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Understanding Doubly Center-Embedded Sentences Through Contrastive Focus

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This manuscript has been read and accepted for the
Graduate Faculty in Linguistics in satisfaction of the
dissertation requirement for the degree of Master of Arts.

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Abstract

UNDERSTANDING DOUBLY CENTER-EMBEDDED SENTENCES THROUGH CONTRASTIVE FOCUS

by

Ashley C. Thorne

Advisor: Professor Janet Dean Fodor

A production and comprehension-judgment experiment examined the relationship between prosody and comprehensibility in doubly center-embedded relative clause constructions in English. Lexically identical sentences with contrastive emphasis on NP1, NP2, or VP1, and a baseline version for comparison, were read aloud for recording and judged for comprehensibility. Contrast on NP2 and VP1 yielded higher comprehensibility judgments compared to baseline than contrast on NP1 compared to baseline. This was contrary to the prediction that contrast on NP1 would encourage the prosodic pattern NP1 || RC || VP3, which in previous work has been reported to be optimal for comprehension. Several explanations for this outcome are considered, including the possibility that contrastive focus does not reliably induce a following prosodic boundary if phrase lengths are not supportive of it.
Acknowledgments

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The practical realities of experiment design came together thanks to Frank Riccobono’s help with code for the recording instrument and Dianne Bradley’s provision of a database of final-stress English words. Numerous friends and family members gave their time to complete test versions of the task, and I especially thank Judy Ko, Andrew Debter, Nora Goldman, and Emily Schatz.

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Thank you to my friends and family for supporting me, and for forgiving me for using “The man the girl the cat scratched kicked died” in conversation.

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1. Introduction

Recent inquiry has indicated that a certain prosodic contour may aid comprehension of doubly center-embedded relative clause (henceforth 2-CE-RC) sentences in English (Fodor and Nickels, 2011; Fodor, 2013; Schott and Fodor, 2013). This “encouraging” (henceforth ENC) contour is created when a phonological phrase$^1$ boundary occurs after the first NP and before the third VP in the sentence, as in (1), also represented as (2a), simplified to (2b). The symbol || represents a phonological phrase boundary:

(1) The last canal || that the engineer that my dad had trained worked on || was in West Virginia.

(2) a. NP1 || NP2 NP3 VP1 VP2 || VP3
    b. NP1 || RC || VP3

This paper presents data from an experiment testing whether contrastive focus can facilitate production of such a prosodic contour. My hypothesis was two-fold. First, that contrastive focus would both lengthen the contrasted constituent and produce a phrase boundary immediately after it (Cooper, 1985; Selkirk, 2002; Görs and Niebuhr, 2012). Second, that if the locus of contrastive focus resulted in an ENC prosodic contour, the sentence would be judged to be more comprehensible than the same sentence pronounced with different contours. I tested that hypothesis by asking participants to pronounce 2-CE-RC sentences with contrastive stress on various constituents and to rate the sentences’ comprehensibility.

---

$^1$ A prosodic phrase associated with a sub-clausal syntactic phrase has been referred to in the literature in various terms: *intermediate phrase* (ip), *major phrase* (MaP), *phonological phrase*, or *p-phrase*. I will use the term *phonological phrase*. 
2. Background

First some context is needed on why 2-CE-RC constructions are interesting to linguists; what role prosody can play in processing 2-CE-RC sentences; and what the effects of contrastive focus are on contrasted constituents.

Doubly center-embedded sentences serve as the most extreme illustration of the long-debated distinction between competence and performance. The question in that debate is, in essence: Does what we know about our language correspond completely with the way we actually use that knowledge in producing and comprehending language on-line? 2-CE-RC sentences are technically grammatical but practically difficult to understand, and they are often deemed ungrammatical by native speakers. Chomsky and Miller wrote in 1963:

…New constructions can be embedded inside of old ones. […] There can be little doubt that natural languages permit this kind of parenthetical embedding and that their grammars must be able to generate such sequences. For example, the English sentence (the rat (the cat (the dog chased) killed) ate the malt) is surely confusing and improbable but it is perfectly grammatical and has a clear and unambiguous meaning.

Research has sought to explain this discrepancy—of near incomprehensibility in spite of grammaticality—by showing that 2-CE-RC constructions violate some tenet of psychology, rendering them perceptually problematic.

A new and compelling explanation is that the impediment to understanding 2-CE-RC sentences is a lack of knowledge as to how to pronounce them—a speaker does not know what prosody to give them (Fodor, 2013). Of the various possible ways to pronounce a 2-CE-RC sentence, it appears that there are “encouraging” and “discouraging” contours, encouraging being
an aid to comprehension and discouraging being a hindrance. I will discuss these contours and what makes them encouraging and discouraging in section 2.2 below.

Among the characteristics of contrastive focus are that it normally introduces a phonological phrase boundary (90 percent of the time in English as reported by Selkirk, 2002) and that it produces lengthening effects on contrasted constituents. There is no change in truth conditions from a sentence without contrastive focus to a lexically identical one with contrastive focus; as Gundel and Fretheim (2004) concluded, “Purely contrastive focus has no truth-conditional effects.” What does change is the discourse role of the sentence, and its prosody. The phonetic realization of contrastive focus may differ across languages, but in English it induces a stressed syllable which has a high tone, rising from a previous low tone. Pragmatically, this indicates that a distinction is being made between the stressed constituent and another constituent, possibly in a preceding or following sentence.

2.1 Doubly Center-Embedded Relative Clause Sentences

Recursive grammar allows language-users to stack clauses on top of other clauses in forming new sentences. Recursion can, in theory, go on ad infinitum (Chomsky, 1980). For example:

\[(3)\]

a. You are happy.

b. I am glad that you are happy.

c. My friend knows that I am glad that you are happy.

d. They just told me that my friend knows that I am glad that you are happy.

And so on. Syntactically the sentences in (3a-d) are right-branching constructions, and each new level of embedding adds new nodes on the right side of the sentence tree structure. Though they
have multiple clauses, and are rich in argument-predicate relations, they are not unduly difficult to parse.

Center-embedded constructions, however, are not so straightforward. In these, a clause is embedded in the middle of another clause. A singly center-embedded clause is easy to pronounce and comprehend; for example:

(4) The girl the man kissed left.  
    [NP1  [NP2  VP1]  VP2]

A doubly center-embedded relative clause construction is notably more difficult:

(5) The girl the man the boy saw kissed left.  
    [NP1  [NP2  [NP3  VP1]  VP2]  VP3]

The surface structure of a doubly center-embedded sentence is shown in Figure 1, simplified for present purposes in order to emphasize the basic branching structure.

Figure 1. Basic surface structure of a 2-CE-RC sentence

---

2 This diagram is from Kimball, 1973.
The sentence is composed of three consecutive NPs followed by three consecutive VPs. Structurally, these compose a clause within a clause within a clause. In (5) the underlying structure of the three clauses are:

(6) a. The boy saw the man.
   b. The man kissed the girl.
   c. The girl left.

Relationships between the NPs and VPs are shown in (7). The arrows at the top, from NPs to VPs, represent subject-verb relationships, and the arrows at the bottom, from VPs to NPs, represent verb-object relationships.

(7) \[
\text{The girl the man the boy saw kissed left.} \\
[\text{NP1} \quad \text{NP2} \quad \text{NP3} \quad \text{VP1} \quad \text{VP2} \quad \text{VP3}]
\]

Compare (5) with (8), a right-branching sentence which also has two levels of clausal embedding, illustrated with subject-verb and verb-object relationships in (9):

(8) The boy saw the man who kissed the girl who left.
\[
[\text{NP1} \quad \text{VP1}] \quad [\text{NP2} \quad \text{VP2}] \quad [\text{NP3} \quad \text{VP3}]
\]

\[^{3}\text{This diagram is modeled after one given in Bever, 1970.}\]
Why are doubly center-embedded sentences so much harder to understand than single center-embeddings and double embeddings with right-branching structure? Numerous explanations have been proposed.

2.1.1 *Theories for Explaining 2-CE-RC Difficulty*

In 1963 Chomsky and Miller were the first to highlight the challenge of 2-CE-RC sentences and proposed that the problem was the limitation of human memory: “from the fact that human memory is finite we can conclude only that some self-embedded structures should not be understandable.” Chomsky and Miller posited that language parsers will allow no more than one interruption of the process of assigning a subject to the following verb, whereas 2-CE-RC sentences are characterized by two such interruptions. To this idea, Bever (1970) raised the objection that it seems arbitrary to allow one interruption—such as in a singly center-embedded sentence—and not two.

Blumenthal (1966) showed that the presence of three NPs in a row often led to a mis-parsing of the sentence as coordination, i.e. “The girl, the man, and the boy…” This mistakenly added conjunction causes a garden path and is hard to resolve. The problem disappears, Fodor and Garrett (1967) observed, when the NPs are each separated by a relative pronoun such as *whom* or *that.*
Another explanation for the difficulty of 2-CE-RC sentences is that there is a high proportion of structure (i.e., sentences or underlying clauses) to words in the construction (Fodor and Garrett, 1967). In (5) above, the ratio is 3:9. But there are other constructions with even higher proportions of sentences to words—such as “that she runs proves that she walks,” with a ratio of 3:7—which are nevertheless perceptually less complex than 2-CE-RC sentences.

Bever (1970) maintained that the problem is the “double function” that NPs in 2-CE-RC constructions must play. For example, in (5) above, “the man” is both the subject (he kissed the girl) and the object (he was seen by the boy). In terms of theta-roles, the man is both the agent and the patient:

(10) the man kissed the girl.
(11) the boy saw the man.

The difficulty arises, Bever argued, when the same perceptual mapping rule is used to assign different functions to the same phrase.

Kimball (1973) offered two principles for predicting the difficulty of 2-CE-RC constructions. One is that “Sentences of natural language organize themselves generally into right-branching structures,” because these are less complex than left-branching or center-embedded ones. While this is true for English, a right-branching language, other languages such as Japanese and Malayalam (Yoshimoto, 2003; Lakshmi et al., 2012) are naturally left-branching. The three types of tree structures are depicted in (12).⁴

---

⁴ These simplified syntactic trees are from Kimball, 1973.
Kimball proposed as well that no more than two sentences may be parsed at one time because two sentences is the maximum that may be held in short-term memory.

Some years later, Gibson and Thomas (1999) also argued that the problem with 2-CE-RC sentences is memory limitation, and proposed that the elements that tax the memory the most are often dropped from the mental representation of the sentence structure. It was found that the second VP is the most likely constituent to be lost. Gibson and Thomas (1999) confirmed experimentally the intuition that center-embedded sentences with a missing second VP were judged to be just as acceptable as sentences containing all three required VPs. This has come to be known as the “missing VP illusion.”

2.2 The Role of Prosody

Fodor (2013) distinguished between the needs of syntax and of prosody: “While natural language syntax thrives on recursion, prosodic phrasing does not,” and argued that this mismatch is the factor (or at least one of the factors) that makes 2-CE-RC sentences especially difficult to process.

Division of a sentence into prosodic phrases follows from the decisions the parser makes in segmenting the sentence according to its parts. Frazier and Fodor (1978) argued that the
complexity of 2-CE-RC constructions can be attributed “not to memory overload but to the problem of establishing the correct phrasal units.”

Frazier and Fodor asserted that syntactic analysis in the mind of a hearer or reader goes through what they called the Preliminary Phrase Packager (PPP, much later re-envisioned as a Prosodic Phrase Processor in Fodor, 2013) known as the Sausage Machine. The Sausage Machine breaks sentences into manageable pieces—approximately six words each—to prevent an overload of the short-term memory.

A 2-CE-RC sentence is too long to be pronounced as one phonological phrase. It needs to be divided by prosodic breaks. The important question is where those breaks should appear.

There are two key guiding constraints on where to place phonological phrase boundaries. First, it is optimal for prosodic breaks to occur at the edges of syntactic phrases, according to Truckenbrodt (1995, Wrap XP): “Each syntactic XP must be contained in a phonological phrase,” and Selkirk (2003): “Phonological constraints […] tend to produce representations in which individual tones align with either the prominent head of a prosodic constituent or with the edge of a constituent.”

Second, it is favorable for phonological phrases in a sentence to have balanced phrase lengths, that is, to have approximately the same number of words and stressed syllables in each one. This is according to Gee and Grosjean (1983), and Ghini’s Uniformity principle (1993): “A string is ideally parsed into same length units.”
There are several possible ways to divide a 2-CE-RC sentence. One possibility, following the syntactic alignment constraint, is to place a break before the last verb, as shown in (13)\(^5\):

(13) The girl the man the boy saw kissed || left.

![Surface Structure Tree](image)

The symbol || in (13) represents a prosodic boundary, which may be realized as an $F_0$ rise or fall, pre-boundary lengthening, and an optional pause (Clifton et al, 2002).

This would place a division at the highest level of the surface structure tree, between the matrix NP with the nested RCs branching below it, and the matrix VP. In this example, however, it results in unbalanced length units, where there is a ratio of 8:1 words and 5:1 stressed syllables.

A break in the middle of the sentence, as in (14), would result in uniform phrase lengths (3:3 stressed syllables and 3 NPs balanced with 3 VPs), but would not align with the syntax.

(14) The girl the man the boy saw kissed left.

---

\(^5\) Diagrams in (13) and (17) are from Fodor and Nickels, 2011.
Another possibility is to put a break after each constituent, as in:

(15) The girl || the man || the boy || saw || kissed || left.

While this contour satisfies both of the main guiding constraints, there are others it does not satisfy, including a minimality constraint that disfavors short prosodic phrases. Having this many breaks gives the sentence a singsong, list-like sound; this pronunciation is the most unfavorable one for comprehension (Miller, 1962).

Thus, intuitively, six prosodic phrases are too many, and two are too few.

Fodor and Nickels (2011) investigated cutting the sentence into either three or four phrases. They predicted that a three-phrase option is helpful (ENCouraging) toward comprehension, and that four-phrase prosody is unhelpful (DISCouraging). The ENC contour they predicted is divided into three phrases as follows:

(16) NP1 || RC || VP3

The RC in the middle contains NP2, NP3, VP1, and VP2. By reference to the balance constraint on phrase lengths (see above), Fodor and Nickels predicted that this prosodic phrasing is most acceptable when NP1 and VP3 are relatively long and RC is relatively short. RC is not shorter than NP1 and VP3, but it is short for an RC, especially for an RC containing another RC. NP1 is relatively long for an NP, and VP3 is long for a VP.
For example:

(17) The elegant woman || that the man I love met || lives in Barcelona.

The ratio of stressed syllables in each segment of (17) is 2:3:3, which is balanced. This contour also aligns with the syntax, even though it does not reflect all structural details of the sentence. However, Fodor and Nickels point out that it is rare in normal language use for a relative clause (such as RC1 here) containing an embedded relative clause (RC2) to constitute a single phonological phrase: it will do so only if all of its internal constituents are extremely short.

In their experiment, Fodor and Nickels used long and short phrase-lengths to induce ENC and DISC prosodic contours in reading aloud. For example:

(18)

a. ENC
[The rusty old ceiling pipes] [that the plumber my dad trained fixed] [continue to leak occasionally.]
[long NP1] [short RC1] [long VP3]

b. DISC
[The pipes] [that the unlicensed plumber the new janitor kindly assisted tried to repair] [still leak.]
[short NP1] [long RC1] [short VP3]
Here, long phrase lengths were used for NP1 and VP3 in the contour meant to generate ENC prosody, while long phrase lengths were used for RC1 for the contour meant to generate DISC prosody. This was important as an initial test of the prosodic explanation of the extreme difficulty of 2-CE-RC constructions, but as discussed below, it necessarily created some mismatches in meaning between the two sentence versions, which could not be factored out in the analysis of outcomes.

For each target stimulus, a ‘familiarization technique’ was used to provide participants with experience of the meaning and prosody of the component parts of each sentence, prior to processing the full 2-CE-RC construction. Participants then made self-judgments as to the pronounceability and comprehensibility of the complete 2-CE-RC version of the sentence.

Fodor and Nickels found that ENC items were judged as both easier to comprehend and easier to pronounce than DISC ones.

A second experiment (Schott and Fodor, 2013) sought to test the hypothesis that the “missing VP illusion” would be diminished for ENC sentences as compared with DISC ones. The three-phrase prosody was again elicited using length manipulation as in Fodor and Nickels (but without pre-familiarization, which was incompatible with this experiment design) and participants were asked, “Is something missing from this sentence?” Unexpectedly, among the approximately 50 percent of subjects who accepted 2-CE-RC sentences at all, judgments were highly accurate and the “missing VP illusion” was not observed. Possible explanations include unlimited time to inspect the sentences before judgment (not reported by the web facility), together with an emphasis in the task instructions on whether something was missing from the sentence (as compared to a general acceptability judgment). As noted above, there was an
inevitable difference in syntactic and semantic content between the ENC and DISC versions of these materials, associated with the phrase length manipulations. While there was no reason to believe that it would have a systematic effect, it could not be decisively ruled out.

An important move forward is to test the advantage of the ENC prosodic pattern over the DISC pattern with lexically identical stimuli. One way to do this is to provide participants with the prosodic contour. This requires an auditory stimulus presentation. An experiment currently in production (Fodor, Goldman, and Thorne, in preparation) is a listening exercise in which participants hear a set of prerecorded sentences played one at a time, and after each one they type back as much as they can recall. Each of the target stimuli in this experiment were recorded in three ENC and DISC prosodic contours. Examples of the three contours are as follows:

(19) a. ENC
   The park ranger that the Dutch tourist that the snake bit had called for stayed calm.  
   NP1 || that NP2 that NP3 VP1 VP2 || VP3

   b. NP-DISC
   The park ranger that the Dutch tourist that the snake bit had called for stayed calm.  
   NP1 that NP2 that NP3 VP1 VP2 || VP3

   c. VP-DISC
   The park ranger that the Dutch tourist that the snake bit had called for stayed calm.  
   NP1 that NP2 that NP3 VP1 VP2 || VP3

(19a) was predicted to be ENC because it follows the three-phrase contour NP1 || RC1 || VP3. (19b) breaks after NP2 instead of NP1 and was predicted to be DISC because it interrupts RC1 (NP2 NP3 VP1 VP2) and violates the Wrap constraint (Schott and Fodor, 2013).

The four-phrase contour (19c) was predicted to be DISC because it creates an incomplete constituent RC in its second segment and makes it difficult for the parser to attach VP2 back into that RC. This is also the case for singly-center-embedded sentences, e.g. The colorful origami ||
that Lucy’s third-grade art teacher \textit{made in class} was impressive. A separation of the VP \textit{(made in class)} out of the RC apparently causes difficulty for the parser (Fodor and Nickels, 2011), even if the difficulty is not as great as in the case of doubly-embedded sentences.

The Fodor, Goldman, and Thorne experiment is the first study of ENC and DISC prosody to use lexically identical sentences for all versions of each target stimulus in a perception experiment. The experiment I am reporting here is the first one to do so in a production task. Lexically identical stimuli allow for a more direct comparison strictly based on prosody, without the variables of differing words and meanings. The practical challenge is how to vary prosodic phrase lengths without varying lexical content. In a perception task, this can be done by controlling the placement of prosodic breaks in the auditory stimulus. This is not possible in a production task. Instead, the present experiment uses contrastive focus as a way of manipulating prosodic break locations in production.

In Fodor, Goldman, and Thorne, the focus is on finding an objective measure of sentence comprehension, as opposed to self-judgment, and the hypothesis is that the sentences spoken with ENC contours will be recalled with fewer errors than those spoken with DISC contours. The underlying assumption is that good comprehension of a 2-CE-RC sentence will be reflected by an accurate memory of it, and thus, a greater probability of a correct transcription.

In the present experiment, participants judged the comprehensibility of identical word strings, which they read aloud, with contrastive accents placed on phrases indicated by the context and orthography.

\textit{2.3 Contrastive Focus}
Because contrastive focus activates prosodic phrase boundaries, it may be used to simulate encouraging and discouraging prosodic phrasing.

Contrastive focus in doubly center-embedded sentences has not previously been formally studied. Its relevant traits are described below.

2.3.1 Characteristics of Contrastive Focus

Speakers use contrastive focus to denote that they are selecting from alternatives or when they intend to correct their interlocutors. For example, the sentence “Mary bought the horses” can have contrastive focus (designated here in all capital letters) on any one of its three constituents:

(20) a. Charles bought the horses.
    b. No, MARY bought the horses.
    c. Mary sold the horses.
    d. No, Mary BOUGHT the horses.
    e. Mary bought the camels.
    f. No, Mary bought THE HORSES.6

There is no change in semantic truth conditions between (20b), (20d), and (20f). The difference between them is pragmatic and phonological. Pragmatically, none of them can stand alone. They each must be preceded or followed by some statement they can be contrasted with, such as (20a), (20c), and (20e). Another distinction between (20b), (20d), and (20f) is that each one serves to introduce a different alternatives set of potential substitutions for the contrasted

6 Examples in (20) are modeled after those in Katz and Selkirk (2011).
constituent. For example in (20b): {Charles bought the horses, Mary bought the horses, Susan bought the horses, Peter bought the horses, etc.} (Katz and Selkirk, 2011).

Phonologically, (20b), (20d), and (20f) differ from one another in terms of pitch accent location. In the standard convention for transcribing tones and break indices (ToBI, Beckman and Hirschberg, 1994), contrastive focus is characterized in English by an L+H* pitch accent. L+H* is defined in ToBI as a “‘rising peak accent’—a high peak target on the accented syllable which is immediately preceded by a relatively sharp rise from a valley in the lowest part of the speaker’s pitch range” (Beckman and Hirschberg, 1994).

In other words, an L+H* pitch accent shows a sharp rise from low to high on a stressed syllable. The star in a transcription denotes the stressed syllable, which here is a high tone. Depicted in a spectrogram, a contrastive pitch accent shows a short low dip and a spike upward that then curves down.

Contrastive focus is especially relevant to this inquiry on prosody both because it usually introduces a phonological phrase boundary (Selkirk, 2002), and because it tends to have a lengthening effect on the contrasted constituent. Cooper et al. (1985) found that “focus (as manifested by contrastive stress) is generally accompanied by an increase in duration on the focused word and by a sharp drop in $F_0$ following the focused item.”

Thus, contrast motivates prosody. Whereas 2-CE-RC sentences have proven to be difficult in part because of the reader’s uncertainty about how best to phrase them prosodically and where to pause, a contrast forces the speaker to lengthen and pause at a pre-designated place.

**2.3.2 Contrastive vs. Non-Contrastive Pitch Accents**
Contrastive focus is often juxtaposed with broad, or non-contrastive, focus (also called presentational focus) to show the distinctions between the two. Whereas non-contrastive focus is implemented by an H* pitch accent, contrastive focus is implemented by an L+H* pitch accent. Görs and Niebuhr (2012) wrote, “Relative to broad focus, contrastive focus is characterized by longer intonation rises […], greater intensity levels, and by lengthening and hyperarticulating those syllables to which the focus is linked.” In addition, a phonological phrase break normally follows a contrastive focus accent but not a presentational focus accent, as Selkirk (2002) explained:

The contrastive FOCUS shows not only an L+H* pitch accent, but also a following phonological phrase break, marked by both an L- phrase accent and temporal disjuncture.

In the same context, presentational focus shows a pitch accent H* and no phonological phrase break (no L- and no disjuncture).

Selkirk’s examples are of Right Node Raising (RNR) constructions. They show contrastive focus being followed by a disjuncture in an otherwise unnatural position, including:

(21) It’s interesting to compare the adults who VILIFY to the children who EMULATE the radical rappers.

The syntactic junctures in a RNR construction like (21) may make it a not fully typical example of the prosody of contrastive focus. But Selkirk’s general description seems correct nonetheless.

Images from Praat recordings I created (shown in Figures 2 and 3) depict examples of non-contrastive and contrastive pitches, respectively, for an NP1 “the house” at the beginning of the sentence, “The house that the carpenter my father trained built is vacant.” The highlighted
sections correspond to the NP1 “the house.”

<table>
<thead>
<tr>
<th>AND NOW, the house that the carpenter my father trained…</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.816551</td>
</tr>
<tr>
<td>500 Hz</td>
</tr>
</tbody>
</table>

**Figure 2.** Non-contrasted pitch signal example. Non-contrasted NP1 ‘the house,’ preceded by contrast on “And now” in the sentence, “AND NOW the house that the carpenter my father trained…”

In Figure 2 the sentence is preceded by the phrase, “AND NOW” (as if in contrast to a previous sentence beginning with “PREVIOUSLY”). Unfocused constituents after the contrast on “AND NOW” in this sentence provide a baseline for comparison against focused versions.

For instance, the highlighted pitch signal for the NP1 “the house” in Figure 2 is fairly flat; “the house” does not receive a pitch accent because it follows a contrastive focus.

<table>
<thead>
<tr>
<th>But THE HOUSE that the carpenter my father trained…</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.218</td>
</tr>
<tr>
<td>500 Hz</td>
</tr>
</tbody>
</table>
Figure 3. Contrasted pitch signal example. Contrasted NP1 ‘the house’ in the sentence, “But THE HOUSE that the carpenter my father trained…”

In Figure 3, NP1 “the house” has contrastive stress, as if in contrast to a previous sentence beginning with, for instance, “THE BARN” or “THE HOTEL.” The highlighted pitch signal for NP1 in Figure 3 has a low dip, a quick spike upward, and a dip after the spike.

3. Experiment

In this experiment, I tested contrastive focus on NP1, NP2, and VP1 in 2-CE-RC sentences, and compared each with a baseline in which there was no contrastive focus except in a phrase preceding the sentence, set off by a comma. I sought to find out which contrast would make a 2-CE-RC sentence most comprehensible. Contrastive focus on NP1 was predicted to lengthen NP1 and induce a break immediately after it (Cooper, 1985; Selkirk, 2002; Görs and Niebuhr, 2012), and thus motivate ENC prosody. Contrastive focus on NP2 and VP1 was predicted to induce breaks after NP2 and VP1, respectively, thus interrupting RC1 to result in DISC prosody.

3.1 Participants

Native speakers of American English (N=40) participated via Amazon Mechanical Turk for $10.00 each. Participants completed the task within 45-177 minutes (mode 58 minutes).

3.2 Materials

Eight doubly center-embedded target sentences were constructed, each with four lexically identical versions with contrastive emphasis on one of the following:

- Pre-sentence adjunct followed by a comma (Baseline)
- NP1
- NP2
- VP1
Baseline versions added a phrase such as “According to the historian,” which was contrasted with a corresponding phrase in the previous sentence. These phrases, set off by a comma, were followed by the lexically identical sentence from the other three versions.

Target sentences were designed with constituents that conformed to particular length constraints, shown in Table 1.

<table>
<thead>
<tr>
<th>NP1</th>
<th>NP2</th>
<th>NP3</th>
<th>VP1</th>
<th>VP2</th>
<th>VP3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Medium</td>
<td>Short</td>
<td>Medium</td>
<td>Short</td>
<td>Long</td>
</tr>
</tbody>
</table>

Medium length was given to the constituents being contrasted, NP1, NP2, and VP1, so that they could become relatively long when contrasted and remain relatively brief when not contrasted. As for the uncontrasted constituents, NP3 and VP2 were kept short because they occurred in the middle of the sentence, and VP3s were made long because they were on the outer edge of the sentence. This is in keeping with Fodor and Nickels’ finding that the most helpful contour for 2-CE-RC sentences is one in which the matrix clause constituents, NP1 and VP3, are relatively long, and the constituents inside the higher and lower RCs are relatively short.

Each contrasted constituent in the target sentences had lexical stress on the final syllable (i.e., *canoes, pioneers, depicts*), so that any prosodic emphasis introduced by the contrast would occur at the right edge of the phrase, where it might be most likely to induce a following phonological phrase boundary (final lengthening plus pause).
Sentences were presented visually in a survey format designed in SurveyMonkey®. The contrasted constituents appeared in all capital letters. Each target sentence was accompanied by two preceding sentences. First was a “Background” sentence to provide context for the coming contrast. Next was a sentence that set up the contrast. The target sentence, beginning with “But,” came last and completed the contrast. The two contrast sentences were identical except for the contrasted constituent and the VP3. (22) shows an example of one target sentence in each of the four versions. A full list of target stimuli is given in Appendix I.

(22) a. Baseline
   Background:  
   *At the screening of the historically-based movie, the filmmaker and a historian spoke afterward, giving different accounts of how the pioneers had built their canoes.*

   Contrast:
   *ACCORDING TO THE FILMMAKER, the canoes that the pioneers that the movie depicts had built were made from random pieces of driftwood.*
   *But ACCORDING TO THE HISTORIAN, the canoes that the pioneers that the movie depicts had built were made from strong cedar tree trunks.*

b. NP1
   Background:
   *An interesting historically-based movie about the pioneers showed their skills in building barns and canoes.*

   Contrast:
   *THE BARNS that the pioneers that the movie depicts built were made from random pieces of driftwood.*
   *But THE CANOES that the pioneers that the movie depicts built were made from strong cedar tree trunks.*
c. NP2

Background:
An interesting historically-based movie showed how the natives and the pioneers used different techniques for building canoes.

Contrast:
The canoes that THE NATIVES that the movie depicts had built were made from random pieces of driftwood.
But the canoes that THE PIONEERS that the movie depicts had built were made from strong cedar tree trunks.

d. VP1

Background:
The movie showed some pioneers who made canoes from cedar but left out others who made canoes from driftwood.

Contrast:
The canoes that the pioneers that the movie LEAVES OUT had built were made from random pieces of driftwood.
But the canoes that the pioneers that the movie DEPICTS had built were made from strong cedar tree trunks.

The 8 targets were interspersed with 19 fillers, which all contained one contrasted constituent in varying locations. Like the targets, each filler was preceded by a background sentence and a sentence to set up the contrast. Fillers ranged in difficulty to blend in with the targets and to induce participants to use the full scale when judging comprehensibility. The 27 total items were arranged in a list beginning with 4 fillers as warm-ups and 1-3 fillers between each target.

Four versions of this list were used. Each one was identical in the order of items but each contained a different order of target versions, as shown in Table 2.
Table 2. Order of target versions

<table>
<thead>
<tr>
<th>Target item</th>
<th>List 1</th>
<th>List 2</th>
<th>List 3</th>
<th>List 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baseline</td>
<td>NP1</td>
<td>NP2</td>
<td>VP1</td>
</tr>
<tr>
<td>2</td>
<td>NP1</td>
<td>NP2</td>
<td>VP1</td>
<td>Baseline</td>
</tr>
<tr>
<td>3</td>
<td>NP2</td>
<td>VP1</td>
<td>Baseline</td>
<td>NP1</td>
</tr>
<tr>
<td>4</td>
<td>VP1</td>
<td>Baseline</td>
<td>NP1</td>
<td>NP2</td>
</tr>
<tr>
<td>5</td>
<td>Baseline</td>
<td>NP1</td>
<td>NP2</td>
<td>VP1</td>
</tr>
<tr>
<td>6</td>
<td>NP1</td>
<td>NP2</td>
<td>VP1</td>
<td>Baseline</td>
</tr>
<tr>
<td>7</td>
<td>NP2</td>
<td>VP1</td>
<td>Baseline</td>
<td>NP1</td>
</tr>
<tr>
<td>8</td>
<td>VP1</td>
<td>Baseline</td>
<td>NP1</td>
<td>NP2</td>
</tr>
</tbody>
</table>

The four different lists ensured that all four versions of each target item were recorded and judged without any participants seeing the same item in more than one version. An individual participant completing the task encountered two of each of the four versions. Each list was used in a separate batch of the experiment; 10 participants completed each batch.

3.3 Procedure

Participants were instructed that this was a study in contrastive emphasis. They were asked to first read through each set of three sentences (one background and two contrast) silently for comprehension, then to read the sentences out loud for recording, putting contrastive stress on one syllable within a phrase that was presented in capital letters. To reduce recording time, they were instructed to read out loud only the two sentences marked “contrast,” and not to read the preceding background sentence. Recordings were made through the application SpeakPipe© which was integrated into the survey. Each recording was saved as an individual file in SpeakPipe©.

For the final sentence in each set, participants were also asked to make a judgment rating its comprehensibility, on a scale of 1 to 5, where 1 was “very difficult” and 5 was “very easy.”
Each of the 27 sentence sets were thus displayed one at a time, in three screens marked “Read silently,” “Read contrast sentences aloud for recording,” and “Judge.” The sequence of the three screens is shown in Figure 4.

Figure 4. Sequence of three screens displayed for each experimental stimulus.

At the beginning of the task, participants were told that the purpose of the study was to identify which syllable in a contrasted constituent receives the most contrastive emphasis. They were instructed:

To indicate contrast, sentence 2 and sentence 3 each have one word or phrase in capital letters. When reading the sentences aloud, your job is to put stress (emphasis) on that word or phrase. Typically, it will be pronounced a bit longer and louder than the rest of the sentence.

7 The latter screen displayed only the third sentence in the set, the one beginning with “But.”
However, you’ll find that inside the emphasized word or phrase, there is usually only one syllable that is most prominent. We are interested in which syllable that is.

Participants were then given sample stimuli with a tutorial on how to use the rating scale and on how to identify the contrasted syllable in the designated capitalized phrase. This is shown in Appendix II.

3.3.1 Note on Method

Another way to break a sentence into sections, without explicitly asking subjects to “pause here,” is to present it with line breaks. For example, (23) could be compared with (24):

(23) The canoes that the pioneers that the movie depicts had built were made from strong cedar tree trunks.
(24) The canoes that the pioneers that the movie depicts had built were made from strong cedar tree trunks.

Such line breaks do induce pauses but they interfere with the natural interplay of phrase lengths and syntactic alignment. It is the parser’s role to determine where phrase boundaries ought to occur, and line boundaries usurp that role.

Furthermore, line breaks are artificial in a way that contrastive focus is not, because they do not occur in spoken language (or even in appropriate places in written texts). They too obviously force the reader to follow a pre-designated pattern. Contrast, however, is not only common in spoken language, but it also allows speakers to choose for themselves when to pause for emphasis and clarity.
3.4 Predictions

The initial predictions were (a) that contrastive pitch accents would activate prosodic contours aligning with ENC and DISC, and that (b) sentences with contrastive focus on NP1 would be judged the most comprehensible of the four contours. In this case, it would be the prosody introduced by the contrast which would make the sentence easier to understand. Contrast on NP1 was predicted to lengthen the constituent, and lengthening would help the prosody conform to the ENC three-phrase prosody, which begins with a long NP1. Further, if a contrast on NP1 led to a pause immediately following it, the prosody would correspond closely to that of the ENC three-phrase prosody, which has phonological phrase breaks after NP1 and before VP3. A pause immediately after each contrasted constituent was predicted based on Selkirk, 2002, which reported “a substantial disjuncture following the FOCUS verb.”

For a 2-CE-RC sentence to be judged as more acceptable, the upper and lower relative clauses embedded in a 2-CE-RC sentence must remain short. Because a pause after either NP2 or VP1 would lengthen constituents in these clauses, contrastive emphasis on NP2 or on VP1 was thus predicted to result in prosody that would discourage comprehension.

4. Results

4.1 Recordings

Initial inspection of a sample of the 320 target sentence recordings indicated that accuracy in contrastive stress placement was generally high, though there were occasional errors

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8 Selkirk in this paper referred to contrastive focus and presentational focus as FOCUS and focus, respectively.
such as emphasizing the entire capitalized constituent rather than only one syllable within it. One
participant emphasizing the entire constituent also tended to add a small pause just before it.

Sample recordings of each version of one target sentence, ‘Canoes,’ were reviewed to
determine whether the contrasted syllable induced an L+H* pitch accent and a phonological
phrase break immediately afterward.

Three of the four recordings did show an L+H* pitch accent. The one that did not was
one where the entire constituent (in this case, the VP1) was emphasized. The pitch accent was an
H* rather than an L+H*. To test this ear judgment acoustically, peak and base Hz of the syllable
were measured. Percentage increases from the base to the peak (lowest to highest points) of the
pitch accents were higher for the Baseline (BL), NP1, and NP2 sample recordings than for the
VP1 sample.

Table 3 includes acoustic information from the sample recordings, as well as the rating
that the participant who recorded the sentence gave when judging its comprehensibility. The
participants recording items with contrast on Baseline and NP1 each rated the sentences “1 - very
difficult” to understand. The participants recording items with contrast on NP2 and VP1 each
rated the sentences “2 - fairly difficult.” These data, of course, may not be representative because
they are across participants.
Table 3. Sample recording results

<table>
<thead>
<tr>
<th>Participant</th>
<th>L+H* pitch accent?</th>
<th>Percent rise L to H</th>
<th>Pause directly afterward?</th>
<th>Pause length</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1 (BL)</td>
<td>✓</td>
<td>38.4 percent</td>
<td>✓</td>
<td>0.31 seconds</td>
<td>1</td>
</tr>
<tr>
<td>Participant 2 (NP1)</td>
<td>✓</td>
<td>49.5 percent</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Participant 3 (NP2)</td>
<td>✓</td>
<td>50.8 percent</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Participant 4 (VP1)</td>
<td>-</td>
<td>13.9 percent</td>
<td>✓</td>
<td>0.49 seconds</td>
<td>2</td>
</tr>
</tbody>
</table>

As for phonological phrase breaks, the Baseline version is the only one that included a comma in visual presentation (to prompt participants to distinguish the preceding phrase from the target sentence); the immediate pause after the contrasted constituent is expected in every Baseline case.

Participant 4, who paused for 0.49 seconds after the contrasted VP1, took a breath in that pause, then paused again between VP2 and VP3. Participants 2 and 3 did not pause after the contrasted constituent (NP1 and NP2, respectively).

Praat representations of these sample recordings, one of each of the four versions of the target sentence “Canoes,” are given below. In each one, the pitch contour corresponding to the contrasted syllable is highlighted. For the Baseline version in Figure 5, pitch contours for NP1, NP2, and VP1 are also circled to show non-contrasted versions of these constituents.
Baseline: Contrast on pre-sentence adjunct “ACCORDING TO THE HISTORIAN”

This figure represents Participant 1 reading, “But ACCORDING TO THE HISTORIAN, the canoes that the pioneers that the movie depicts had built...” The highlighted L+H* pitch accent is the contrasted syllable “TOR” in “HISTORIAN.”

This version of the sentence also provides a baseline showing the $F_0$ contours for NP1, NP2, and VP1 in their unfocused forms (their contours are fairly flat in the Baseline version), for comparison with their contrasted forms in the other versions:

- The first circled contour is the NP1, “the canoes.”
- The second circled contour is the NP2, “the pioneers.”
- The third circled contour is the VP1, “depicts.”
NP1: Contrast on “THE CANOES”

This figure represents Participant 2 reading, “But THE CANOES that the pioneers that the movie depicts had built...” The highlighted pitch accent is the contrasted syllable “NOES” in “CANOES.”

NP2: Contrast on “THE PIONEERS”

This figure represents Participant 3 reading, “But the canoes that THE PIONEERS that the movie depicts had built were made from...” The highlighted pitch accent is the contrasted syllable “NEERS” in “PIONEERS.”
VP1: Contrast on “DEPICTS”

Figure 8. Sample VP1 recording in Praat: contrast on “PICTS” in “DEPICTS”

This figure represents Participant 4 reading, “But the canoes that the pioneers that the movie DEPICTS had built...” The highlighted pitch accent is the contrasted syllable “PICTS” in “DEPICTS.”

Again, these samples may not be representative, but broad review of recordings showed that L+H* pitch accents were commonly assigned to focused constituents, but that such constituents were not always followed by a pause.

4.2 Judgments

Descriptive statistics are reported in Table 4. Overall mean comprehensibility ratings by target version are shown in Figure 9.
Table 4. Descriptive statistics

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>40</td>
<td>2.24</td>
<td>0.97</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>NP1</td>
<td>40</td>
<td>2.45</td>
<td>0.9</td>
<td>1</td>
<td>4.5</td>
</tr>
<tr>
<td>NP2</td>
<td>40</td>
<td>2.56</td>
<td>0.81</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>VP1</td>
<td>40</td>
<td>2.6</td>
<td>1.08</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 9. Mean comprehensibility ratings by target version, Error bars: ± SE

The grand mean comprehensibility rating for targets was 2.472. Of the 40 participants, 33 (83 percent) used at least three different ratings for the eight target sentences. The target item “Balloons” received the highest comprehensibility ratings (2.9 mean), and the target sentence “Volunteer” received the lowest (2.25 mean).

Mixed-effects modeling with crossed random effects for participants and items was used to examine the differences between ratings for target versions. Mixed-effects modeling accounts
for the clustered nature of the data, with responses (level-1) nested within participants and items (level-2); furthermore, it allows examination of the variability within and between participants and items, and of the effects and interactions within and across participants and items (Raudenbush & Bryk, 2002). This approach has been shown to be superior to traditional analyses (Baayen, Davidson & Bates, 2008).

Univariate outliers, level-1 residuals, and level-2 residuals were examined and no influential values were detected, and therefore no data was excluded from the analysis.

The mixed-effects regression analysis and post hoc comparisons showed that NP2 ($p = 0.028$) and VP1 items ($p = 0.014$) each received statistically significantly higher comprehensibility ratings than Baseline items. The differences, however, between Baseline and NP1, between NP1 and NP2, and between NP1 and VP1 were not statistically significant. The difference between the two DISC items, NP2 and VP1, was also not statistically significant.

That there was not a significant difference between NP1 and Baseline items, and that NP2 and VP1 items were rated for comprehensibility higher than NP1 items, was contrary to what was predicted.

Data were analyzed with R version 3.1.1 (R Core Team, 2014) using the lmer function from the lme4 package, version 1.1-7 (Bates, Maechler, Bolker & Walker, 2014).
Table 5. Summary of mixed-effects regression analysis for comprehensibility ratings by target version

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate(SE)</th>
<th>df</th>
<th>t</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.25(0.162)</td>
<td>54</td>
<td>13.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NP1</td>
<td>0.225(0.142)</td>
<td>272.7</td>
<td>1.59</td>
<td>0.114</td>
</tr>
<tr>
<td>NP2</td>
<td>0.313(0.142)</td>
<td>272.7</td>
<td>2.2</td>
<td>0.028</td>
</tr>
<tr>
<td>VP1</td>
<td>0.35(0.142)</td>
<td>272.7</td>
<td>2.47</td>
<td>0.014</td>
</tr>
</tbody>
</table>

For Subjects, n = 40; for Items, n= 8. Total number of observations (level-1) = 320.

Table 6. Post hoc comparisons

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Estimate</th>
<th>SE</th>
<th>z</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP1 – Baseline</td>
<td>0.225</td>
<td>0.142</td>
<td>1.586</td>
<td>0.113</td>
</tr>
<tr>
<td>NP2 – Baseline</td>
<td>0.313</td>
<td>0.142</td>
<td>2.203</td>
<td>0.028*</td>
</tr>
<tr>
<td>VP1 – Baseline</td>
<td>0.35</td>
<td>0.142</td>
<td>2.467</td>
<td>0.014*</td>
</tr>
<tr>
<td>NP2 – NP1</td>
<td>0.088</td>
<td>0.142</td>
<td>0.617</td>
<td>0.537</td>
</tr>
<tr>
<td>VP1 – NP1</td>
<td>0.125</td>
<td>0.142</td>
<td>0.881</td>
<td>0.378</td>
</tr>
<tr>
<td>VP1 – NP2</td>
<td>0.038</td>
<td>0.142</td>
<td>0.264</td>
<td>0.792</td>
</tr>
</tbody>
</table>

*p < .05.

5. General Discussion

It is clear that the data do not support the initial hypothesis, which was that sentence versions with contrastive focus on NP1 would be rated as more comprehensible than versions with contrastive accent on NP2 or VP1, presumably due to the lengthening and pausing induced at the end of a constituent bearing contrastive focus. The results are surprising and call for some explanation. Several factors may help to account for the results showing NP1 items not being rated more comprehensible than NP2 and VP1 items.
First, an L+H* accent tends to flatten out the prosody of the rest of the sentence coming after it (Kjelgaard and Speer, 1999). The words following contrastive focus are de-accented, and the earlier in the sentence the contrastive focus appears, the more de-accented words there will be. It is probable that the longer the de-accented portion of the sentence, the harder the sentence is to understand. This was borne out by the data: the sentences judged to be the most difficult were the ones with contrast on the pre-sentence adjunct (Baseline), and the ones judged to be the least difficult were the ones with contrast on VP1, the test constituent that came latest in the sentence.

Second, in the materials for this experiment, NP1 may have been too short to serve as a prosodic phrase. Prosodic phrasing must respect optimal phrase length constraints as well as alignment constraints (Shafran and Fodor, 2014), and phrase lengths thus play an important role in motivating prosodic boundaries. Participants may also have been stringing together longer phrases (such as NP1 and NP2 together) because they had learned to anticipate long sentences in this study—and so could guess how much there was to pronounce in an upcoming sentence—and were trying to get as much in one breath as possible.

Third, there are other prosodic considerations, such as balance, that may have prevented a pause after NP1. Balance could have encouraged a prosodic break after NP2, rather than after NP1, because that would divide the sentence into better balanced elements. For example, in the sample recording of the NP1 contrast, reported above, the most significant pause was just before VP3, (as in many examples), but there was also a slight pause after NP2 (“the pioneers”):

(25) But THE CANOES that the pioneers | that the movie depicts built || were made from strong cedar tree trunks.
Here the segments are somewhat balanced, with a ratio of 6:5:7 words (and 9:7:8 syllables) per phrase. Participants may have instinctually sought balance in their pronunciation. A break after NP1 would have yielded imbalanced phrases: a ratio of 3:8:7 words (and 4:12:8 syllables).

Fourth, initial review of the data indicate that the greatest changes in pitch were on contrasts where no pause followed. Participants might have been using intonation, rather than timing, to parse the sentence when reading it aloud.

The sample recording of NP1 contrast lacking a pause after the contrasted constituent may be representative of a larger pattern because of these four considerations, and especially because of length and balance constraints. More data should be examined to test whether it is the norm not to put a phonological phrase boundary after a contrasted NP1. If it is, and a pause after NP1 is missing in other recordings, then the lower comprehensibility ratings may correspond, in a predictable way, to participants’ DISC pronunciation.

Again, a pause after a contrasted constituent was predicted because of the finding reported by Selkirk (2002). While this pause-after-contrast effect may be true statistically, it may not be obligatory: not every contrast must be followed by a pause. Furthermore, Selkirk’s examples of breaks after contrastive focus are only for RNR constructions, and in those examples phonological phrase boundaries follow syntactic disjuncture, which is not always the case in the materials in the present experiment.

One further consideration is that some participants may have read the sentence preceding the target (the one setting up the contrast) more expressively than they did the target sentence. This may be because the two sentences were lexically very similar—differing only in the
contrasted constituent and the VP3—and the repetitiveness of discourse-given constituents may have led participants to hasten through the second contrast sentence.

Drawing together these strands of evidence and initial inspection of the recording data, it appears that what has been challenged by the results of this study is not whether three-phrase ENC prosody as NP1 || RC1 || VP3 is encouraging toward comprehension, but whether contrastive focus necessarily elicits this contour, at least for contrast on NP1. This was worth trying, in view of available data, and its potential insight on the relation between prosody and syntactic and semantic processing.

The recordings are a rich source of data for further study. They can be acoustically analyzed and compared with the corresponding judgments. A subsequent inquiry would ideally include additional target sentences; a larger sample size should aid in yielding more statistically significant results.
Appendix I: Target Materials

The full text of the eight target sentences, each with the four versions (Baseline, NP1, NP2, and VP1) and their corresponding background and contrast sentences, are listed below.

1. Canal

   a. Baseline

      Background:
      *The young engineer that my dad had trained became famous for his work on canals and was profiled in a newspaper article on Sunday.*

      Contrast:
      ACCORDING TO THE NEWSPAPER, the last canal that the engineer that my dad had trained worked on was in West Virginia. 
      But ACCORDING TO GOOGLE, the last canal that the young engineer that my dad had trained worked on was in the Canary Islands.

   b. NP1

      Background:
      *The young engineer my dad had trained works on both bridges and canals.*

      Contrast:
      THE LAST BRIDGE that the young engineer that my dad had trained worked on was located in West Virginia.
      But THE LAST CANAL that the engineer that my dad had trained worked on was in the Canary Islands.

   c. NP2

      Background:
      *My dad has trained a young architect and an engineer, both of whom now work on creating waterways.*

      Contrast:
      The last canal that THE YOUNG ARCHITECT that my dad had trained worked on was located in West Virginia.
      But the last canal that THE YOUNG ENGINEER that my dad had trained worked on was in the Canary Islands.
d. VP1

**Background:**
At a professional reunion, my dad met two engineers, one of whom he had trained and one of whom he had studied under; both of them still work on creating waterways.

Contrast:
The last canal that the young engineer that my dad HAD STUDIED UNDER worked on was located in West Virginia.
But last canal that the young engineer that my dad HAD TRAINED worked on was in the Canary Islands.

2. Report
   
a. Baseline

**Background:**
At the local army base there is a mean cadet whom Paul detests who has a bad habit of sending in false reports, year after year.

Contrast:
LAST YEAR, the false report that the mean cadet that Paul detests sent in was completely fabricated.
But THIS YEAR, the false report that the mean cadet that Paul detests sent in actually had a small grain of truth in it.

b. NP1

**Background:**
At the local army base there is a mean cadet whom Paul detests who has a bad habit of faking his official documents.

Contrast:
THE COLLEGE TRANSCRIPT that the mean cadet that Paul detests sent in was completely fabricated.
But THE FALSE REPORT that the mean cadet that Paul detests sent in actually had a small grain of truth in it.

c. NP2

**Background:**
Paul detests both the mean captain and the mean cadet in his regiment, each of whom sent in false annual reports to the authorities.

Contrast:
The false report that THE MEAN CAPTAIN that Paul detests sent in was completely fabricated.
But the false report that THE MEAN CADET that Paul detests sent in actually had a small grain of truth in it.
d. VP1

Background:
Paul is adjusting to army life and understands that there are several mean cadets in the regiment who file false reports to the authorities, but he is friends with one of them though he detests another one.

Contrast:
The false report that the mean cadet that Paul IS FRIENDS WITH sent in was completely fabricated. But the false report that the mean cadet that Paul DETESTS sent in actually had a small grain of truth in it.

3. Champagne

a. Baseline

Background:
Ruth, who is about to adopt a teenage Somalian refugee, brought him along with her to my wedding, where he tasted champagne for the first time thinking it was soda.

Contrast:
AT THE BEGINNING OF THE WEDDING, the champagne that the refugee that Ruth will adopt drank was from Europe and very expensive. But LATER IN THE EVENING, the champagne that the refugee that Ruth will adopt drank was just cheap booze from South America.

b. NP1

Background:
Ruth is about to adopt a teenage Somalian refugee, and she brought him along with her to my wedding where he tasted both sherry and champagne for the first time, thinking they were soda.

Contrast:
THE SHERRY that the refugee that Ruth will adopt drank was from Europe and very expensive. But THE CHAMPAGNE that the refugee that Ruth will adopt drank was just cheap booze from South America.
c. NP2

Background:
Ruth, who is about to adopt both a foster child and a refugee, brought them along to my wedding, where each of them tried different brands of French champagne for the first time.

Contrast:
The champagne that THE FOSTER CHILD that Ruth will adopt drank was from Europe and very expensive.
But the champagne that THE REFUGEE that Ruth will adopt drank was just cheap booze from South America.

d. VP1

Background:
Ruth, who is about to adopt one refugee from Somalia and tutor another one, brought them both along to my wedding where they tasted different brands of champagne.

Contrast:
The champagne that the refugee that Ruth WILL TUTOR drank was from Europe and very expensive.
But the champagne that the refugee that Ruth WILL ADOPT drank was just cheap booze from South America.

4. Plums

a. Baseline

Background:
Some little girls and their parents were picking fruit at Bill's orchard, and he was trying to help the children find the best ones.

Contrast:
IN THE PARENTS' OPINION, the ripe plums that the little girls that Bill helped the most were picking had remarkably little flavor.
But IN THE CHILDREN'S OPINION, the ripe plums that the little girls that Bill helped the most were picking were quite delicious.

b. NP1

Background:
Some little girls and their parents were picking ripe fruits of all kinds at Bill's orchard, and he was trying to help the children find the best ones.

Contrast:
THE RIPE APRICOTS that the little girls that Bill helped the most were picking had remarkably little flavor.
But THE RIPE PLUMS that the little girls that Bill helped the most were picking were quite delicious.
b. NP2

**Background:**
Some little girls and their parents were picking plums at Bill's orchard, and he was kept busy trying to help them find the best ones.

Contrast:
The ripe plums that THE PARENTS that Bill helped the most were picking had remarkably little flavor.
But the ripe plums that THE LITTLE GIRLS that Bill helped the most were picking were quite delicious.

d. VP1

**Background:**
*Bill was doing his best to assist the little girls who were picking plums in his orchard, but he couldn’t work with them all equally.*

Contrast:
The ripe plums that the little girls that Bill HELPED THE LEAST were picking had remarkably little flavor.
But the ripe plums that the little girls that Bill HELPED THE MOST were picking were quite delicious.

5. Marionette

a. Baseline

**Background:**
*Dan is a theatrical agent who represents a puppeteer who uses vintage marionettes in his show.*

Contrast:
LAST WEEK, the marionette that the puppeteer that Dan represents works with fell apart after the show.
But TODAY, the marionette that the puppeteer that Dan represents works with only needed a paint job.

b. NP1

**Background:**
*Dan is a theatrical agent who represents a puppeteer who uses both a toy dragon and a marionette in his show.*

Contrast:
THE TOY DRAGON that the puppeteer that Dan represents works with fell apart after the show.
But THE MARIONETTE that the puppeteer that Dan represents works with only needed a paint job.
c. NP2

*Background:*
*Dan is a theatrical agent who represents a ventriloquist and a puppeteer, both of whom perform in the same show using vintage marionettes.*

*Contrast:*
The marionette that THE VENTRILOQUIST that Dan represents works with fell apart after the show.
But the marionette that THE PUPPETEER that Dan represents works with only needed a paint job.

d. VP1

*Background:*
*Two puppeteers perform in one show; Dan is a theatrical agent representing one of them, and the other one he always makes fun of.*

*Contrast:*
The marionette that the puppeteer that Dan RIDICULES works with fell apart after the show.
But the marionette that the puppeteer that Dan REPRESENTS works with only needed a paint job.

6. Volunteer

a. Baseline

*Background:*
*A smart volunteer who toured with the president-elect that Jane respects made a campaign video that went viral.*

*Contrast:*
*TO AN OLDER DEMOGRAPHIC, the smart volunteer that the president-elect that Jane respects toured with is relatively obscure.*
*But TO THE YOUNGER GENERATION, the smart volunteer that the president-elect that Jane respects toured with is becoming a household name.*
b. NP1

Background:
The president-elect that Jane respects toured with a smart politician, and also with a smart volunteer who later made a very successful campaign video.

Contrast:
THE SMART POLITICIAN that the president-elect that Jane respects toured with is relatively obscure.
But THE SMART VOLUNTEER that the president-elect that Jane respects toured with is becoming a household name.

c. NP2

Background:
The losing candidate and the president-elect, both of whom Jane respects, each went on tour aided by a smart volunteer, but the president-elect's volunteer gained fame from a successful campaign video.

Contrast:
The smart volunteer that THE LOSING CANDIDATE that Jane respects toured with is relatively obscure.
But the smart volunteer that THE PRESIDENT-ELECT that Jane respects toured with is becoming a household name.

d. VP1

Background:
The president-elect of one small European country, whom Jane mocks, and the president-elect of another one, whom Jane respects, each went on tour with a smart volunteer.

Contrast:
The smart volunteer that the president-elect that Jane MAKES FUN OF toured with is relatively obscure.
But the smart volunteer that the president-elect that Jane RESPECTS toured with is becoming a household name.

7. Balloons

a. Baseline

Background:
At birthday parties, the goofy clown that the children adored gives out big balloons.

Contrast:
IN THE PAST, the big balloons that the goofy clown that the kids adored gave out were met with yawns.
But ON THIS OCCASION, the big balloons that the goofy clown that the kids adored gave out were the high point of the show.
b. NP1

Background:
The goofy clown that the children loved was giving out both light-up yoyos and big balloons at the birthday party.

Contrast:
THE LIGHT-UP YOYOS that the goofy clown that the kids adored gave out were met with yawns. But THE BIG BALLOONS that the goofy clown that the kids adored gave out were the high point of the show.

c. NP2

Background:
At the birthday party, the children loved the goofy magician and the goofy clown, who both gave out big balloons.

Contrast:
The big balloons that THE GOOFY MAGICIAN that the kids adored gave out were met with yawns. But the big balloons that THE GOOFY CLOWN that the kids adored gave out were the high point of the show.

d. VP1

Background:
There were two goofy clowns at the birthday party—one of whom the kids hated and one of whom they adored—both of whom were giving out big balloons.

Contrast:
The big balloons that the goofy clown that the kids HATED gave out were met with yawns. But the big balloons that the goofy clown that the kids ADORED gave out were the high point of the show.
8. Canoes

a. Baseline

*Background:* 
At the screening of the historically-based movie, the filmmaker and a historian spoke afterward, giving different accounts of how the pioneers had built their canoes.

*Contrast:* 
According to the filmmaker, the canoes that the pioneers that the movie depicts had built were made from random pieces of driftwood. But according to the historian, the canoes that the pioneers that the movie depicts had built were made from strong cedar tree trunks.

b. NP1

*Background:* 
An interesting historically-based movie about the pioneers showed their skills in building barns and canoes.

*Contrast:* 
The barns that the pioneers that the movie depicts built were made from random pieces of driftwood. But the canoes that the pioneers that the movie depicts built were made from strong cedar tree trunks.

c. NP2

*Background:* 
An interesting historically-based movie showed how the natives and the pioneers used different techniques for building canoes.

*Contrast:* 
The canoes that the natives that the movie depicts had built were made from random pieces of driftwood. But the canoes that the pioneers that the movie depicts had built were made from strong cedar tree trunks.
d. VP1

**Background:**
The movie showed some pioneers who made canoes from cedar but left out others who made canoes from driftwood.

**Contrast:**
The canoes that the pioneers that the movie LEAVES OUT had built were made from random pieces of driftwood.
But the canoes that the pioneers that the movie DEPICTS had built were made from strong cedar tree trunks.
Appendix II: Experiment Instructions and Tutorial

SCREEN 1

INSTRUCTIONS:

This is a study of contrastive emphasis in spoken language for American English. You will be shown sentences to read, in groups of three. The first one (in italics), gives a background for the two following ones, which express a contrast.

For each sentence group, you should first read through them silently to yourself for understanding. In reading silently, think about how you would pronounce them when reading aloud.

On the next screen, when you’re ready, click “record,” then, “start recording,” and read out loud the two sentences labeled "contrast," clearly and with full expression, for recording. The first time you record, you will be prompted to click “allow” to enable your computer’s microphone. After recording, enter your Amazon Mechanical Turk ID in the name field that will appear (you will need to do this for each recording). You do not need to enter an email address. Click “send” to complete the recording. You must confirm that you recorded the contrast sentences in order to move forward.

On the next screen, you will be asked to judge how easy the third (final) sentence is to understand. The sentence to judge always begins with the word “But.” The scale goes:

1 - Very difficult  2 - Fairly difficult  3 - Ok  4 - Fairly easy  5 - Very easy

CONTRASTIVE FOCUS:

All the sentences you will see are well-formed sentences of English, but some are easier to understand than others.

To indicate contrast, sentence 2 and sentence 3 each have one word or phrase in capital letters. When reading the sentences aloud, your job is to put stress (emphasis) on that word or phrase. Typically, it will be pronounced a bit longer and louder than the rest of the sentence.

However, you’ll find that inside the emphasized word or phrase, there is usually only one syllable that is most prominent. We are interested in which syllable that is.

Click next to practice on a sample sentence set.
Some bestselling books are being formatted for large-print publication.

Large-print editions of THE HARRY POTTER BOOKS will be released soon.
But large-print editions of THE HUNGER GAMES BOOKS will not be available for years.

Try reading the two contrast sentences out loud, as you would do for recording. Which syllable would you emphasize in THE HARRY POTTER BOOKS?

Most people would emphasize “POT” in “POTTER.”

Which syllable would you emphasize in THE HUNGER GAMES BOOKS?

Most people would emphasize “HUN” in “HUNGER.”

How difficult to understand is the last sentence?
But large-print editions of THE HUNGER GAMES BOOKS will not be available for years.

1 - Very difficult  2 - Fairly difficult  3 - Ok  4 - Fairly easy  5 - Very easy

Most people would probably rate this as 5 - Very easy
SCREEN 3

Let’s try another one. Read the following silently, then read the contrast sentences (the second two) out loud:

*The Olympic committee took stock of the heights of those who had broken men’s records in track and field.*

Nobody has ever broken THE MEN’S LONG JUMP RECORD unless he is at least six feet tall except for Asian and South American athletes, although this year was different. But nobody has ever broken THE MEN’S HIGH JUMP RECORD who is shorter than six feet tall unless he can run a four-minute mile keeping his heart rate down to 150 beats per minute or less.

Which syllables did you emphasize? Most people would stress “LONG” and “HIGH.”

**Judge:** But nobody has ever broken THE MEN’S HIGH JUMP RECORD who is shorter than six feet tall unless he can run a four-minute mile keeping his heart rate down to 150 beats per minute or less.

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Most people would probably rate this as 1 - Very difficult or 2 - Fairly difficult
One more practice set before we begin. Read all three sentences silently, then out loud, this time for recording. Then judge how easy the final sentence is to understand.

Read silently:

The grandparents were watching the baby while the parents were away overnight.

While THE GRANDPA was bathing the baby slept peacefully.
But while THE GRANDMA was bathing the baby threw up.

Read contrast sentences out loud for recording, clearly and with full expression:

Background:
The grandparents were watching the baby while the parents were away overnight.

Contrast:
While THE GRANDPA was bathing the baby slept peacefully.
But while THE GRANDMA was bathing the baby threw up.

In these, most people would emphasize “PA” in "GRANDPA" and “MA” in “GRANDMA.”

Judge:

But while THE GRANDMA was bathing the baby threw up.

Judge:

1 - Very difficult  2 - Fairly difficult  3 - Ok  4 - Fairly easy  5 - Very easy

Most people would probably rate this as 2 - Fairly difficult or 3 - Ok.

This is the end of the practice sets. When you are ready to begin, click next to get started.
### Appendix III: Complete Data Set for Target Comprehensibility Ratings

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