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Effects of Prosody on Conceptual Combination

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Abstract

Previous theories of conceptual combination comprehension have failed to address the possible role of suprasegmental factors such as prosody and emphasis patterns. In this study, we investigated the effect of prosody on the comprehension of novel noun-noun compounds. First, we formulate some predictions based on existing theories of conceptual combination and linguistic accounts of emphasis assignment. We then present a study that examines the effects different emphasis patterns on people's comprehension of novel compounds. We found that emphasis influences the comprehension of novel word combinations, affecting the ease with which people can think of meanings. Overall we found that people exhibited a preference for initial word emphasis (Modifier emphasis) over equal (Dual) or final word (Head) emphasis. We also observed that some of these effects were dependent on the types of concepts being comprehended. We argue that existing theories need to incorporate suprasegmental factors to provide a fully-fledged account of conceptual combination.

Introduction

Wrap rage, *tunnel advertising* and *latte factor*¹ are all examples of novel noun-noun compounds, generally referred to as concept combinations. These novel combinations reflect a fundamental aspect of language generativity, accounting for between 30% and 60% of new terms in English (Cannon, 1987; McFedries, 2004). It often happens that such compounds survive to become permanent fixtures of the language and used everyday by the wider language community (e.g., “soccer mom”, “laptop computer”). Others may only be used in one specific context and not become part of the language as term in its own right (e.g., *daisy cup* as “a cup with a daisy pattern on it”). With these phrases occurring everywhere from newspaper headlines to advertisements and novels, it is clear that they represent an important aspect of language and language growth.

Over the past 25 years there has been a wealth of research on the comprehension of concept combinations, with a number of different theoretical positions being proposed (e.g., Clark & Hecht, 1982; Costello & Keane, 2000; Gagné & Shoben, 1997; Hampton, 1987; Levi, 1978; Wisniewski, 1996). Most recent research acknowledges that for any given novel combination there can be many possible interpretations (e.g., Constraint Theory, Costello & Keane,

2000; Competition Among Relations in Nominals, CARIN, Gagné, 2000; Integrated Production and Comprehension theory, Lynott, 2004; Concept Specialisation, Murphy, 1990; Dual-Process Theory, Wisniewski & Love, 1998). For example, the compound *aeroplane bed* could refer to either “a bed that is shaped like an aeroplane” or “a bed that can be used in an aeroplane”. Each of the above theories proposes different mechanisms for the generation of different interpretations and also makes different predictions as to how easy people arrive at interpretations for different compounds. For example, the CARIN theory focuses on relational interpretations of compounds, where a thematic relation links the modifier (the first concept) and head (second concept) in an interpretation (e.g., “a river LOCATED in a mountain”, “a magazine ABOUT restaurants”). The ease of comprehension for compounds has also been predicted using the frequency with which relations have occurred with specific concepts in the past (see Gagné, 2000 etc.). The CARIN theory also argues for the primacy of the modifier during the comprehension process, suggesting that the modifying concept is the most important component of the compound when making predictions about people's responses. This contrasts with the other theories mentioned above. Constraint Theory and Dual-Process theory place equal emphasis on both the head and modifier concepts, while Concept Specialisation puts much greater emphasis on the role of the head concept in the interpretation process. Other views (e.g., Lynott's Integrated Production and Comprehension account, 2004) maintain that we cannot assume in advance which concept is most important for interpreting a compound. Rather it is dependent on each individual concept and that concept's internal structure. These latter theories also propose greater interaction between the head and modifier concepts when constructing interpretations, compared to the modifier-driven theory of Gagné.

Despite the range of views put forward to account for the comprehension of novel word combinations, none of the aforementioned theories specifies a role for suprasegmental information (e.g., prosodic information) in this process. This is a curious omission, in light of the fact that general linguistic theories of language have noted the meaning-altering effects of prosody for a long time (Bresnan, 1971; Chomsky & Halle, 1964; Ladd, 1980, 1996). Furthermore, the frequency with which complex noun phrases occur only adds to mystery of this oversight.

Broadly speaking, prosody refers to changes in aspects of speech such as emphasis, pitch, intonation, rhythm and

¹ Definitions for these and many more combinations can be seen at www.thewordspy.com (McFedries, 2004).

timing. It is well known, that changes in prosody can affect meaning. For example, words such as *contract*, *refuse* and *object*, all change meaning depending on which syllable emphasis is placed. Similarly, larger linguistic units can have their meaning changed by a simple prosody alteration. For example, there is a difference between “a BLUE bottle” and “a bluebottle” – the first referring to the colour of a bottle, the second referring to a type of fly.

From these general examples of prosody, the potential of prosody to alter meaning is clear. However, the primary question we address in this study is this: if prosodic changes can affect meaning change in non-novel words and phrases then can it not also effect meaning change in novel phrases (i.e., concept combinations)?

To address this issue, we must look first at the prevailing theories of conceptual combination to ascertain what predictions, if any, they might make regarding the influences of prosody on meaning. Second, we turn to linguistic views of prosody and emphasis placement in compounding to see whether they offer us an alternative view when we apply those models to novel word combinations.

Linguistic versus Psychological models of compounds

In investigating the possible effects of prosody on novel noun-noun compounds, there are essentially three possible prosodic patterns that need to be considered; namely Modifier emphasis (emphasis on the first word; e.g., *CHOCOLATE cake*), Dual emphasis (equal emphasis on both words; e.g., *CHOCOLATE CAKE*) and Head Emphasis (emphasis on the second word; e.g., *chocolate CAKE*). The question is whether using these different patterns affects the interpretation process in quantifiably different ways. We consider this in two ways. First, can different emphasis patterns facilitate comprehension by allowing people to respond more quickly to novel combinations? Second, can different emphasis patterns enable people to think of meanings for novel combinations more readily? In answering these questions, we must first turn to the existing theories of conceptual combination, followed by linguistic views of prosody in compounds to see whether they can shed light on the possible effects.

The CARIN theory makes the strongest claims as to which of the constituents of a novel compound is more important to a comprehender. Gagné and colleagues (e.g., Gagné, 2000, Gagné & Shoben, 1997) have shown repeatedly that the relational information carried by the modifier has a greater impact on the time course of interpretation compared to the relational information carried by the head. For example, *tax magazine* is responded to more quickly than *mountain magazine*, because the ABOUT relation is used more frequently with *tax* than with *mountain*. Although, prosodic effects are not discussed by Gagné, the theory can be viewed as predicting that compounds interpreted with Modifier emphasis should be easier to comprehend than those using Head or Dual emphasis. If the modifier is the

most important aspect of the combination to attend to, then emphasising it should facilitate the retrieval of information from the modifier (i.e., relations) and so aid the process of forming an interpretation. By contrast, emphasising the head concept could in some way inhibit the comprehension process by directing attention away from the modifier concept.

Such clear predictions however, are not readily extractable from the other theories. The Constraint Theory (and also Dual-Process theory) does suggest that both modifier and head concepts are of equal importance; this has been encoded in a computational model of Constraint Theory, C3 (Costello & Keane, 2000). From this we would surmise that perhaps Dual emphasis might be the greater facilitator for comprehension. The Concept Specialisation approach sees the head concept as being the driving force behind the construction of interpretations. This would suggest that Head emphasis should facilitate faster comprehension than the alternative patterns. Finally, we have the IPAC theory (Lynott, 2004; see also Lynott, Tagalakakis & Keane, 2004) which argues that we cannot know a priori whether the head or modifier concept is going to contribute more to an interpretation; it depends on what the specific concepts are. In other words, there are no default rules which might allow us to predict the effects of the different prosodic patterns. That said, Lynott et al, do note that existing evidence points to the possibility of the modifier being the chief differentiator of comprehension times.

While the previous psychological views of conceptual combination have been silent on the effects of prosody, there has been an amount of linguistic analysis that has focussed on finding accurate ways of predicting emphasis patterns in complex noun phrases (i.e., where there is a string of two or more than nouns together. See Cinque, 1993; Selkirk, 1984), but these approaches have had limited success. However, the problems of finding adequate rules for prosody and emphasis prediction have also been of particular interest to researchers working in the area of speech synthesis technologies (see Hirschberg, 1990, 1994; Monaghan, 1990; Sproat, 1990, 1994). The simple reason for this interest is that poor prosody rules can lead to synthetic speech sounding unnatural and reduce intelligibility (Monaghan, 1991). Such studies can tell us about the general patterns people use when pronouncing complex noun phrases, which might provide us with some insights into people’s preferences. We focus on one study by Sproat (1994) that analysed a large number (approx 8,000) of common noun-noun combinations (e.g., *animal abuse*, *fellow actor*) with the sole purpose of examining the emphasis patterns that people generally use.

Sproat found that the majority of compounds (71%) took Modifier emphasis (e.g., *NEWS agency*), but that a large proportion (29%) took Head emphasis (e.g., *invasion AFTERMATH*). Such analysis would suggest that Modifier emphasis should work to facilitate comprehension compared to Head emphasis. Connell (2000) also found that Modifier emphasis was most common (68.2%), lending support to the

idea that Modifier emphasis may facilitate comprehension to a greater extent. It should be noted, however, that Sproat does not allow for Dual emphasis to play a role in his model. This contrasts with Connell's analysis where Dual emphasis accounted for more compounds (22.3%) than those taking Head emphasis (9.4%). Despite the fact that there is disagreement over the frequency of dual and Head emphasis, and that both studies admit there will be some degree of inter-speaker variability, the overriding trend is for Modifier emphasis as the dominant pattern of emphasis. From these analyses of common and lexicalised compounds it would seem that Modifier emphasis should facilitate faster and more accurate comprehension. The one caveat with both of these approaches is that these accounts have looked at how to derive patterns for non-novel or lexicalised compounds. They do not address the issue of how different patterns might affect meanings in new word combinations.

An issue of real concern to us is whether prosody may have an effect on the specific interpretations that people generate. Connell (2000) observed that the same compound with a different meaning description attached was read with different emphasis patterns. For example when given the compound *kidnapper killer* with the meaning "a person who kidnaps and kills", participants read the compound with dual emphasis (i.e., *KIDNAPPER KILLER*). However, when given the compound with the meaning "a person who kills kidnappers" they read with modifier emphasis (i.e., *KIDNAPPER killer*). In this example, the meaning being conveyed is influencing the emphasis people ascribe to the same compound. When a person highlights one term above the other it is with the goal of conveying specific information by highlighting specific dimensions of the concepts concerned that might not be immediately obvious with an alternative emphasis placement². Therefore, it might be reasonable to assume that prosodic effects can work in the opposite direction, with different emphases leading to different meaning activations and therefore different response patterns.

Thus, while some current psychological theories make strong cases for the precedence of either the head or modifier concept over the other, they all remain silent on the possible effects of prosody on the interpretation process. Similarly, linguistic analyses have pointed to Modifier emphasis as being the most prevalent, but they have failed to address prosodic effects on novel noun-noun compounds. Taken together, the strongest case is provided for the modifier concept as being the focus in terms of facilitating interpretation.

In the following section we present an experiment that examines which patterns of emphasis facilitate or inhibit the comprehension process to the greatest extent. We achieve this by presenting people with novel noun-noun compounds as auditory stimuli with different patterns of emphasis. The speed of participant responses and the ease with which they

can arrive at interpretations are then analysed. We first describe the construction and evaluation of the materials followed by the details and analysis of the experiment proper.

Experiment

The aim of the experiment is to examine whether the use of different patterns of emphasis (Modifier, Dual or Head emphasis) affect people's ability to comprehend novel noun-noun combinations. Because of the nature of the experiment we felt that using human readers in the recording of our stimuli would lead to unplanned cues, with readers making subjective choices as to how words should be read. There is also the problem of consistency, with readers possibly altering their pitch and levels of emphasis from one phrase to the next. Either of these issues could lead to confounds in our results. Instead we chose to use a high quality speech synthesis system that would provide us with objective and consistent sound stimuli. We provide the full details for the materials construction and evaluation below.

Based on our review of previous research, it appears that the strongest predictions point towards emphasis on Modifier concepts as being the greatest facilitation of the comprehension process. However, as Lynott (2004) points out, we may not be able to make such general statements, with interpretation being reliant on the specific concepts involved or at the very least, specific types of concept. As our materials contain a variety of concept types (e.g., abstract, artefact, natural kinds), it may be informative to examine the effects of prosody within these subgroups.

Due to the difficulty of the task we expected a high percentage of "No" responses for the judgement task. due to stimuli being presented aurally, and due to the compounds having been constructed in a random fashion.

Materials Preparation and Evaluation

To select the words for our stimuli we selected 100 concepts used previously in the conceptual combination literature from three sources - Costello & Keane (2001); Gagné & Shoben (2001); Wisniewski (1996). The concepts used were a mix of artefacts, natural kinds, abstract concepts, object and non-object concepts (see Medin, Lynch & Solomon, 2000). We randomly generated approximately 200 two-word combinations from this set. From this set we removed any compounds where the same word was used for both head and modifier. We took the remaining compounds and input them into a speech synthesis system in order to create audio files for each phrase, with each different pattern of emphasis. The synthesis system we used was rVoice by Rhetorical Systems (rVoice, 2005). We used rVoice's female, UK-English voice (F015) for all stimuli. In order to create consistent emphasis patterns we used a speech markup language known as SSML (Speech Synthesis Markup Language, similar to HTML). We constructed three templates to represent the different possible emphasis patterns; Modifier, Dual or Head emphasis. In each of these cases, emphasis was achieved by increasing the pitch and

² In discourse, the given/new distinction will lead people to emphasis new terms over previously mentioned terms (Ladd, 1996; Sproat, 1994), but this is not the case here as there is no preceding discourse. Cf. Fodor (2002).

reducing the speed of utterance for that portion of the phrase (see Sproat, 1994). The appendix provides the specific tags we used. The files were generated at high-quality, 32 kHz sampling frequency at 16-bit resolution, with the volume being normalised for all files. This gave us approximately 600 audio files (200 for each emphasis pattern).

In order to ensure the sounds were of good quality we had three independent raters listen to the sound files and a) write down the words they heard, and b) indicate whether the clarity of the phrase was Good, Ok or Bad. This process ensured that all of the sound files selected would be of good clarity (i.e., if the words could be correctly identified) with a high level of naturalness. Additionally, at this point some phrases that contained homophones became apparent and so were excluded from the candidate materials (e.g., *bowl kangaroo* and *bole kangaroo*). Only phrases that were correctly transcribed by all three judges, and that were also judged as being of Good clarity by all three were selected. From the compounds selected, there was no difference between the number of compounds selected from each of the emphasis groups ($\chi^2 = 3.88$, $df = 2$, $p > 0.1$). From this pool 27 compounds novel compounds were selected as test items for the experiment. We also created a set of filler compounds, which had also been judged as acceptable using the same process.

During the experiment auditory stimuli were presented through standard closed-ear headphones (Unitone HD-1010) using a 16 bit sound card (Sound Master) with 16 kHz digital sampling. The presentation of the stimuli and the measurement of response latencies were controlled by the Presentation experimental software package, with a sub-millisecond level of precision. We provide a list of the test items used in the appendix.

Method

Participants 54 native English speakers from Northumbria University were paid a nominal fee for their participation. 24 of these participants were assigned to a text version of the experiment, while the remainder completed the audio version. 2 participants were removed from analysis for answering incorrectly to more than 50% of the filler items. The mean error rate was 6.1%.

Design The experiment had a single factor design with Emphasis as a within participant factor. Participants only ever heard one version of a test item i.e., a participant would hear the Modifier emphasis of *antelope coconut*, but not the Dual or Head emphasis versions.

Materials Twenty-seven novel noun-noun compounds were used as test items, with 14 additional lexicalised compounds used as fillers using a mix of emphasis types. The lexicalised compounds all had a frequency greater than 20 in the British National Corpus (BNC, 2005).

Procedure Participants were seated in front of a Toshiba Tecra M1 Laptop and told that they would be presented with two-word phrases through their headphones; some of these phrases would be familiar to them, while others would not. They were instructed to press the key labelled “yes” to indicate that “Yes, I can think of a meaning” or to push the key labelled “No” to indicate that “No, I don’t think the

phrase is meaningful”. Once they had pressed a key, there was a brief pause, then “Ready” appeared on the screen for 2000ms after which the next stimuli was played. There was a short break halfway through the experiment. Each judgement response was recorded via the keyboard. Before the start of the experiment proper the participant proceeded through a series of six practice trials without feedback. The practice trials contained a mix of lexicalised and novel compounds not featured in the main experiment. During the practise trials participants had the opportunity to have the volume level altered on their headphones.

For the text version of the experiment, the procedure was the same, except compounds were presented onscreen and participants pressed either the Yes or No keys to respond to each compound. The experiment took approximately 10 minutes to complete.

Results Analysis of Yes/No responses were first carried out on all responses, followed by a response time analysis carried out on “Yes” responses to the judgement task. Outliers greater than 3 SD from a participant mean per item were excluded from this analysis.

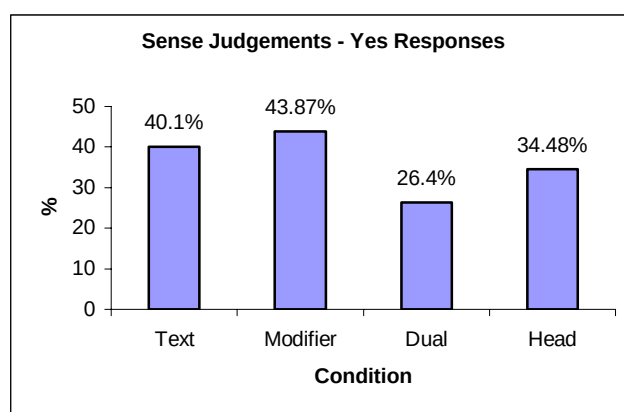


Figure 1 Percentage of Yes responses for the sense judgement task in each condition.

In analysing response times we observed no main effect of Emphasis, either by participants or by items (p 's > 0.1), with mean response times being almost equal (Modifier = 2068ms, Dual = 1975ms, Head = 2031ms). Similarly, we found no differences between the conditions when analysing the proportion of “yes” responses for the judgement task ($\chi^2 = 2.851$, $df = 2$, $p > 0.1$), although there were more “Yes” responses to compounds in the Modifier condition overall (30.5%) when compared to the Head (25%) and Dual (24.6%) conditions.

However, as mentioned previously, it may that the type of concept in a compound may also impact people’s responses. Thus, we categorised concepts as being natural kind, artefact, or as other non-object. In the following analyses we retained only concrete concepts (i.e., natural kind, artefact). This resulted in a loss of 11.1% of responses (3 compounds – indicated by “*” in the Appendix).

This did not affect the pattern of results for response times in analyses by participants and by items (p 's > 0.1).

However, we did find that people made significantly more “Yes” responses to compounds heard with Modifier emphasis (43.9%) than those with Head (34.5%) or Dual (26.4%) emphasis ($\chi^2 = 5.42$, $df = 2$, $p = 0.067$; see Figure 1). A Page’s L trend test revealed a reliable trend in this response pattern - $L(23) = 301.5$, $p = 0.026$. There were more Yes responses made for compounds with Modifier Emphasis than those with Dual Emphasis ($p = 0.02$), but not those with Head Emphasis ($p = 0.25$).

The pattern of the sensibility judgements seems to suggest that people’s responses for Modifier emphasis were closest to those of the text condition – 43.9% and 40.1% Yes responses respectively. To further examine this we submitted the numbers of Yes responses for each item to several Pearson’s correlations to examine which condition was closest to that of the text condition. We found that the correlation ($Ns = 24$) between the responses in the Modifier condition and those of the text condition was considerably higher (0.755) than the correlations between the Dual emphasis compounds and the Text condition (0.355) or the Head emphasis condition and the text condition (0.438).

Thus, our results suggest that while prosody can influence the comprehension of novel word combinations, this effect cannot be applied to all concept types. It may be that differences in the internal structure of abstract concepts make them less susceptible to the effects of prosody. Of the previous theories mentioned, only CARIN has used abstract concepts as part of the materials used to validate hypotheses. It is clear that other views (e.g., Constraint and Dual-Process theories) need to consider the ramifications of such a distinction in light of these results. As our initial material set was generated using a random process, further research must be done to make specific comparisons between concept types in such a task. Nevertheless, we have observed that Modifier emphasis facilitates comprehension of novel combinations of concrete concepts.

General Discussion

We have presented the first study to explicitly consider the effects of prosody on the comprehension of novel noun-noun combinations. We found that while different patterns of emphasis do not influence the time-course of people’s judgements, they do influence the likelihood of people judging a compound to be sensible. We found that for novel combinations containing concrete concepts (artefacts and natural kinds), people were more likely to judge concepts sensible if emphasis was placed on the modifier concept than if it was placed on equally on both concepts, or just on the head concept. This finding seems to fit with the predictions generated from the CARIN account of conceptual combination and the linguistic analysis of emphasis patterns carried out by Sproat (1994). It is important to bear in mind that this preference for Modifier emphasis was only evident for concrete concepts, which follows Lynott’s (2004) claim that individual concepts and concept types may not rely on the same general rules that have been proposed by existing theories of conceptual combination. So we might ask why is it better to have

modifier emphasis? It may be the case that by emphasising the modifier concept, relevant conceptual features that facilitate meaning creation are highlighted. However, as we observed, this does not necessarily speed the meaning creation process. While it may be the case that conceptual features from either concept may need to be highlighted for successful meaning creation, it may be beneficial to adopt a default modifier emphasis. However, that discussion is beyond the scope of this paper.

With this study we have made the first step in identifying a role for prosody in the interpretation of novel word combinations. Now we need to consider whether the alteration of prosodic emphasis patterns affects the specific interpretations that people arrive at. Lynott and Connell (in prep) suggest that there is at least some evidence that this does occur. They found that different emphasis placement can lead to different distributions of interpretation types.

One thing to bear in mind with this study and previous analyses of emphasis patterns in compounds (e.g., Sproat, 1994), is that they have been based on British-English prosodic patterns. It has been suggested by several researchers that there are striking differences between British-English and American-English speakers when it comes to emphasis placement in compounds. Bauer, Dienhart, Hartvigson and Jakobsen (1980) found that there are many compounds in American English where people apply Modifier emphasis, but that have Head emphasis in British English (e.g., *ice cream*). Berg (2000) has found however, that where differences occur between British and American English, the pattern is consistent; where a compound has modifier emphasis in American English it does not in British English (e.g., *world weary*). Thus, it may be fruitful to compare both American-English and British-English speakers’ comprehension using a similar paradigm to the one we have outlined here.

We have demonstrated that prosody can influence the comprehension process for novel word combinations. This study brings together previous research from the areas of linguistics, speech processing and conceptual combination. Apart from highlighting the role of prosody in determining meaning, this study has ramifications for the development of applications in the domain of speech processing where high levels of accuracy are expected from supporting linguistic models. These findings find relevance in each of the above fields, providing supporting evidence for previous linguistic analyses and identifying some deficiencies in current theories of conceptual combination. It seems clear that for existing theories to provide a complete picture of conceptual combination, they will have to adopt a multimodal approach, rather than using investigations that fixate solely on textual or imagistic representations.

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References

- Bauer, L., Dienhart, J. M., Hartvigson, H. H., & Jakobsen, L. K. (1980). *American English Pronunciation*. Copenhagen: Gyldendal.
- Berg, T. (1999). Stress variation in British and American English. *World Englishes*, 18 (2), 123-143.
- Bresnan, J. (1971). Sentence stress and syntactic transformations. *Language*, 47, 257-281.
- BNC, (2005). <http://www.natcorp.ox.ac.uk>
- Cannon, G. (1987). *Historical change and English word-formation*. New York: Lang.
- Chomsky, N., & Halle, M. (1968). *The Sound Pattern of English*. Harper and Row, New York.
- Cinque, G. (1993). A null theory of phrase and compound stress. *Linguistic Inquiry*, 24, 239-297.
- Clark, E. V. & Hecht, B. F. (1982). Learning to coin agent and instrument nouns. *Cognition*, 12, 1-24.
- Connell, L. (2000) Compound stress: A conceptual combination perspective. Unpublished manuscript. Division of Informatics, University of Edinburgh.
- Costello, F. J., & Keane, M. T. (2001). Testing two theories of conceptual combination: Alignment versus diagnosticity in the comprehension and production of combined concepts. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 27 (1), 255-271.
- Costello, F. J. & Keane, M. T. (2000). Efficient creativity: Constraints on conceptual combination. *Cognitive Science*, 24, 2, 299-349.
- Fodor, J. D. (2002). Prosodic disambiguation in silent reading. In M. Hirotani (Ed.), *Proceedings of NELS 32*, pp.113-132. Amherst, MA: GLSA.
- Gagné, C. L. (2000). Relation-based combinations versus property-based combinations: A test of the CARIN theory and dual-process theory of conceptual combination. *Journal of Memory and Language*, 42, 365-389.
- 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.
- Hampton, J. A. (1987). Inheritance of attributes in natural concept conjunctions. *Memory & Cognition*, 15(1), 55-71.
- Hirschberg, J. (1990). Assigning pitch accent in synthetic speech: the given/new distinction and deaccentability. *Proceedings of the Seventh National Conference*, Boston, 1990. American Association for Artificial Intelligence.
- Hirschberg, J. (1994). Pitch accent in context: predicting intonational prominence from text. *Artificial Intelligence*, 63 (1-2), pp.305-340.
- Ladd, D. R., (1980). *The structure of intonational meaning*. Indiana University Press, Bloomington, Indiana.
- Ladd, D. R., (1996) *Intonational Phonology*. Cambridge: Cambridge University Press.
- Levi, J. N. (1978). *The Syntax and Semantics of Complex Nominals*. New York: Academic Press.
- Lynott, D. (2004). *Comprehension and Production in Conceptual Combination*. Unpublished Doctoral Dissertation, University College Dublin.
- Lynott, D., & Connell, L. (in prep). The effects of prosody in the interpretations of novel word combinations. *Manuscript in preparation*.
- Lynott, D., Tagalakakis, G., & Keane, M.T. (2004). Conceptual Combination with PUNC. *Artificial Intelligence Review*, 21(3-4), 353-374.
- Medin, D. L., Lynch, E. B., & Solomon, K. O. (2000). Are there kinds of concepts? *Annual Review of Psychology*, 51, 121-147.
- McFriedes, Paul. (2004). *The Word Spy*. Broadway Books.
- Monaghan, A. I. C. (1990). Rhythm and stress-shift in speech synthesis. *Computer Speech and Language*, 4, 71-78.
- Monaghan, A. I. C. (1991). Evaluation of the naturalness of Prosody generated by the CSTR TTS system. In the *Proceedings of Eurospeech*, Genoa, pp. 883-886.
- rVoice (2005). <http://www.rhetorical.com/tts-en/technical/rvoice.html>. Retrieved February 1st, 2005.
- Selkirk, E. (1984). Phonology and syntax: the Relation between sound and structure. Cambridge, MA: MIT Press.
- Sproat, R. (1990). Stress assignment in complex nominals for English text-to-speech. In *Proceedings of ESCA Workshop on Speech Synthesis*, 129-132.
- Sproat, R. (1994). English noun-phrase accent prediction for text-to-speech. *Computer Speech and Language*, 8, 79-94.
- Wisniewski, E. J., (1996). Construal and similarity in conceptual combination. *Journal of Memory and Language*, 35, 434-453.

Appendix

Test items used in our study

Airplane chemical	Whiskey giraffe	Antelope coconut	Army* decision	Bed helicopter
Cabbage cup	Whale knife	Celebrity spear*	Skunk tent	Chocolate clay
Pig restaurant	Termite frog	Lobster college	Monkey chisel	Octopus apartment
Scarf coconut	Spider moth	Piano cow	Tent shirt	Rhinoceros cactus
Drill tile	Steam saxophone	Seal viper	Snail shark	Slug tree
			Onion bus	Elephant* complaint

SSML Templates for three emphasis patterns

Modifier Emphasis	<prosody rate="85%"><prosody pitch = "125%"> modifier </prosody></prosody> head
Dual Emphasis	<prosody rate="85%"><prosody pitch = "125%">modifier-head</prosody></prosody>
Head Emphasis	Head <prosody rate="85%"><prosody pitch = "125%">modifier</prosody> </prosody>