The Processing of Conditional Inversion: A Reading Task Study, Part II*

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This work concerns the on-line processing of the Conditional Inversion Construction (CI) in English. According to the traditional approach to the syntax of Conditional Inversion, this construction involves I-to-C Movement (Iatridou and Embick 1994), identical to the movement involved in Subject-Auxiliary Inversion. However, recent analyses of Conditional Inversion claim that this construction involves raising of I-to-C-to-X, the head of an XP projected above CP (Bjorkman 2011). Assuming that these steps of movement are costly processing-wise, the traditional approach predicts that Conditional Inversion and Subject Auxiliary Inversion are equally costly with regard to their non-inverted structures, while the contemporary analysis predicts that Conditional Inversion is more costly than Subject Auxiliary Inversion with regard to their non-inverted structures. In order to investigate these predictions, we conduct a Self-Paced Reading Task experiment with seven monolingual-English speakers. Subjects are presented with one hundred sentences: fifty experimental and fifty fillers; half of the experimental sentences include CI and the other half includes SAI Constructions. After half of the total sentences, subjects are presented with a comprehension question. Reading times for each sentence are recorded. The result of a paired samples t-test revealed a significant difference in reading times between sentences with CI (M=64.95, SD=22.27) and SAI (M=34.28, SD=5.83), t(7)=4.821, p<0.003. For reading times per character, the difference is .003, which is significant. Assuming that “reading times are reflective of processing difficulty” (Levelt 1989; Rayner and Sereno 1994), the shorter processing time involved in computing SAI as contrasted with CI provides support for the claim that CI involves a more complex operation, which is predicted by Bjorkman’s I-to-C-to-X Analysis.

1. Introduction

The meaning expressed by *Irrealis Mood* is found in many languages. In Modern English, *Conditional Inversion (CI)* is a construction used to

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represent this meaning. CI occurs in indicative and counterfactual conditionals. There has been a great deal of attention in the literature on the syntax of CI, as it has been claimed that movement is involved in its derivation. Earlier generative analyses of this construction claim that CI is derived from its counterpart with overt “if” in the head of CP, with (1b) derived from (1a), and (2b) derived from (2a):

(1) a. If I had known, I would have acted differently.
   b. Had I known, I would have acted differently.
(2) a. If Sue pushed harder, the door would have stayed open
   much longer
   b. Had Sue pushed harder, the door would have stayed
      open much longer.

As has been noted, this process of inversion seems to take place not only in CI, but in Subject Auxiliary Inversion Constructions as well. The assumed pre- and post-movement structures of these examples are as in (3a)-(3b), and (4a)-(4b):

(3) a. John would fix this problem.
   b. Would John fix this problem?
(4) a. The students had already completed their exams.
   b. Had the students already completed their exams?

Relevant to the discussion of the derivation of these forms is the Minimal Structure Principle.

This principle was proposed in the literature as a constraint on syntactic derivations, and recent discussion has considered the claim that this principle may be relevant in computing processing cost of syntactic structures (see Enzinna 2013; Enzinna and Thompson 2013). According to the Principle of Economy of Representation (see Law 1991), formalized as the Minimal Structure Principle (MSP) (see Bošković 2011; Heck and Muller 2011), if two representations have the same lexical structure and serve the same function, once provided lexical requirements of relevant elements are satisfied, then the representation that has fewer projections is to be chosen as the syntactic representation serving that function. Taking into consideration results of recent research (Kang and Thompson 2013), the present experiment has been constructed by utilizing a counterbalanced self-paced reading task.
2. Analysis of Conditional Inversion

2.1. Traditional Analysis

Analyzing the structure of Conditional Inversion, there are two main approaches in the generative literature.\(^1\) CI has been claimed to involve one instance of head movement, I-to-C, with the head of IP raising to the head of CP, as illustrated in the tree diagram below (3), from Iatridou & Embick 1994. The traditional analysis of SAI is as in (4), as discussed in Radford (1997). Given the similarity in derivation between these two structures, we may inquire whether they involve a similar processing cost.

\(^1\) Note that throughout, this paper assumes that Head Movement is a possible process of the Syntactic Component. The status of Head Movement has been recently robustly discussed – see Roberts (2013) for an overview.
2.2. Contemporary Analysis

A distinct analysis of CI from Iatridou & Embick (1994) is presented in Bjorkman (2011). Bjorkman reasons that the covert trace of ‘if’ in the head of CP blocks raising of head of IP to head of CP; therefore the head of IP raises to a higher projection, XP. The tree structure is as in (5):

![Tree Diagram for Contemporary Analysis]

(5) Tree Diagram for Contemporary Analysis

3. Assumptions and Predictions

The first key assumption that we make regarding processing is the claim that any type of movement is costly: “(Other things being equal), sentences involving an instance of movement are more difficult to process than their counterparts without an instance of movement” (Kouizumi and Tamaoka 2010; see Miyamoto and Takahashi 2002, Tamaoka et al. 2005 for further discussion.)

The second assumption that we make is that “reading times reflect processing difficulty” (see Levelt 1989, Rayner and Sereno 1994, and Rayner et al.1989 for discussion). Consequently, we may discover which sentence structure is more difficult to process by measuring reaction times to the inverted and non-inverted counterparts of the CI and SAI Constructions.

The traditional analysis of CI of Iatridou & Embick and the contemporary analysis of Bjorkman make distinct processing predictions. According to Iatridou & Embick, since CI has only one instance of movement, I-to-C,
there should be no significant difference in processing times between the CI and SAI Constructions. On the other hand, according to Bjorkman’s point of view, there is predicted to be a reaction time difference between CI and SAI, since CI involves two instances of movement (I-to-C-to-X).

4. Experimental Design

We investigated these predictions by conducting a Self-Paced Reading Task with seven English adult monolinguals. Subjects are displayed one hundred sentences one-by-one on a computer screen. Subjects were asked to press the spacebar when they have finished reading a sentence to move to the next one. The amount of time that the participant takes to press the spacebar from the appearance of the sentence on the screen is measured as is the reading time of the sentence.

4.1. Experimental Stimuli

One-hundred experimental sentences were presented to seven participants in the stimuli: twenty-five sentences with CI, twenty-five sentences with SAI, and fifty filler sentences. Reading times were recorded and divided, by the number of characters of each sentence to normalize for sentence length. The order of the sentences were random to be shown on the screen. The experimental sentences are as illustrated in (6)-(11):

**Conditional Inversion Sentences**
(6) Had we booked our flight earlier, the flight fee would have been cheaper than now.
(7) Were Jim proposing to you, what would have been your response at that moment?

**Subject Auxiliay Sentences**
(8) Should the political monarch be found not guilty by the Supreme Court next month?
(9) Will many articles be piled onto the desk because of discussion about the budget?

**Filler Sentences**
(10) Bennett does not want to share a room with someone who is messy around the house.
(11) Why is that long ladder connected to the motorcycle like that on the right side?
4.2. Wrap-up Effects

Sentence-final modifiers are included in all experimental sentences, because, as has been discussed in the literature, sentence-final position in general involves extra processing cost. (Aaronson & Scarborough, 1976; Just & Carpenter, 1980; Rayner, Sereno, Morris, Schmauder, & Cliffton, 1989). All lexical items used in sentence-final modifiers were high-frequency, and none except functional items were repeated, in order to avoid priming effects. Therefore, none of the same sentence-final modifiers were used so that the reaction time would not be reduced or affected by only participants’ memory. Some examples of the sentence-final modifiers that were used in this experiment are as follow: this semester, next month, around the house, about the budget, etc.

4.3. Comprehension Questions

The presentation of experimental sentences was randomized per subject. Half of the sentences were followed by comprehension questions, in order to ensure that subjects maintained attention. The subject pressed either the Y key (if the answer was ‘yes’) or the N key (if the answer was ‘no’) to move to the next sentence. These are illustrated in (12-14):

(12) Had I known the answer to the homework question, I would have told you before class.
   Q. Is the homework given in class?
   Answer: Yes

(13) Should the political monarch be found not guilty by the Supreme Court next month?
   Q. Is there a political monarch?
   Answer: Yes

(14) Why is that long ladder connected to the motorcycle like that on the right side?
   Q. Is the long ladder connected to the car like that on the right side?
   Answer: No

In short, there were twenty-five comprehension questions each for CI, SAI, and filler sentences. These questions were used to check on the participants’ comprehension and focus on the task. We did not give feedback on the comprehension questions during the task so as to avoid interrupting the sentence processing. If a participant asked, we told them their score when the experiment was over. Both comprehension questions and reading were self-paced. Note that this method of presentation involves the entire sentence on the screen at once, as opposed to a word-
by-word presentation or a phrase-by-phrase presentation. We assume that this methodology best captures the processing time involved in the natural reading of these sentences (see Koizumi and Tamaoka 2010 for discussion).

4.4. Participants

The data from seven subjects is analyzed in this paper. To avoid effects of interference from other languages, we used only English monolinguals. The age range of participants is between twenty to sixty-five years old. All participants work or study at Florida International University, Miami, FL.

5. Experimental Task

SuperLab was used to present the Reading Task Study. Before conducting the experimental task, we ran a trial task which consisted of three types of sentences followed by comprehension questions one by one in randomized order. The trial task familiarized the participants with the experimental design. During this trial task, subjects were encouraged to ask any questions about the activity. The experimental task was conducted in the same manner as the trial task.

6. Results

6.1. Average Reading Times per Character

We initially attempted to formulate experimental sentences with identical numbers of characters. However, in order to allow a little variation, we included sentences of similar length. Experimental sentences varied from sixty-four number of characters to seventy-five number of characters. We normalized the reading rates for sentence length by dividing the reading times of each sentence by the number of characters in each sentence (see Enzinna 2013; Enzinna and Thompson 2013). The mean values of the average reading times per character are presented below in Figure 1.

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2 In total, 16 subjects participated in the experiment. They were split into two lists of 8, and only one list is analyzed here. The data from 3 subjects had to be excluded because they were distracted during the testing procedure or reported making typographical mistakes in response to the stimulus.
6.2. Comprehension Questions

The mean correct response rate to the comprehension questions across subjects is 95.71% (range: 92%-98%). Because of this high rate, we assume that all the participants were paying attention during the experiment, and we can fully rely on the reading times.

6.3. Overview of Results

The mean reading times of the Conditional Inversion sentences the Subject Auxiliary Inversion sentences was compared. Recall that a significant result would provide support for Bjorkman’s analysis of CI as involving two steps of movement. A paired samples t-test comparing the mean reading time in the CI construction to the mean reading time in the SAI construction.

<table>
<thead>
<tr>
<th>Paired Samples Test</th>
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<tbody>
<tr>
<td></td>
<td>Paired ...</td>
<td>95% Confidence ...</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td></td>
<td>Upper</td>
<td>t</td>
<td>df</td>
</tr>
<tr>
<td>Pair 1 Total_CBIs - Total_CBSAIs</td>
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<td>4.821</td>
<td>6</td>
</tr>
</tbody>
</table>

(15) Figure 1. Average Reading Times (in ms)

(16) Table 1. Paired Samples t-test result
Table 1 indicates that there was significant difference in response time for CI sentences (M=64.95, SD=22.27) versus SAI sentences (M=34.28, SD=5.83), t(7)=4.821, p<0.003. CI sentences took significantly longer to read than SAI sentences.

7. Discussion

Even though all the sentences were controlled, the number of characters ranged from sixty-four to seventy-five across sentences. We normalized the reading time results by the number of characters to control for these differences. We also checked for the number of both function words and content words, and the result was as same as above. In further studies with more subjects, analysis will be improved by using corpus data which analyzes the average frequency of content and function words in each sentence. All these minor issues will be improved with large number of subjects in the extended version of our Task Study 3, which also includes the Do-insertion sentence structure that is known to have one movement (T-to-C) as SAI structure does.

8. Conclusions

The result of this study is interesting as it strongly support one claim that had been questioned. The predictions of the Contemporary Analysis of Bjorkman (2011) are supported by result from the experimental data – the Subject Auxiliary Inversion construction takes significantly less time to process than the Conditional Inversion construction.

This result is suggestive, but limited numbers of subjects prevent it from being conclusive. It seems that it is necessary to include a higher number of participants in order to determine whether the results that we have obtained are indicative of a general trend.

References
