When is “good enough” good enough? The effects of plausibility and syntax on spoken language comprehension

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Abstract

Researchers have attempted to unravel the mechanisms individuals use to comprehend language throughout the 20th century. Specifically, researchers have debated as to whether individuals use heuristic shortcuts or a complete syntactic analysis when processing an incoming sentence. This study aims to build upon previous research by exploring the roles of syntax and plausibility in a sentence in order to untangle these language comprehension mechanisms. After presenting 24 participants with sentences of either active or passive syntactic forms that are either plausible or implausible, a systematic evaluation of comprehension accuracy and latencies comprehension responses was conducted. We found that when syntax is difficult, plausibility overrides syntax. This suggests that individuals tend not to undergo a complete syntactic analysis and instead opt for a more efficient heuristic shortcut. This study lays promising foundation for future studies involving the effect of perceptual difficulties on this phenomenon.
Introduction

Over 50 years ago, the linguist Noam Chomsky postulated that the production and comprehension of sentences are governed not by learned associations but by an internalized set of well-specified syntactic rules (Chomsky, 1959, 1971). It was further argued that the implementation of these syntactic rules guided the production of sentences and that, in comprehension, determination of the syntactic relations among the words of a sentence must precede access the sentence meaning. This view of the primacy of syntactic parsing in sentence processing became a dogma in psycholinguistics that few challenged (Fodor, Bever, & Garrett, 1974). Indeed, syntactic parsing was assumed to be an automatic and obligatory process (Caplan & Waters, 1999).

To be sure, exceptions to a detailed syntactic analysis as a requisite for comprehension have been postulated in cases of left hemisphere brain damage leading to agrammatic Broca’s aphasia. In these cases patients hearing a sentence with non-canonical word-order, such as the passive sentence “The girl was pushed by the boy”, may treat the sentence as if it were a more canonical active declarative sentence in which the first noun is the agent of the action, and not the recipient (Caplan, Alpert, Waters, & Olivieri, 2000; Grodzinsky, 2000; Novick, Trueswell, & Thompson-Schill, 2005).

A “Good enough” approach. Ferreira (2003) has offered the suggestion that heuristic shortcuts may be taken by all listeners, bypassing a full syntactic analysis but instead using word-order and plausibility as a rapid first-pass comprehension strategy. On average, such a strategy would be maximally efficient. This is so because most sentences we hear reflect a simple, canonical non-verb-noun structure (Goldman-Eisler, 1968), such that assuming the initial noun to be the agent of the action will, on average, be the correct interpretation without engaging
in a detailed syntactic analysis. Plausibility can be added as a second, usually effective, heuristic shortcut for determining who or what in a sentence is the agent of the action and who or what is the recipient. In a similar way of expecting sentences to reflect a canonical word order, we also expect in everyday experience for the meaning of the utterances to be plausible rather than implausible. Following this logic, when faced with comprehension of sentences with complex syntax and with non-canonical word orders, individuals will still tend to make rapid interpretations of agency based on word-order and plausibility rather than engaging in a full syntactic analysis (Ferreira, 2003; Ferreira, Bailey, & Ferraro, 2002; Ferreira, Engelhardt, & Jones, 2009; Ferreira & Patson, 2007; Sanford & Sturt, 2002).

Consistent with this notion, it has been shown that individuals will often misinterpret a sentence in a direction that makes them more plausible in a real world context (Fillenbaum, 1971, 1974). Indeed the general argument has been made that individuals’ interpretations of sentences are often not consistent with the strict content of the sentence, suggesting that individuals rely heavily on plausibility in determining sentence meaning (Garnham & Oakhill, 1987). Additionally, in cases were the syntax of a sentence is complex, comprehenders can be observed produce meanings that imply analyses that were not detailed enough to yield correct interpretations of these sentences (Sanford & Sturt, 2002).

**Late Assignment of Syntax.** One sentence-processing model that is consistent with Ferreira’s notion that listeners adopt a strategy that is not exact but is ordinarily “good enough” for comprehension is the Late Assignment of Syntax Theory (Townsend & Bever, 2001). This theory suggests that people process a sentence in two waves. The first pass is a ‘quick and dirty’ approach; a fast form of processing based simply on a few key words, without the use of detailed syntactic analysis. The second pass of processing is represented by a slower and more thorough
analysis. If the listener has time they will use the detailed syntactic analysis approach. If not, they will make their comprehension decisions based on ‘quick and dirty’ processing. The risk here is that if the first pass of processing is incorrect, and there is no time for the second, more detailed syntactic analysis, then the sentence will be misinterpreted. This represents an everyday example of a speed versus accuracy trade-off that will be effective when faced with single syntax and/or a plausible content that will fail only in the less common cases of complex syntax and/or implausible content.

“Fast and Frugal” Heuristics. Such a “good-enough” approach to sentence comprehension functions similarly to the “fast and frugal” heuristic that has been described for decision-making (Ferreira & Patson, 2007). The “fast and frugal” heuristic for decision-making suggests that individuals maintain a stopping rule, in which a decision-maker will discontinue processing as soon as they feel they can make a decision in order to sift through information efficiently (Gigerenzer, 2000). If a listener is constrained by limited resources (Kahnemann, 1973) one might expect the individual to be especially likely to make rapid, and usually “good enough” determinations, thus avoiding a more time-consuming detailed syntactic analysis (Gigerenzer, Todd, & Group, 1999). These heuristic shortcuts would reflect a trade-off with rapid processing with occasional errors.

The theoretical question is whether hearing speech input results in a “good-enough” shallow processing of a sentence that relies heavily on the use of plausibility either before, or instead of, a more detailed syntactic analysis to fully understand sentence meaning. This would result in rapid responses in which plausibility would dominate in comprehension.

The present study employed four conditions: sentences that have a canonical noun-verb-noun word order (active declarative sentences: “The dog bit the man”) versus sentences that are
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equally meaningful but that have the meaning expressed with a non-canonical word order (passive-form sentences: “The man was bitten by the dog”), with each of these syntactic forms representing a meaning that is either likely (plausible) as in the above examples, or possible but unlikely (implausible: “The man bit the dog”; “The dog was bitten by the man”). Following Ferriera’s procedure, comprehension was tested by asking participants to listen to sentences and to name the agent who was performing action or the recipient of the action. Based on the above argument, we would expect that more weight will be given to plausibility than syntax-derived meaning, especially when the meaning is expressed with a more complex passive form. Specifically, one would expect the greatest number of comprehension errors to occur for syntactically complex sentences with implausible content.

Method

Participants. The participants of this study were 24 young adults (2 males, 22 females). All participants had age-normal hearing acuity, with a pure tone average (PTA) <10 dB HL across 5, 1, 2, kHz. All participants received a small honorarium. Participants signed an informed consent document approved by the Brandeis Institutional Review Board. (An additional two individuals were interviewed but not tested because they seemed not to understand the instructions in the pre-experiment practice session. Two subjects were lost due to computer malfunctions. This left us with 24 participants available for analysis).

Stimuli

Test Stimuli. In this study we examined four types of sentences, each varying on the basis of syntactic clause and plausibility. The sentences consisted of (1) simple active sentences that were plausible (the black dog bit the man), (2) active sentences that were implausible (the man bit the black dog), (3) more difficult passive sentences that were plausible (the man was
bitten by the black dog), and (4) passive sentences that were implausible (the black dog was bitten by the man). The plausible and implausible forms of sentences all included one animate stimulus acting on another, albeit with one scenario much more plausible than its implausible counterpart.

The stimuli were created from 16 core sentences based on Ferreira (2003). The core sentences were comprised of simple active-declarative sentences with a plausible situation. These sentences contained an animate stimulus acting on another animate stimulus in a predictable manner. We then took these 16 core sentences and transformed them into their passive syntactic forms. Then, for each active and passive plausible form we interchanged the animate stimulus to create an its implausible (unlikely) form. After the transformations, there were 16 sentences for each of the 4 test stimuli types resulting in a corpus of 64 test sentences available for the experiment. Sentences were recorded onto computer sound files by a female speaker of American English with natural intonation at a normal speech rate.

**Filler Sentences.** To discourage listeners from developing task-specific strategies, an additional 94 “filler” sentences of two types were added. Twenty-three consisted of active and passive sentences in which one animate stimulus acts on another, but any agent or receiver combination within the sentence was equally plausible. That is, these reversible sentences that had no impact on plausibility, but simply reversed two interchangeable words. For example, one sentence might be “the boy thanked the girl” and the reversed sentence would “the girl thanked the boy”. Both of these sentences are likely scenarios.

The second type of filler consisted of 71 active and passive sentences. We refer to these as nonspecific fillers. These sentences had a mix of two animate stimuli or an animate stimulus acting on an animate stimulus. Rather than asking for the agent or the recipient, which requires
comprehension, participants were simply asked, “What was the color?” or “What was the action?”.

<table>
<thead>
<tr>
<th>Table 1. Examples of Test and Filler Stimuli</th>
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<tbody>
<tr>
<td><strong>Examples Sentences of Test Stimuli</strong></td>
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<tr>
<td>Active Plausible</td>
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<tr>
<td>The blue bird ate the worm.</td>
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<tr>
<td>The worm ate the blue bird.</td>
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<tr>
<td>The worm was eaten by the blue bird.</td>
</tr>
<tr>
<td>The blue bird was eaten by the worm.</td>
</tr>
<tr>
<td>The brother hugged the sister.</td>
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**Procedure**

Each participant heard a total of 158 sentences. These included 64 test stimuli, of which 16 were active plausible, 16 were active implausible, 16 were passive plausible, 16 were passive implausible. The particular test stimuli were counterbalanced so that no one participant heard the same sentence twice, but among four different running orders assigned to different participants, all sentence forms were heard. In addition, each participant heard all 94 filler stimuli, 23 were reversible fillers and 71 were nonspecific fillers.

Each participant heard an equal number of test and filler stimuli. The sentences were organized as a mixed list design. For the test stimuli, there were four running orders created to ensure no participant heard the same core sentence more than once, but by the end, each core sentence was heard an equal number of times in its active and passive forms and plausible and implausible forms, with a “doer” or “receiver” question.

The sentences were initiated by the participant who, when ready, pressed the space key on a keyboard to begin a sentence. They then heard the recorded sentence, 250 milliseconds of silence, and then the corresponding question. Each sentence was presented followed by a spoken question. The two possible questions for the experimental set of sentences were “Who was the
doer?” and “Who was the receiver?”. We systematically assigned equal parts “doer” and “receiver” questions to each of the four conditions.

Participant responses were audio recorded and scored for correct agent or receiver of the action responses and reaction times. Reaction times were measured from the end of the question to the beginning of the participant’s answer. We anticipated that participants would give longer reaction time to passive sentences and implausible sentences than active sentences and plausible sentences. Our question is whether this will be differentially so for passive versus active sentences, and implausible versus plausible responses.

**Instructions.** Participants were told that they would be listening to sentences with corresponding questions that they would have to respond to into a microphone. They were told that there would be an array of sentence types with varying levels of complexity. They were told that the sentence would be paired with one of four questions: (1) “who was the doer?”, (2) “who was the receiver?”, (3) “what was the action?”, or (4) “what was the color?”. They were asked to listen to the sentence carefully as to ensure the correct answer. The experimenter instructed the participant to be both as fast, but as accurate as possible. In light of that, they were told there were no time constraints. They were then told to respond into the microphone, and when they were ready to initiate the task with the space bar of a near by keyboard.

**Presentation level.** To ensure participant could easily hear the sentences presented and respond accordingly, all stimuli were presented at an absolute level of 60 dB.

Eight practice sentences and questions were given to participants before undergoing the main experiment. This was to ensure that they understood the instructions.
All sentences were presented to the participant in a sound attenuated testing room, stimuli given binaurally using calibrated Eartone 3A insert earphones via a GS-audiometer. The study lasted approximately 30-45 minutes in length.

**Results**

**Accuracy of responses.** Figure 1 shows the percentage of correct agent or recipient of the action responses against the syntactic form (active or passive) and plausibility (plausible or implausible). As can be seen in Figure 1, participants were generally very accurate across all conditions, with a narrow range of correct responses from 91.7% to 96.6%. As can also be seen in Figure 1, responses to active sentences appeared to be more accurate than passive sentences. This was confirmed by a 2 (Syntax: Active, passive) x 2 (Plausibility: plausible, implausible) repeated measures ANOVA. With this, we found a significant main effect for syntax, $F(1, 23) = 8.06, p = .01$. Although Figure 1 would suggest a greater difference between implausible sentences than plausible sentences, there was no main effect found for plausibility, $F(1, 23) = 1.03, p = .32$. Additionally, although Figure 1 appeared to suggest that implausible sentences have an effect on syntax, the interaction was not significant, $F(2,23) = 2.46, p = .13$. Although the interaction was not significant, we conducted a series of
planned comparisons that were consistent with our predictions. That is, the difference between comprehension accuracy for active plausible and active implausible was not significant, \( t(23) = 1.64, p = .12 \), but there was a significant difference between comprehension accuracy for the passive implausible and passive plausible sentences, \( t(23) = 3.4, p < .01 \). This is consistent with the appearance of Figure 1, as the actual percentage point differences among the data were very small, especially for the active sentences.

**Latencies of responses.** Figure 2 shows the mean latencies to correct responses for each condition. As Figure 2 shows, passive sentences were overall slower than the active conditions and the implausible conditions were slower than the plausible conditions. Figure 2 appears to show longer reaction times for passive sentences than active sentences, which was confirmed by 2 (Syntax: Active, passive) x 2 (Plausibility: plausible, implausible) repeated measures ANOVA, with a significant main effect of syntax, \( F(1, 23) = 6.791, p = .016 \). Figure 2 shows longer latencies for implausible than plausible sentences, which was also confirmed with a main effect of plausibility, \( F(1, 23) = 26.31, p < .001 \). We found no significant interaction between syntax and plausibility, \( F(2, 23) = 1.82, p = .19 \). Although there was no significant interaction, we conducted 2 planned comparisons which confirmed our predictions.
that plausibility effects did not significantly differ in active sentences, $t(23) = 1.74, p = .095$, but for the harder passive sentences, there was a significant differences between latencies to implausible and plausible sentences, $t(23) = 2.38, p < .05$.

**Discussion**

Overall, although participants were generally very accurate, some differences did emerge among the conditions. Even so, differences in plausibility seemed to be more important depending on the different syntactic form. It appears that for both accuracy and the more sensitive latency data, when syntax is difficult, plausibility overrides syntax.

Our findings were consistent with Ferreira’s (2003) suggestion, that plausibility takes precedent over a detailed syntactic analysis especially in more complex passive sentences. People use both word order and plausibility. This study would suggest word order over plausibility, but you are still not completing a detailed syntactic analysis. A contributing factor to errors in the passive form could be explained by previous research suggesting that English speakers tend to choose the first noun phrase presented in a sentence as the agent of the sentence, even if it is nonsensical (MacWhinney, Bates, & Kliegl, 1984). For example, English speakers tend to choose the first agent of the first noun phrase in sentences such as “The dogs are kicking the horse.” From this, it seems that a combination of simple heuristic shortcuts and syntactic detailed syntactic analysis are used to comprehend complex syntax. In this case, simple heuristic shortcuts produce shallow processing in language comprehension. When a sentence has both simple syntax and is plausible, as most sentences are (Goldman-Eisler, 1968), listeners’ comprehension will be both fast and accurate. However, when a sentence has complex syntax and/or is implausible (a man biting a dog), errors will occur. A complete syntactic analysis is the
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only method to consistently arrive at a correct conclusion, although it requires both time and resources to complete.

In the present experiment and in Ferriera’s (2003), stimuli were presented to young adults with good hearing suggesting a heuristic shortcut takes priority over a detailed syntactic analysis. One way of making the stimuli more difficult to process was to include a passive sentence structure; another would be listening to degraded stimuli. One would expect that if the listener were instructed to perform the task with difficult to hear degraded stimuli, one would see this trend amplified.

This prediction is particularly interesting in light of a current alternative model to the “good enough” approach: an “Ease of Language Understanding” (ELU) Model (Ronnberg, 2003). Unlike the previously described models, the ELU model is focused specifically on the way in which people process information in difficult-to-hear situations. The model proposes that when the speech-understanding conditions are difficult, processing will change from fast and automatic (“implicit”) processing to a slow controlled (“explicit”) processing. This shift to “explicit” processing reflects a detailed syntactic analysis, additionally supported by real-world knowledge in long-term memory.

If modeled after the study presented above except, among older adults with hearing challenges, we expect a future study would reflect many of the findings found in the present study. We anticipate this because of the weight given to plausibility over a detailed syntactic analysis, consistent with the “good enough” approach and fail to support the ELU model. Alternatively, longer reaction times, against a baseline of plausible, syntactically simpler sentences, could reflect a conflict between syntactic analysis and plausibility heuristic shortcuts.
whereas faster reaction times would reflect a smooth analysis where syntactic analysis and plausibility heuristic shortcuts both lead to the same semantic conclusions.

The ELU model would imply that perceptual difficulty would engage a more complete syntactic and semantic analysis to include bringing to bear the context of real-world knowledge. That is, if speech is degraded – either artificially or due to a hearing loss, the “good enough” approach would result in rapid responses in which plausibility would dominate comprehension, while the latter would result in slower responses, in which a full syntactic analysis of the sentence would dominate plausibility. The second scenario would reflect the predictions of the “good enough” model. If the first scenario were true, this would fail to support the ELU model.

This is an empirically testable hypothesis by replicating the current experimental process with individuals with perceptual difficulties. This would either support the “good enough” model, or fail to support the ELU model.

**Future Directions.** This research lends promise to future research investigating language comprehension and effects of hearing loss on processing syntactic structure and plausibility of spoken sentences in adults age 65 or older, the most rapidly expanding population in the U.S. today (Kempler, 2005). Within this population, hearing loss is a prevalent health issue, affecting 83% of the population over the age of 70 (Cruickshanks et al., 1998). This health issue can affect perception outside simply missing or mishearing words. Even when successful, a perceptual effort due to reduced hearing acuity can draw resources ordinarily available for language comprehension and memory for what has been heard (Wingfield, McCoy, Peelle, Tun, & Clarke Cox, 2006; Wingfield, Tun, & McCoy, 2005).

In addition to declines in hearing acuity, cognitive declines in factors such as processing speed (Pichora-Fuller, 2003; Salthouse, 1996), working memory (Lockhart & Craik, 1990), and
executive function (Fisk & Sharp, 2004), can further challenge language comprehension in the older adult population (Wingfield et al., 2006). Given this challenge, research surrounding the intersection of declines in age-related cognitive and auditory functioning and spoken language comprehension is critical. This includes the critical area of language comprehension that we are currently examining: the way in which individuals process syntactic structure.

**Conclusion.** The data reported suggest that when using a more complex passive form, word order and plausibility take priority over a detailed syntactic analysis. Consistent with the “good enough” approach, by presenting young adults with sentences with active (easier) or passive (more difficult) syntactic structure that were either plausible or implausible, we are able to suggest that individuals use a plausibility heuristic shortcut to make language processing more efficient. Despite audible stimuli and the absence of experimental time constraints, participants made errors in identifying the doer of the action in sentences such as *the dog was bitten by the man*. Additionally, sentences that were presented in an implausible form took the participant more time to answer. This suggests that plausibility overrides a word-by-word syntactic analysis after looking at derivative effects among conditions. Overall, when syntax is difficult, plausibility overrides syntax. Thus, in a real world scenario people tend not to do a full syntactic analysis, but instead opt for a more efficient heuristic shortcut.
References


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