“The Kindergarten-path Effect: Studying Sentence Processing in Young Children”

*How do children process language in real time? Do they coordinate multiple sources of information during interpretation?
  - Adults don’t take into account discourse/pragmatics principles to solve temporary syntactic ambiguities, and they show little to no ability to revise initial parsing commitment.
    - It’s rapid and context-sensitive.
    - Adults make initial mistakes that they later revise.

“Garden-path phenomenon.”- listeners can make a choice to go down a path when they encounter an ambiguity, then they can later retrace their steps and go back to the intended interpretation.

*What kinds of information take priority?*
Consider these sentences:
1. Anne hit the thief with the stick.
2. Anne hit the thief with the wart.

*How do adults arrive at these conclusions?*
- They use lexically specific syntactic information, semantic plausibility, frequency of lexical co-occurrence, and referential context.
- They use statistical regularities pertaining to the syntax of a language, not broad structural heuristics.
- They coordinate the linguistic properties of the message with information from the context to determine processing commitments.

**Constraint-based lexical theory**- assumes a constraint-satisfaction approach to ambiguity resolution. Multiple sources of information can be used to converge on one interpretation.

**Referential Principle**- relevant sources of information from the context can affect processing commitments, especially when lexical properties of the stimulus are relatively neutral.

**Children’s On-line Language Processing Abilities**
*How do children process the PP-attachment ambiguity?*
*Do they use the Referential Principle?*
- Anaphoric (ie something that refers back) mapping processes appeared to be well mastered in all age groups, but developmental differences were observed for pronouns
- 5 year olds rely more on pragmatic plausibility than lexical factors (such as gender-marking) in their assignment of pronominal co-reference.
  - Children have knowledge of contextual factors associated with the Referential Principle, and this knowledge can interfere with the understanding of restrictive relative
clauses. (Though some studies have found weaker or no effect of referential factors on relative clause comprehensions.)

**Experiment 1: The Frog(s), Horse, Napkins, and Box Experiment**

Referents: possible objects to be moved  
1-Referent: one frog, one horse  
2-Referents: two frogs, one on a napkin, one not.  
Context: either one or two referents  
Target: the frog on the napkin, the correct one to move  
Incorrect/Other: the frog on the table or the horse, the wrong animal to move  
Incorrect Destination: the empty napkin  
Ambiguous Phrase: “Put the frog on the napkin in the box.”  
Non-ambiguous Phrase: “Put the frog that is on the napkin in the box.”  
Modifier: The interpretation that “on the napkin” tells you which frog to move  
Destination: The interpretation that “on the napkin” tells you where to put a frog  
NP Attachment: Like “modifier” it refers to “on the napkin” being a sister of the noun “frog”  
VP Attachment: Like “destination,” it refers to “on the napkin” being a sister of the verb “put”  
Course Grain Data: what the subjects picked, where they put it, etc.  
Fine Grain Data: where their eyes looked, for how long, when, etc.  
Cross Checking: comparing Course Grain conclusions with Fine Grain conclusions  
Onset Phoneme: first sound of the words, especially the relevant ones, like frog vs. horse

-Adults used the Referential Preference; they considered the empty napkin only when the sentence was Ambiguous and it was a 1-Referent trial.  
-Children looked at the empty napkin for 1 or 2 referent ambiguous trials. Data showed an effect of ambiguity, and no interaction between ambiguity and context. Children didn’t use the Referential Principle, but rather had a bias for the destination interpretation. They were often unable to recover from their initial mistake

**Observations:**  
-1-Referent trial mistakes almost always had the correct animal, but incorrect destination  
-2-Referent trials had almost an equal number of correct animals moved as incorrect animals moved.  
-Children adopt a single strategy (structural or interpretive) for dealing with ambiguity.

**“Course Grain Data”**  
-Five year olds prefer the Destination interpretation.  
-Subjects usually directed gaze at incorrect destination during ambiguous trials, regardless of referential context.  
-Subjects were at chance levels when selecting Target over Other animal in two-referent trials, suggesting that “on the napkin” was not treated as a Modifier and therefore was uninformative in determining a possible referent.
“Fine Grain Data”
- Children looked more at the Incorrect Destination about 300 ms after the onset of the word “napkin,” mostly under the Ambiguous conditions.
- This occurs in both 1-Referent and 2-Referent trials, suggesting insensitivity to the Referential Principle.
- Ambiguity had an effect, context did not, and the two factors didn’t interact.

Fine Grain analyses revealed looks to the Incorrect Destination occurred more in the Ambiguous sentences, independent of Context, even at the earliest stages of processing. Reliable signs of considering the Incorrect Destination on Ambiguous trials began when subjects heard approximately 300 ms of the word “napkin. Cross checking with Course Grain analysis: 91.1% of the time, the two analyses agreed.

Recognition of Direct Object Noun “Frog” (and Referential Ambiguity)
- The 1-Referent conditions showed a divergence between fixations on the Target and Other animals, with the higher probability on the Target, telling us the correct referent was established soon after disambiguating phonemic material was perceived.
- In all 1-Referent contexts, the onset phoneme was different for the Target and Other animal (frog vs. horse.)

- In the 2-Referent Unambiguous contexts, a similar divergence between fixations on the Target and Other was delayed in the 2-Referent contexts, until the onset of the word “napkin,” when fixations on the Target would increase.

Statistics
1. Prior to any phonemic information to discriminate between the two animals, there were no significant differences in looking times to the Target and Other animals.
2. Upon hearing “frog” and before hearing “napkin” more time was spent looking at the Target animal in the 1-referent context, but not the 2-referent context.
3. After hearing “napkin” subjects fixated more on the Target in all conditions but the Two-referent ambiguous condition. Thus the phrase “on the napkin” was taken as a Modifier in the 2-Referent Unambiguous condition, helping to distinguish the Target from the Other. It was NOT taken as a Modifier in the 2-Referent context, resulting in continued competition between the two possible Referents.

Summary of the Fine Grain Analyses
- It indicated that children’s first interpretation of the ambiguous phrase “on the napkin” tends to be a Destination rather than a Modifier.
- More looks to the Incorrect Referent were found in the ambiguous trials than the unambiguous after they heard “napkin.”
- Children’s assignment of interpretation (correct or otherwise) is highly incremental.
- Referential competition between the Target and the Other animals was consistently resolved at the points in speech where phonemic information could help distinguish the two referents: at “frog” in the 1-Referent conditions, and at “napkin” in the 2-Referent Unambiguous condition.
-The 2-Referent Ambiguous condition showed no resolution, suggesting the inability to take the ambiguous phrase “on the napkin” as a Modifier.

Eye Movements for Correct and Incorrect Trials
- Early looks to the Target or Other animal would correlate with which of the two animals were moved first in a trial in Ambiguous Environments. Subjects were choosing the referent based on which animal they happened to look at first.

Experiment 2: Adults
- Adults experienced a “garden path” in for the Ambiguous 1-Referent trials.
- There were increased looks to the Incorrect Destination for those trials only.
- Interaction between context and ambiguity.

Fine Grain Analysis
- Increased looks to the Incorrect Destination occur shortly after the onset of the word “napkin,” restricted to the 1-Referent Ambiguous trials, implying an initial Destination interpretation.
- Sensitivity to the Referential Principle is essentially immediate.
- Ambiguity and Context interact.
- Disambiguation occurs just after the onset of the word “frog” in the 1-Referent Contexts.
- Looks to the Target animal are greater in the 1-Referent Unambiguous than the 1-Referent Ambiguous trials, because subjects are inspecting the Incorrect Destination in the latter but not the former.
- The 2-Referent Contexts showed more consideration of the Other.
- Divergence was early, especially in the 2-Referent conditions, showing that subjects were using the preposition “on” as a clue.

Statistics:
Before the word “frog,” there was no difference between looking at the Target or Other, in any run.
- Between “frog” and “napkin,” the subjects looked more at frogs.
- “On” helped, but not reliably.
- After “napkin,” subjects looked more at the Target in all conditions.

This tells us...
The Modifier interpretation was pursued in both Ambiguous and Non-Ambiguous conditions, distinguishing the Target from the Other.

Comparison with 5 Year Olds
- There was a reliable triple interaction between Context, Ambiguity and Age.
- Adults were affected by Context and Ambiguity, Children only by Ambiguity.
- Both groups showed rapid incremental interpretation.
- They differed in how they handled temporary syntactic ambiguity.
- Adults resolved it with the Referential Principle, 5 year olds did not.
- Adults chose the Modifier in 2-Reference contexts, children always preferred the Destination option.
- They chose Destination when the context indicated that the Modifier was unnecessary (1-Referent context.)
- The preferences came early, just after hearing the phrase “on the napkin.”
- Adults recovered from incorrect interpretations, children did not.
- Adults had very few errors.
- Children’s choice of referent in 2-Referent Ambiguous trials was random.

Explanations for VP Attachment Preference for the Younger Group

Explanation 1: Children parse according to some principle, such as “choose the least complicated structure.” Maybe as people age, their Minimal Attachment parsing commitment (based on lexical and context factors) becomes faster.

Explanation 2: Lexical properties of a child’s input matters. They might be using syntactic or semantic knowledge of verbs and possible arguments. This makes the Destination option more likely because “put the frog on the napkin” is the most likely syntactic alternative given the lexical input. Young children exhibit strong sensitivity to lexically specific syntactic preferences. Also, patterns of incorrect interpretations are best accounted for by assuming emerging sensitivity to lexically specific properties, such as animacy, subcategory, and control information.

Wiggle Frog Experiment
Lexically specific syntactic biases play a role in children’s processing commitments, but there must be other constraints leading to a preference for the Destination interpretation.

Insensitivity to the Referential Principle in the Youngest Parsers
- Verb specific syntactic and semantic properties present in the stimuli so strongly supported the Destination interpretation that referential factors were unable to impact processing preferences.
- It’s possible that children have the Referential Principle, but can’t use it in certain circumstances.

Summary and Closing Marks

- Five year olds have a language processing system that relies more heavily on local linguistic factors to inform parsing preferences, along with a general inability to reverse commitments to initial interpretations. They have a highly incremental processing system. Word recognition and referential resolution in syntactically unambiguous environments appears to proceed smoothly, showing patterns similar to adults.
- Adults can use relevant contextual factors to inform parsing commitments, and they can revise.