Syntactic Cues Alone in Adjective Learning
Michael Clauss and Jeremy Hartman

1. The Tough problem
1.1. Types of adjectives

English has a large and diverse class of adjectives which allow for an infinitival clause as a complement. These have been the subject of a great deal of experimental and theoretical research in linguistics, and have a number of different syntactic and semantic properties (Bresnan 1971, Lasnik and Fiengo 1974, Hartman 2012, among others). All of these adjectives can appear in the frame 'Subject is Adjective to VP'

(1) Infinitival complement adjectives
   a. John is tough to see
   b. Flowers are pretty to look at
   c. I am devastated to hear that
   d. John is eager to see

   One pre-theoretic division among these sentences is whether the main clause Subject is interpreted as Subject or Object in the embedded clause.

(2) a. John is eager to see
   A sentence about John seeing
   b. John is tough to see
   A sentence about seeing John

We can broadly refer to these as Subject vs. Object oriented adjectives; these two in particular are generally called Tough (or Tough Movement) or Control type (referring to particular syntactic analyses illustrated in (3)), though this simplifies the variety available considerably (see Hartman 2012).

(3) a. John₁ is tough [PROarb to see (e)₁]
   b. John₁ is eager [PRO₁ to see]
An open, and difficult, question is: given novel adjective that has appeared in this surface ambiguous frame (4a), how does a learner decide whether to assign this adjective to the Subject oriented class (like *eager*) or the Object oriented class (like *easy*)?

(4) a. John is **daxy** to see
    = ?John₁ is daxy [PROₐrb to see (e)₁]
    = ?John₁ is daxy [PRO₁ to see]

    An important fact about these examples is that while the particular frame in (4a) is ambiguous between Subject and Object types, certain changes to the frame remove this ambiguity. For instance, adding an expletive *it* to the main clause, adding an overt second argument to the embedded clause, or making the embedded verb obligatorily transitive, all allow only a single reading for the adjective, and thus only some adjectives would be allowed.

(5) a. John is tough/eager to see
    b. It's tough/*eager* to see John
    c. John is *tough/eager* to see Tom → Only Subject
    d. John is tough/*eager* to look at → Only Object

As such, hearing a novel adjective in a frame like (5b-d) would in principle reveal its type, and thus sentences of the form in (5a) would be disambiguated.

(6) a. John is daxy to see → Ambiguous
    b. It's daxy to see John → Object reading only
    c. John is daxy to see Tom → Subject reading only
    d. John is daxy to look at → Object reading only

The question we will explore in the rest of this paper is: is hearing a novel adjective in a disambiguating frame sufficient information for learners to determine the syntactic type of that adjective? We will address this question for both child and adult learners. Below we will review some previous acquisition literature on these adjective types, and how these inform the methods we used to address this question.

1.2. The acquisition of Tough adjectives

There is a sizable body of previous literature illustrating that, in various sorts of comprehension tasks, children often do not correctly parse familiar Tough-type adjectives with Object readings. That is, for a sentence like 'The doll is tough to see', adults will give it a parse like (7a), and children up to around the age of 8 will give it a parse something like (7b). This is the result found by C. Chomsky (1969), Solan (1978), and Anderson (2005), among others.
(7) a. The doll\textsubscript{1} is tough [PRO\textsubscript{arb} to see (e)\textsubscript{1}]
   = It is not easy to see the doll
b. The doll\textsubscript{1} is tough [PRO\textsubscript{1} to see]
   = It is not easy for the doll to see

However, recent work by Becker et al (2012) and Becker (2015) has shown that certain semantic cues during the learning of a new adjective – namely the animacy of the subject with which it occurs – can inform children of its type. Specifically, the claim is that if children hear a novel adjective with an animate subject in the ambiguous frame, they will assume that the adjective is Subject oriented, and if they hear it with an inanimate subject, it is Object oriented.

(8) a. Apples are daxy to draw
   = Apples\textsubscript{1} are daxy [PRO\textsubscript{arb} to draw (e)\textsubscript{1}]
b. The policeman is daxy to draw
   = The policeman\textsubscript{1} is daxy [PRO\textsubscript{1} to draw]

These studies made use of the sorts of syntactic differences between Subject and Object oriented adjectives, but notably did not control for them during training. The metric Becker used was Reaction Time after sentences which, based on their surface syntax, would or wouldn't be predicted based on the orientation of the adjective. That is, if the adjective was analyzed as Subject oriented, it was predicted that there would be longer reaction times after expletive subject sentences (like 6b above); similarly, if an adjective was analyzed as Subject oriented, longer reaction times were predicted if the adjective was heard in a sentence which did not support Tough-type adjectives. Becker (2015) did not report accuracy as a measure of performance.

The central finding of Becker et al (2012) and Becker's (2015) experiments was that for 3 year old children, even with no information in the training besides the animacy of the NPs which occurred with the adjective, there was a greater RT where an adjective was learned with inanimate Subjects and a test sentence was heard which did not support Tough-type adjectives. The sentence type used had null infinitival complements, as in (9). Four year olds were found to be sensitive to this training manipulation, but only when the adjective was heard in a more enriched discourse.

(9) a. *John is easy
b. John is daxy $\rightarrow$ John\textsubscript{1} is daxy [PRO\textsubscript{1} to see]

Based on this, we can see that children appear to show some sensitivity to the syntactic frames allowed by different adjectival types, judging by increased reaction times when one analysis of the novel adjective did not support the frame which was heard. Further, we can see that, for training purposes, semantic cues are available to children as a way to categorize adjectives as either Subject or Object oriented.
However, these results do not show whether these sorts of manipulations of training, either semantic or syntactic, show an effect on children's accuracy in interpreting the adjectives – that is, whether or not training of this sort would predict correct adultlike responses to the sentences, rather than just differences in response times. The experiment described below aims to address this, in particularly for syntactic cues during training in the absence of semantic cues like animacy.

2. The present study: methodology

To answer the question of interest, we designed a nonce-adjective learning experiment manipulating syntactic frames during training. The experiment consisted of a training period and a test period. Prior to training, participants were told that they would be learning a new word, \textit{daxy} [dæksi], which they would hear several times in a short video, and then be asked questions about the word. They were not told any meaning for the word.

2.1. Training conditions

During training the participant saw a video consisting of a series of pictures, each of which was accompanied by a voice reading two sentences describing the picture using the word \textit{daxy}. The pictures each showed two characters interacting in some way, and nothing else.

For each training item, the first sentence would either be in (a) the ambiguous frame, (b) the expletive subject frame, (c) the overt object frame, or (d) the obligatorily-transitive frame. The second sentence in all four training conditions was in the ambiguous frame. The predicates used were \textit{see} (\textit{push over} in the obligatorily transitive condition), \textit{hear} (\textit{listen to}), and \textit{push} (\textit{push over}). (10) shows all of the possible training conditions for a particular picture.

\begin{enumerate}
\item A training condition
\begin{enumerate}
\item John is daxy to see. John is daxy to see.
\item It's daxy to see John. John is daxy to see.
\item John is daxy to see Tom. John is daxy to see.
\item John is daxy to look at. John is daxy to see.
\end{enumerate}
\end{enumerate}

The images used for the training items were intentionally uninformative about the intended meaning of \textit{daxy}; each picture could be described equally well as being about the person seeing or the person being seen. This was done to minimize any plausibility confound biasing the participant toward the subject vs. object readings of a sentence like 'John is daxy to see'. Thus, the only potential cues to meaning would be from the syntax of the frame.
2.2. Test conditions

Following the training period, the participants were shown a series of four pictures, and given a forced choice question about each, again involving the word 'daxy'. The same test items, consisting of one picture and one sentence, were used for all participants regardless of training condition, and items were presented in a random order.

Since the object of study here is the interpretation of frames which allow for both Subject and Object readings (and thus the analysis of the adjective involved), the test questions were all in the ambiguous frame.

The form of each test item was a presentation of a picture and a description of the two characters in it (“Here is a picture of an X and a Y”) followed by a question about which of the characters is daxy (“Can you tell me which one is daxy to Verb?”). Crucially, all verbs used allow both transitive and intransitive readings, in order to ensure the frame was indeed ambiguous. The verbs used were clean, teach, kick, and ride. With the children, but not with the adults, we asked participants at the end of the experiment what they thought daxy meant.

The goals of this design were (i) to understand the effect of hearing various syntactic frames during the learning of a novel adjective on performance in interpreting the ambiguous frame, and (ii) to observe novel adjective learning in conditions with as little semantic information as possible. Varying the training frames across participants and holding test items constant was intended to achieve (i); the use of ambiguous predicates and images with extremely simple presentations was intended to achieve (ii).

3. Adult study

To get a baseline understanding of how useful syntactic cues are in this sort of brief learning task, we conducted this experiment first with native English-speaking adults. If adults had proved unable to use syntactic cues to choose between Subject and Object readings for novel adjectives, there would be little reason to expect children to be able to.

3.1. Predictions

If adults in general make use of syntactic cues in word learning to analyze finer points of lexical categorization, we would expect that after training conditions which disambiguate between Subject and Object readings, adults would be prompted to give Subject or Object readings, respectively, on the test items.

It was less clear what should be predicted a priori for the ambiguous training condition. It plausibly could have turned out that adults would be in the aggregate indecisive about the result (either within or across participants responses might be roughly evenly split between Subject and Object responses), or that in adults general would be biased towards either Subject or Object
responses generally. Adults being biased towards Object responses would be surprising given children's bias towards Subject responses, but nothing in principle would rule it out.

For the sake of concreteness, Table 1 shows an idealized result assuming that adults are split evenly between Subject and Object responses (though nothing relies crucially on this assumption). Values are given as proportions of Subject responses (100% = only giving Subject responses); we will continue this throughout.

Table 1. Idealized adult results

<table>
<thead>
<tr>
<th>Ambiguous</th>
<th>Expletive</th>
<th>Filled-Gap</th>
<th>Transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
</tr>
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</table>

3.2. Adult results

The adult study was conducted online, with participants being 77 native English speaking University of Massachusetts undergraduate students. The results are summarized in Table 2, which shows the grand mean of individual performances (in terms of rate of Subject responses) by training condition. A one-way ANOVA showed a main effect of training on response ($F = 19.25, p < .001$). The results align quite closely with the idealized results. Figure 1 compares the predicted and real results.

Table 2. Adult performance, Rate of Subject responses (standard error)

<table>
<thead>
<tr>
<th>Ambiguous</th>
<th>Expletive</th>
<th>Filled-Gap</th>
<th>Transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.75% (4.9)</td>
<td>25% (4.9)</td>
<td>96.6% (.9)</td>
<td>25% (4.4)</td>
</tr>
</tbody>
</table>

In general these results show quite strong evidence that adults are sensitive to syntactic cues and make use of them, even after very short training periods, in choosing between adjective types. They do not show any evidence for differences in how well the two Object-biased training conditions (B and D) do in prompting Object responses, but they do seem to show some difference between these two and C, with C prompting Subject responses slightly more reliably than B and D prompt Object responses. Below we will discuss briefly why this might be.

4. Child study

The methods for the child version of the study were essentially the same as in the adult version, the only difference being that children were tested in person rather than online.
Given that the adult experiment showed that the syntactic cues under investigation are generally useful in choosing between Subject and Object readings in surface ambiguous conditions, we might have taken the null hypothesis for children to be that children would have an adultlike performance in this task. However, given the Subject bias observed for the ambiguous frame in previous child studies, it is possible that children will show non-adultlike performance in other conditions as well.

A more likely result would be that children show adultlike performance in every condition except where there is no syntactic disambiguation (condition A). We will call this potential result Weak Subject Bias; children are biased toward Subject responses except in the case of specific evidence against them. This is the most similar to the result based on semantic disambiguation observed by Becker (2015).

A third possibility is that children in general do not show adultlike performance, and skew towards Subject responses regardless of training. We will call this a Strong Subject Bias result.

Table 3 shows possible results. Note that in the adultlike result, we do not predict 0% Subject responses for conditions B and D as adults did not give this sort of result, but rather only skewed toward Object responses. We thus predict
that children would perform similarly at best and still give about 25% Subject responses in these conditions.

Table 3. Possible outcomes for children by approximate rate of Subject response

<table>
<thead>
<tr>
<th></th>
<th>Ambiguous</th>
<th>Expletive</th>
<th>Filled-Gap</th>
<th>Transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adultlike</td>
<td>50%</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
</tr>
<tr>
<td>Strong Subject bias</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Weak Subject bias</td>
<td>100%</td>
<td>25%</td>
<td>100%</td>
<td>25%</td>
</tr>
</tbody>
</table>

4.2. Results

The child experiment was run with 58 children ages 4, 5, and 6 at schools in Western Massachusetts. All were typically developing and monolingual English-speaking.

Results for children as a whole showed what appeared to be a strong subject bias; for all training conditions, children showed greater-than-chance preference of Subject responses. Breaking down the results by age group, it appears that there is no large difference between the age groups; the 4 year olds show slightly divergent behavior in condition C, performing close to chance (which is, in fact, specifically neither adultlike nor Subject-biased). A two-way ANOVA shows no effect of condition ($F = 1.11$, $p = .35$), a marginal effect of age ($F = 2.84$, $p < .1$), and no interaction ($F = 1.88$, $p = .14$).

Table 4 shows child results by age group. Figure 2 compares child results (collapsed across age groups) with observed adult results.

Table 4. Observed child results by age group and condition (standard error)

<table>
<thead>
<tr>
<th></th>
<th>Ambiguous</th>
<th>Expletive</th>
<th>Filled-Gap</th>
<th>Transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fours</td>
<td>91.67% (5.3)</td>
<td>75% (11.2)</td>
<td>55% (16.6)</td>
<td>83% (8.2)</td>
</tr>
<tr>
<td>Fives</td>
<td>85% (10.0)</td>
<td>85% (10.0)</td>
<td>90% (6.1)</td>
<td>70% (18.4)</td>
</tr>
<tr>
<td>Sixes</td>
<td>100% (7.2)</td>
<td>80% (12.2)</td>
<td>100% (16.9)</td>
<td>80% (9.3)</td>
</tr>
</tbody>
</table>

While the performance of six year olds starts to trend to what is described above as a Weak Subject Bias (only conditions B and D trend away from Subject responses), there is still a general trend in almost every age and condition for Subject responses. So, under these training conditions, for children of these ages the general bias towards Subject responses seems quite real and undisturbed by the training. Children at age 6 are still not showing evidence that they use syntactic cues to disambiguate readings of novel adjectives.
While adults performed essentially at ceiling in acquiring Subject oriented adjectives based on syntactic cues, and they showed above chance but below ceiling performance learning Object orientation from either of the Object oriented training conditions (Expletive Subjects and obligatorily transitive embedded verbs). This leaves open the question of where this difference in performance across conditions from, as well as what sort of alterations to training could improve performance on the Object oriented conditions. We made one alteration to the experiment to investigate this.

Recall that in the original experimental design, the participant heard the unambiguous condition once, followed by the ambiguous frame (11a). This was intended to make clear to the learner that these adjectives allowed an alternation between the two frames, as the ambiguous frame was used for the test items. For the altered version of the experiment, we replaced the alternation with a repetition of the unambiguous frame, hoping to reinforce the cue that the adjective was Object oriented (11b). We did this for both of the Object oriented conditions.

5. Further investigation of adult learning

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We ran this new version of the experiment with 35 native English speaking University of Massachusetts undergraduate students. The results show essentially no difference from the corresponding conditions in the original study, both altered conditions producing a number of Subject responses despite Object oriented training. Table 5 shows the results from the altered study, and Figure 3 compares the results from the original and altered conditions.

Table 5. Results from altered experiment with adults (standard errors)

<table>
<thead>
<tr>
<th>Expletive</th>
<th>Transitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.6% (3.5)</td>
<td>30.6% (4.2)</td>
</tr>
</tbody>
</table>

Fig. 3. Results of original and altered experiments.

The fact that adults do not perform at ceiling particularly on the Object oriented training conditions leads us to believe that whatever causes the bias toward Subject orientation for children is to some extent present for adults despite the fact that Subject oriented adjectives are generally available. Further studies are necessary to identify what types of training (if any) would allow adults to perform at ceiling learning Object oriented adjectives from syntactic cues.
6. General discussion

We have observed across these several experiments that both adults and children show some amount of resistance to learning novel Object-oriented adjectives. This is in keeping with general findings from work on the acquisition of Tough-type adjectives (C. Chomsky 1969, inter alia), that children do not give adultlike interpretations for familiar Tough adjectives.

We have shown that adults are in general sensitive to syntactic cues in disambiguating Subject and Object oriented adjectives in the absence of helpful semantic cues, since adults performed above chance at learning both of these. However, we have also shown that adults seem to show a relative preference for learning Subject orientation over Object orientation. This is predicted by some general theories of Subject vs. Object dependencies (Keenan and Comrie 1977, Rizzi 1990); whatever grammatical principle makes Subject-gap dependencies more accessible than Object-gap dependencies cross-linguistically and for children during acquisition is at work for adult English grammars.

We have not shown that children have access to syntactic cues during learning of a novel adjective in these conditions; children of all the age groups we studied showed no significant difference in performance based on the syntactic frame in which the adjective appeared during training. This is itself an interesting result in itself, given Becker's (2015) finding that children showed sensitivity to syntactic frames licensed by Object vs. Subject adjectives.

Comparing our results with Becker's suggests several paths forward for further experimentation: The previous findings that 3 year olds seem to do better acquiring Object orientation based on animacy as a learning cue without enriched learning conditions, whereas 4 year olds only show sensitivity to the distinction with animacy as a manipulation and more contentful stories during learning (Becker 2015) suggests that 3 year olds might in fact do better than 4-6 year olds on the task we used, which lacked the sort of detailed stories used by Becker. Conversely, an alteration of our study using syntax as the main learning cue during training within a slightly more enriched learning condition might produce better results for 4-6 year olds. The findings that children begin to show adultlike performance with Tough adjectives around 8 (Solan 1978) suggests that our task might be doable by children around this age.

Lastly, other correlates of subjecthood manipulated during training might improve both children's and adult's performance on this sort of task. The most obvious such option to be explored would be that of animacy; while Becker et al (2012) and Becker (2015) showed that 3 and 4 year olds are sensitive to animacy as a learning cue, they did not use accuracy in response as a metric of learning, but rather reaction time. Using our sorts of methods with animacy as the manipulated factor (12) would add more to the picture developed by Becker's methods. Another option is manipulating the thematic role of the overt argument by using different types of predicates in the embedded clause (13); while previous work on Tough adjectives has used verbs which alternate between transitive and unergative (like see) in experiments, using transitive-unaccusative
alternating verbs (like freeze) might reveal more particularly what semantic cues in learning are important to learners.

(12) a. John is daxy to see → Subject oriented
    b. The tree is daxy to see → Object oriented

(13) a. John is daxy to see → Subject oriented
    b. John is daxy to freeze → Object oriented

Comparing these adult and child learning experiments in general shows that a bias towards interpreting novel adjectives as Subject oriented is present for all English speakers, though it manifests itself in a number of ways. Continuing to build on the sort of work done here will increase our understanding of how this bias is overcome as constructions like Tough Movement are acquired.

References


Becker, Misha. 2015. Animacy and the Acquisition of Tough Adjectives. Language Acquisition 22. 68-103.


