* as a modifier will typically invoke a [MADE OF] interpretation, as in *brick house, brick building, brick wall*. On the other hand *factory* will invoke a [MAKES] relation, as in *car factory, hat factory* or *furniture factory*. Placing the stress on the modifier *brick* thus gives the relation preferred by the head (a factory that makes bricks), whereas stressing the head noun *factory* gives the relation derived from the modifier (a factory made of brick).

To make the principle operational and testable we needed some means to be able to generate ambiguous compounds where the ambiguity depended on two competing relations, one derived from the modifier and one from the head. Both interpretations needed to be plausible meanings for the written phrase (that is, as read in the absence of auditory stress information). Rather than depend on a frequency analysis of individual words occurring in either position, as Gagné and Shoben (1997) proposed, we adopted a suggestion from Maguire, Wisniewski & Storms (2010) who proposed, on the basis of a corpus study of semantic patterns in compounding, that preferred semantic relations follow from the general ontological category into which a noun falls, rather than being individual to each noun. Thus *brick* is a member of the category of *compositional materials*, along with *jam, water, cork, plastic* etc. All of these will have a preference as modifiers for a MADE OF relation. Similarly *factory* belongs to a category of sources or origins of objects, from which the relation MAKES will naturally follow. The idea of interpreting NN compounds by recourse to a superordinate semantic categorization of nouns has had much support, particularly in the domain of automatic processing of natural language (Rosario & Hearst, 2001), although no agreed semantic taxonomy has yet been developed.

Our strategy in creating a set of ambiguous compounds for testing was therefore first to find individual examples, and then to generate further examples using the same superordinate categories. The results of this process can be seen in Table 1 which shows the analysis of the compounds into general categories, together with examples of the materials used. The classification is necessarily fairly broad and provisional, but it serves to illustrate the analogies between, say, an airplane magazine and a church painting, both of which take either a LOCATION or an ABOUT

relation, and it provides some systematicity to our search for suitable examples. We predicted that with left stress, the compounds will have an interpretation of magazine (or painting) ABOUT an airplane or a church, while with right stress, the location relation will be dominant, yielding a magazine or painting LOCATED IN an airplane or church.

To assess the validity of our analysis, we put our predictions to the test. Experiment 1 and 2 provided participants with the ambiguous compounds spoken with either left or right stress, and asked them to write down their interpretation of the meaning. Experiment 3 provided participants with the spoken phrases, and then asked them to judge the plausibility of a given interpretation which could either match or mismatch the interpretation predicted for the stress pattern. We predicted that stressing the modifier or head would influence both the interpretations generated in Experiment 1 and 2 and the speed and accuracy of judgments in Experiment 3.

Experiment 1

The purpose of Experiment 1 was to test our proposal that the unstressed word in an ambiguous compound should be the one from which the semantic relation will be derived. Hence a *chimpanzee DRAWING* should be a drawing done by a chimpanzee (taking the agency from the animate modifier noun), while a *CHIMPANZEE drawing* will be a drawing of a chimpanzee (taking the "information source about" relation from the head noun).

Method

Participants Twenty-four students at City University London participated. All were native speakers of English.

Materials Forty ambiguous compounds were recorded spoken by a female voice in Received Pronunciation British English. The compounds were selected from a larger sample through pretesting. Participants in the pre-test read each compound (i.e., no stress information was given) and wrote down an interpretation. Items were then selected where just two alternatives were generated, each by at least 25% of the participants. For the final selection, on average the more frequent meaning was generated 57% of the time, and the less frequent meaning 35% of the time. Each compound was recorded once with stress on the first word, and once with stress on the second word. To reduce the likelihood that the ambiguity of phrases would be noticed, 12 unambiguous fillers were included, two at the start, and ten more distributed every three to five trials through the rest of the experiment. They were familiar phrases like *book bag* and *oak table.*

Procedure Participants were seated in front of a PC, and wore sound insulating headphones, through which the speech samples were played. Instructions were displayed on the screen as follows:

> In the present study we are investigating the meaning of so-called noun-noun phrases, phrases consisting of two nouns, such as "park bench". We are interested in your intuitive understanding of these phrases. For each noun-noun phrase, we would like you to write down its meaning in the textbox provided. A short description of the meaning that first comes to mind is sufficient. For example, when you hear "park bench", the first thing that might come to mind might be: A bench in a park.

Once the instructions were understood the trials began. Each trial began with the playing of the recording of a phrase. A button on the screen allowed the participant to repeat the playback if they wished to hear it again. If the replay button was clicked three times, a window appeared displaying the phrase (very occasionally people had trouble hearing the words spoken). Being written, no cue was given as to the stress pattern. A text box was provided on screen into which the participant typed their interpretation of the phrase. A "NEXT" button took them after a short pause to the next screen and a new recorded phrase.

Design Participants were divided into four groups of 6. Two groups had 20 compounds with left stress and 20 with right, while the other two groups had the alternative. In addition two different random orders were used.

Results

One item was omitted owing to an error in the programming. The results were based on the remaining 39 items. The interpretations entered by participants to each

Modifier Category M	Head Category H	Modifier-based Relation	Head-based Relation	Examples
AGENT/ PATIENT	AGENT	H who is M	H for M	*athlete lawyer, celebrity doctor*
AGENT/ PATIENT	ACTION/EVENT	H by/from M	H for/to M	*company award, dolphin strategy*
AGENT/ PATIENT	INFORMATION SOURCE	H produced by M	H about M	*politician novel, chimpanzee drawing*
LOCATION	AGENT	H comes from M	H done of M	*Iceland painter*
LOCATION	INFORMATION SOURCE	H found in M	H about M	*airplane magazine, church painting*
MATERIAL	INSTRUMENT	H made of M	H for making M	*ceramic oven*
MATERIAL	CONTAINER	H made of M	H contains M	*clay bucket, wax pot*
MATERIAL	INFORMATION SOURCE	H made of M	H about M	*chocolate book, paper catalogue*
MATERIAL	MATERIAL	H made of M	H for M	*juice dye, plant poison*
INSTRUMENT	ACTION/EVENT	H done using M	H done to M	*dollar purchase, skateboard damage*

Table 1: General categories of noun, and the semantic relations to which they are biased, together with examples of compounds used

phrase were collated into a single table, without any information about the original stress pattern that they had heard. The first two authors worked through the table independently to code the interpretations as either (a) the meaning derived from the modifier, (b) the meaning derived from the head, or (c) other or unclassifiable. Initial agreement between the judges was 90%. Disagreements were resolved by each judge reconsidering the disputed interpretations in the knowledge of the other judge's rating. Any remaining disagreements were treated as "other". (There were 13% of responses that could not be classified.) The predicted effect of stress was borne out in the data across 39 items, with more modifier meanings resulting from right stress (19.8) than from left stress (14.2), and more head meanings resulting from left stress (18.6) than from right stress (15.1). Overall, 57% of responses were as predicted by stress. The effect was highly reliable across participants, with 21 of 24 following the prediction on average, and none against it ($p<.001$, sign test). Across items the effect was less strong statistically, with 25 of 39 compounds following the prediction and 12 against ($p = .01$, sign test).

Experiment 2

The effect in Experiment 1 was relatively small, with stress inducing a bias in interpretation of 57% versus 43%. Experiment 2 was a replication in which we tested whether a new selection of materials and an improved quality of the sound recordings might show a stronger effect.

Method

Participants Twenty-four students participated for course credit.

Materials Ambiguous compounds were constructed as in Experiment 1, with 40 compounds, 25 of which were new to this study. (The effect size in Experiment 1 for the 15 items used in both studies was identical to the overall mean effect size for that study, so these were not retained just on the basis of their being "good" items in terms of results.) New recordings were made, under improved recording conditions using a sound-proof studio and high quality microphone and recorder. The speaker had a London accent, more familiar to the student participant pool than was the RP used in Experiment 1. In addition when creating the recordings, to help the speaker produce meaningful stress patterns we used contrastive stress to generate the left versus right stress patterns. The speaker first read out a sentence such as "It's not a CLAY pot it's a … WAX pot", while pausing before the last two words. In a second recording, the speaker read out the sentence "It's not a wax CANDLE, it's a … wax POT". All speech except for the final two words of each sentence was then edited out to leave just the final two word phrase for use in the experiment. Hence participants in the experiment proper had no access to the contrastive meaning used in generating the spoken phrases, but just heard each phrase either with left or with right stress.

Design and Procedure The design and procedure was identical to Experiment 1.

Results and Discussion

Responses were classified as before. The effect size was considerably increased. For left stress, across the 40 items there were on average 27.8 head meanings and only 11.3 modifier meanings, while with right stress the means were reversed with 14.3 head meanings and 24.0 modifier meanings. The proportion of all responses in line with prediction increased from 57% in Experiment 1 to 67% in Experiment 2. Across items, 34 out of 40 (85%) showed the predicted effect, and only 6 went against the hypothesis. Across participants, 20 (83%) showed the predicted effect, and only 3 went against. (Both, $p < .001$ on a sign test).

Experiment 2 strengthened the evidence for our hypothesis. With a new selection of items and improved recording of the stress patterns, the effect size was greatly increased. The relatively weak consistency across items in Experiment 1 can probably be attributed to problems in the original recorded materials. For the set of 15 items used in both experiments effect size correlated across experiments at .56 ($p < .05$). In the first experiment these items had the same effect size as the remaining items. In Experiment 2 their effect size increased in line with the other new materials (8.6 for the 15 retained items, and 7.3 for the 25 new items), supporting the effect of the improved audio recordings.

Experiment 3

If stress assignment directs interpretation in the way we propose, then it should be easier to judge that a particular given interpretation is plausible for a spoken compound if the interpretation being judged is consistent with the stress pattern used. In Experiment 3, participants heard the same phrases as in Experiment 1 with either left or right stress. They were then immediately given a written interpretation, which was either one of the two plausible meanings, or a new implausible one. When the interpretation was plausible, it could either match that predicted from the assigned stress, or mismatch it (i.e. match the alternative interpretation). We predicted that trials on which a match occurred should lead to faster and more accurate responding.

(Because Experiment 3 was conducted before Experiment 2, the materials and recordings were the same as in Experiment 1).

Method

Participants Initially 60 students at City University London participated in the study, of which 11 were replaced as they made more than 50% errors on all trials taken together.

Materials The same 40 spoken word phrases were used as in Experiment 1. Since the programming error for one item

was not detected in time, only 39 of the phrases could be used for the analysis. Fillers were included at the start (the first 5 trials), and throughout the sequence so that not all the phrases were ambiguous. In addition a set of 40 implausible meanings for familiar compound nouns was constructed (e.g., *box office* "an office about a box", *bus seat* "a seat that is a bus".)

Procedure Participants heard the spoken phrase over headphones, and then after a delay of 2 seconds saw an interpretation of the phrase on the screen. They had to decide as quickly as possible whether it was a plausible meaning or not. The following instructions appeared on the screen at the start of the experiment:

> "In the present study we are investigating the meaning of so-called noun-noun phrases, phrases consisting of two nouns, such as "park bench". We are interested in how long it takes to understand different phrases. You will be presented with a spoken phrase, and shortly after you will see a possible meaning on the screen. If you think the meaning makes sense, then press the ALT GR key (on the right of the space bar). If it doesn't make sense as a meaning for the phrase, then press the ALT key on the left of the space bar. The first five trials are for practice, so feel free to ask if you don't understand what you are supposed to be doing. After that we would like you to proceed, making your responses as fast as you can while not making any errors. The experiment will take 10 to 15 minutes."

Design There were two random orders or presentation and two assignments of stress to each spoken compound. In addition the interpretation offered for judgment could be either the modifier-based or the head-based interpretation.

Results and Discussion

Mean correct reaction times and error rates were calculated for Matching and Mismatching plausible trials for each participant and each item. Three RTs of over 10 seconds were removed from the analysis entirely, and another 18 reaction times of over 3 standard deviations above the mean for individual participants were truncated. Table 2 shows the results for RT and Error rates. When the interpretation to be judged as meaningful was consistent with the stress assignment, responses were on average 100ms faster and about 10% more accurate. Two 2-way ANOVA were run for RT and Errors with stress assignment and interpretation as factors, and with participants and items as random effects. (The error distribution for error rates was normal, skew = -0.1, matching the assumptions of ANOVA.)

Although RT showed the predicted interaction (2338 ms for matching and 2438 ms for mismatching meanings), it failed to reach significance ($p = .15$). However Errors showed the predicted interaction as significant (26% for matching and 31% for mismatching trials), with $F(1,59) = 6.0$, $p = .018$ by subjects, $F(1,38) = 4.3$, $p = .044$ by items. No main effects were significant. (For filler implausible trials, mean RT was 2300ms, sd = 771, and the error rate was 17%.)

While supportive of our hypothesis, the procedure in Experiment 3 is clearly less sensitive to the effects of spoken stress, requiring as it does a "sensicality" judgment. The weak effects may (as in Experiment 1) have reflected some difficulty that some participants may have had in clearly perceiving the spoken phrases. The high error rate may also be owing to this factor. It is also possible that some participants may have focussed on identifying the nonsensical meanings, which would allow them to ignore the spoken stress all together.

	MEANING			
	Resp. Time (ms)		Error (%)	
STRESS	Modifier	Head	Modifier	Head
Left	2453 (952)	2324 (833)	30.5 (18.1)	25.3 (17.0)
Right	2353 (943)	2424 (869)	27.7 (16.2)	30.9 (17.7)

Table 2. Mean (SD) for response times and errors for Experiment 3

General Discussion

In these studies we have sought to find evidence for our explanation of how stress assignment can disambiguate the interpretation of NN compounds. We showed in Experiments 1 and 2 that spontaneously generated meanings were influenced in the predicted direction by stress, and this result was supported in Experiment 3 with evidence that on-line processing of a potential meaning of a phrase was similarly affected by hearing a spoken phrase with the stress on the left or right word, at least in terms of error rates.

The results were typical of psycholinguistic data, in that the main effect of interest was (to various degrees) obscured by other factors and noise in the data. Using a speaker with a London accent, and a procedure for generating the spoken phrases that used contrastive stress ("It's not a CLAY pot it's a WAX pot) produced a marked increase in the size of the predicted effect in the second experiment. It is also very possible that different speakers are differentially responsive to the influence of stress. Both Experiments 1 and 2 found a bimodal distribution across participants. For example in Experiment 2, 16 participants had effects ranging from 43% to 65%, but the other 8 participants were in the range 87% to 100%.

The principle explanation that we offer is that the unstressed word in an ambiguous NN compound determines the semantic relation. In light of the role of stress in directing attention, this principle may at first appear paradoxical. One might suppose that attention should be directed towards the noun that is "doing the work". However stress in spoken language is also often used to direct attention to the focus or new information in an utterance (Bell & Plag, 2010; Bock & Mazzella, 1983;

Clark & Haviland, 1977). The difference between "I phoned my mother on FRIDAY" and "I phoned my MOTHER on Friday" is a matter of whether the focus of the utterance is the date of the call or the person called. In the case of our proposed principle, a similar analysis can be made. In an ambiguous compound, one of the nouns provides the background schema from which the general meaning will be derived, and the other provides the highlighted information placed into that schema. Take an example like *chimpanzee drawing.* Is the issue a matter of what kinds of things chimpanzees get up to, or is it about the kinds of things that get drawn? If the former, then *chimpanzee* goes unstressed as the new information is that they do *drawings*. If the latter, then *drawing* is the unstressed background schema, and the new information is that it is a *chimpanzee* that is the subject of the drawing. The two interpretations can be (loosely) represented thus;

(4) *A chimpanzee DRAWING*

CHIMPANZEE .. [type of creature {mammal, primate..}]
.. [activities {swinging from trees, hooting, DRAWING…}]

(5) *A CHIMPANZEE drawing*

DRAWING.. [implements needed {pencil, paper …}]
.. [subject {scene, still life, CHIMPANZEE…}]

There may therefore be close parallels between the different roles that stress can play within discourse processes and in compound interpretation.

Our result is also consistent with Plag et al.'s (2008) finding that stress assignment is often constant across families of similar compounds, based on the similarity of either head or modifier nouns (see also Plag, 2010). Semantically similar concepts tend to have similar preferred relations, and so enter into similar patterns of stress assignment. For example location modifiers and material modifiers typically take right stress in unambiguous compounds, and there are other cases where given semantic relations are associated with particular stress direction. However, there must be other factors (such as historical accident) at work, as the example given in the introduction of the different stress assignment for pies versus cakes clearly demonstrates. More recently Bell and Plag (2010) have reported that stress can also be predicted from the relative informativeness of the two nouns in a compound, with the more informative being stressed. Our principle fits well with this idea. The unstressed noun sets up a background schema into which the stressed noun is placed as the new information.

The principle that we have described helps to shed some light on at least one aspect of the use of stress patterns in English. It remains to be seen how broadly the principle can now be applied outside of the realm of ambiguous NN compounds.

References

Bell, M., & Plag, I. (2010). Informativeness is a determinant of compound stress in English. Unpublished MS from DFG-Project website, http://www2.uni-siegen.de/~engspra / DFG-Project/Bell-Plag-2010.pdf, viewed March 1, 2011.

Bloomfield, L. (1933). *Language*. New York: Henry Holt and Co.

Bock, J. K. & Mazzella, J. R. (1983). Intonational marking of given and new information: Some consequences for comprehension. *Memory & Cognition, 11,* 64-76.

Chomsky, N. & Halle, M. (1968). *The sound pattern of English*. New York: Harper and Row.

Clark, H. H. & Haviland, S. E. (1977). Comprehension and the given-new contract. In R.Freedle (Ed.), *Discourse production and comprehension* (pp. 1-40). Norwood, NJ: Ablex.

Cutler, A., Dahan, D., & van Donselaar, W. A. (1997). Prosody in the comprehension of spoken language: A literature review. *Language and Speech, 40,* 141-202.

Downing, P. (1977). On the creation and use of English compound nouns. *Language, 53,* 810-842.

Gagné, C. L. & Shoben, E. J. (1997). Influence of thematic relations on the comprehension of Modifier-Noun combinations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 71-87.

Gleitman, L. R. & Gleitman, H. (1970). *Phrase and paraphrase*. New York: Academic Press.

Kamp, H. & Partee, B. (1995). Prototype theory and compositionality. *Cognition, 57,* 129-191.

Lees, R. D. (1963). *The grammar of English nominal-izations*. Bloomington IN: Indiana University Press.

Levi, J. (1978). *The syntax and semantics of complex nominals*. New York: Academic Press.

Maguire, P., Wisniewski, E. J., & Storms, G. (2010). A corpus study of semantic patterns in compounding. *Corpus Linguistics and Linguistic Theory, 6,* 49-73.

Plag, I. (2006). The variability of compound stress in English: structural, semantic and analogical factors. *English Language and Linguistics, 10,* 143-172.

Plag, I. (2010). Compound stress assignment by analogy: The constituent family bias. *Zeitschrift für Sprachwissen-schaft,29*, 243-282.

Plag, I., Kunter, G., Lappe, S., & Braun, M. (2008). The role of semantics, argument structure, and lexicalization in compound stress assignment in English. *Language, 84*, 760-794.

Rosario, B. & Hearst, M. (2001). Classifying the semantic relations in noun compounds via a domain-specific lexical hierarchy. In *Proceedings of the 2001 Conference on Empirical Methods in Natural Language Processing (EMNLP2001).* Pittsburgh, PA.

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