1 Background: evidence and learning

- Basic assumptions about learning:
  - The learner brings to the task a hypothesis space (each point in which represents a grammar)
  - She chooses a point in that space that can generate the data

- If two grammars $G, G'$ are compatible with the data and the child ends up converging on $G$, we can draw interesting conclusions regarding learning, such that $G'$ is outside of the child’s hypothesis space or that the child is biased towards choosing $G$ over $G'$

- Example from the syntactic literature: *that-trace effects* in English (Perlmutter, 1971; discussed in the context of acquisition by Chomsky and Lasnik, 1977)

(1) Object extraction is possible with or without an overt complementizer
   a. Who do you think Mary met _?
   b. Who do you think that Mary met _?

(2) Subject extraction is only possible without an overt complementizer
   a. Who do you think _ met Mary?
   b. *Who do you think that _ met Mary?

- Negative evidence directly informing the child that (2b) is not part of the language is unavailable.

(3) a. $G = \text{The grammar of English}$
    b. $G' = \text{Can generate (2b) in addition to whatever } G \text{ generates}$
• Learners of English converge on the more restrictive grammar $G$ – an instance of the so-called *subset problem* of language acquisition – which could mean that $G'$ is not part of the hypothesis space or that the learner is biased in favor of $G$ over the more inclusive $G'$

• A candidate for a similar learning problem in semantics: the meaning of quantificational determiners like *every* and *some*

(4) $[[\text{every}]] = \lambda A : A \neq \emptyset . \lambda B . A \subseteq B$

(5) $[[\text{some}]] = \lambda A . \lambda B . A \cap B \neq \emptyset$

• $[[\text{every}]]$ asymmetrically entails $[[\text{some}]]$: in many contexts, the usage of *every* is consistent with the existential meaning, but not the other way around

(6) Five out of five girls ran
   a. some girl ran (true)
   b. every girl ran (true)

(7) Three out of five girls ran
   a. some girl ran (true)
   b. every girl ran (false)

• The challenge: the child needs to converge on a subset meaning for *every*

(8) $[[\text{every}]] \subseteq [[\text{some}]]$

• A semantic analog to the challenge raised by *that-trace effects* in syntax:

(9) $[[\text{every}]]' = \lambda A . \lambda B . A \cap B \neq \emptyset$ (= SOME)

(10) Lexicon of $G'$:
   - $[[\text{every}]]' = \lambda A . \lambda B . A \cap B \neq \emptyset$
   - $[[\text{some}]] = \lambda A . \lambda B . A \cap B \neq \emptyset$
   - ….

• If $G'$ is consistent with the input available to the child, the fact that the child converges on the grammar of English (with the stronger meaning for *every*) over $G'$ would mean that the child is biased against $G'$

• The same point could be made for any pair of quantifiers with an entailment relation

• Learning biases that would push the child away from $G'$ and towards $G$ have been proposed in the literature. Examples include the principle of contrast (Clark 1980), the Semantic Subset Principle (Crain et al. 1994), and Bayesian inference (Piantadosi et al. 2014)
• The assumption that $G'$ is consistent with the input relies on there not being evidence against the weaker meaning, but it has already been pointed out that the nature of the stimulus in semantics is different than in syntax. For example, while parents do not correct their children for grammaticality, they do object to false statements made by the child (Brown and Hanlon, 1970).

• Our goal is to understand the relationship between the stimulus in semantics and the hypothesis space. We will not try to characterize the child’s learning strategies and we will not discuss whether the child can use the evidence available in the input (but we will make the connection to the acquisition literature whenever relevant).

• **Question:** are there logically weaker or logically stronger alternatives to quantifier meanings that are consistent with the child’s input, or is the input rich enough to eliminate competing hypotheses?

• Previous literature on the nature of the semantic stimulus has focused on non-lexical learning problems (Crain et al. 1994 et seq.; Musolino, 2006; Gualmini and Schwarz, 2009; among others).

• Goals:
  – Discuss alternative conceivable meanings for *every* (both logically weaker and logically stronger alternatives)
  – Discuss whether the semantic stimulus is rich enough to rule out the alternatives

• Method: qualitative examination of the input available to English-learning children

• Brown and Cornell (pilot)
  – A total of 310 caregiver utterances involving *every*
  – Children aged 1;6 - 5;1

• Manchester Corpus (more systematic)
  – Longitudinal corpus of 12 British English speaking children ages 1;8 - 3;0, recorded weekly for ~1 year.
  – 793 caregiver utterances involving *every*
  – Examined in context (± 12 utterances) and coded for logical and pragmatic properties

• Preview of the conclusions:
  – Logically weaker alternatives:
    * Systematic truth-conditional evidence for ruling out logically weaker meanings does not seem to be available
    * Pragmatic evidence for ruling out logically weaker meanings is available
  – Logically stronger alternatives:
* We construct classes of quantifiers with complex, logically stronger meanings designed to be consistent with any finite number of utterances. If such quantifiers are in the child’s hypothesis space and are consistent with the input then converging on adult meanings would require non-trivial induction

2 Logically weaker alternatives

2.1 Informative truth-conditional input

2.1.1 Direct objection

- Brown and Hanlon (1970): Parents object to \(\sim 25\%\) of false statements made by children
- Objection could provide evidence against the hypothesis that every means SOME
- The hypothetical exchange in (11) would constitute informative input for the child

  (11) Scenario: a family expects three guests for dinner: Mary, John, and Sue. Mary has arrived in time, but John and Sue are late
  a. Child: every guest is here.
  b. Parent: no. Only Mary is here. John and Sue are not here.

- The exchange is inconsistent with the hypothesis that every means SOME
- Two examples of this sort found in the corpora (2/1103):

  (12) Context: Pretend play with train. Child pretends to get on the train with sister and dad, but states that “Mommy left behind”
  a. Child: that one Nina [sister]
     Child: and that one Daddy
     Child: and Mummy left behind
     Mother: oh
     ...
     Child: Look
     Child: Everybody’s on the train
  b. Mother: Not everybody

Manchester Corpus, Dominic, Age 2;7

2.1.2 Downward-entailing environments

- Gualmini and Schwarz (2009) note that evidence from downward-entailing environment may provide a general solution to the subset problem
- Downward-entailing environments reverse entailment relations. Usages of every in downward-entailing environments may be inconsistent with an existential meaning
(13)  (a) → (b)
   a. It’s not the case that any girl ran
   b. It’s not the case that every girl ran

- Replacing EVERY with SOME yields a stronger meaning
- An utterance like (13b) in a context in which (13b) is true but (13a) is false would provide evidence that every cannot mean SOME

(14) Informative evidence:
   a. Context: Three out of five girls ran
   b. Utterance: It’s not the case that every girl ran

Negation

- Propositional negation of the form it’s not the case that is typically not available in child language corpora. The more common form is not, which makes the picture more complicated
- Example: every in the scope of negation

(15) Context: the child is asking to put more Mercurochrome on her cut, even though some had been used in a previous day. The mother rejects the request because Mercurochrome should not be used on a daily basis.
   a. Child: Mercurochrome on it.
   b. Mother: you got Mercurochrome on it. You only put a little bit. You don’t put it on every day, you know. It’ll go away.

- Assuming that the quantifier takes scope under negation, its meaning cannot be SOME: given this meaning, the mother’s utterance would mean that Mercurochrome should never be used, which is too strong in this context
- But every could mean SOME if it could take scope over negation, which would yield an equivalent meaning to EVERY scoping under negation. The equivalence is exemplified below, using unambiguous paraphrases:

(16) a. It’s not the case that one puts Mercurochrome every day.
    b. Some day is such that one doesn’t put Mercurochrome then.

- Note: it has been claimed that children have a preference for surface scope readings for sentences containing a quantifier and negation (Musolino 1998, Musolino, Crain and Thornton 2000, Lidz and Musolino 2002), but also that children can access inverse scope readings at the same ages (Musolino 2006, Gualmini et al. 2008)

- Conclusion: the mother’s utterance is compatible with a grammar in which every means SOME that allows SOME to take scope over negation
• To rule out SOME, we need to consider downward-entailing environments where no scope possibility for SOME has the property that it yields an equivalent or a weaker meaning.

**Downward-entailing environments that break equivalence**

• Consider downward-entailing operators like *no*:

  (17) No girl read every book

• Surface scope with EVERY is weaker than both surface and inverse scope with SOME

  (18) No girl read any book
  (19) Some book is such that no girl read it

• Informative scenario:

  (20) No girl read every book
      a. books = \{b_1, b_2, b_3\}
      b. girls = \{g_1, g_2, g_3\}
      c. g_1 only read b_1, g_2 only read b_2, g_3 only read b_3

• There were no occurrences of *no* or *fewer than n* (which has the same behavior) in the corpora (0/1103)

• Equivalence could break down when another operator intervenes between negation and the quantifier. A modal is such an operator, and relevant examples were available in the corpora:

  (21) Context: the family is deciding on what to have for dinner.
      Aunt: We should really use up that roast beef.
      Mother: Yeah, you know, but we can’t have meat every day.

      *Cornell Corpus, Mom 0218*

• The utterance is multiply ambiguous. To see why, let us represent the three operators as follows: *not* = \(\neg\), *can* = \(\Diamond\), *every* = \(\forall\). Let us also assume that the relative scope between negation and *can* is fixed such that \(\neg\) out-scopes \(\Diamond\) (\(\neg > \Diamond\)), as is the case in English. This leaves three potential meanings, where (a) is the intended meaning:

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1Example from child-directed speech:

(1) Context: Playtime; the child is refusing to share his toys with his mother. Whenever she asks if she can play with a certain toy, the child says that he will play with that toy.
   a. Mother: So if I play with this yellow car that’s alright then?
   b. Child: I play yellow car
   c. Mother: You can’t play with everything.

   *Manchester Corpus, Dominic, Age 2;3*
(22) a. \( \neg > \diamond > \forall \)
   We can’t eat meat on a daily basis
b. \( \neg > \forall > \diamond \)
   There is a day in which we can’t eat meat
c. \( \forall > \neg > \diamond \)
   Every day is such that we can’t eat meat then (i.e., we can never eat meat)

- Both (a) and (b) are compatible with the mother’s utterance: if we can’t eat meat on a daily basis, this could be a reason not to eat meat today; if there is a day in which we can’t eat meat, and this day is today, this could also be a reason not to eat meat today. (c) would be inappropriate given that the family eats meat regularly and the child presumably had eaten meat recently
- Corresponding meanings when EVERY is replaced with SOME:

(23) a. \( \neg > \diamond > \exists \)
   Every day is such that you can’t eat meat then (i.e., you can never eat meat)
b. \( \neg > \exists > \diamond \)
   Every day is such that you can’t eat meat then (i.e., you can never eat meat)
c. \( \exists > \neg > \diamond \)
   There is a day in which you can’t eat meat

- The meaning in which SOME takes scope over negation is no longer equivalent to the intended meaning, but it is equivalent to the stronger meaning there is a day in which you can’t eat meat, which is not strong enough to be incompatible with the context
- Conclusion: considering truth-conditions alone, downward-entailing environments did not provide unambiguous evidence against the weaker meaning

2.1.3 Non-monotone environments

- Replacing EVERY with SOME in non-monotone environments does not yield a weaker meaning, so it is easy to construct scenarios that are inconsistent with any scope for SOME
- Informative scenario:

(24) Exactly two girls read every book
   a. books = \( \{b_1, b_2, b_3\} \)
b. girls = \( \{g_1, g_2, g_3, g_4\} \)
c. \( g_1 \) and \( g_2 \) each read \( b_1, b_2, \) and \( b_3 \); \( g_3 \) read \( b_1 \) and \( b_2 \); \( g_4 \) read \( b_2 \) and \( b_3 \)

- Neither surface nor inverse scope with the existential are weaker than surface scope with the universal

(25) Exactly two girls are such that they read some book
Some book is such that exactly two girls read it

- Surface existential scope is false because more than two girls read books and inverse scope is false because each book was read by at least three girls
- There were no occurrences of exactly or between m and n (which has the same behavior) in the corpora (0/1103)

2.1.4 Existential-rejecting environments

1. Polarity
   - every is downward-entailing in its restrictor, licensing NPIs
   - An NPI in the restrictor of every is incompatible with alternative meanings for every whose restrictor is not DE, including SOME

   (27) a. Adult #1: you know she put her arms way up when she finished her glass of milk.
   b. Mother: oh, she does that everytime she finishes anything.
      Brown Corpus, Sarah, Age 2;3

   - Only one utterance in the corpora (1/1103) had an NPI in the restrictor of every

2. Almost, nearly
   - almost and nearly only take universal complements (every, no)

   (28) a. Almost every/no girl read a book
   b. *Almost some/most girl(s) read a book

   - Five examples in total (5/1103) had almost or nearly with every

3. Exceptives
   - Universality restriction on the distribution of exceptives

   (29) a. every girl but Mary read a book
   b. *some girl but Mary read a book

   - Seven examples in total (7/1103) had but with every (5 of them by the same parent)

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There is evidence from the acquisition literature that children as young as 2 treat any as an NPI and seem to understand where it is licensed (Tieu 2015, Gualmini 2004), and that 4-year-olds are sensitive to the fact that every is downward-entailing in its restrictor. (Gualmini, Meroni and Crain 2003, Crain, Meroni and Minai 2012)
2.1.5 Intermediate summary: truth-conditional evidence

- Truth-conditional evidence was quite rare: direct objection, downward-entailing environments, non-monotone environments, NPI-licensing, \textit{almost, nearly}, and exceptives all provided a total of 15/1103 informative examples (5 by the same parent)
- Most informative examples (13/15) were specific to \textit{every} and would not, say, help reject \textit{SOME} as an alternative to non-universal quantifiers like \textit{most}
- Conclusion: the input is not rich enough to systematically rule out weaker meanings using truth-conditional evidence alone

2.2 Informative pragmatic evidence

2.2.1 Maxim of Quantity

- A hypothetical example:

  \begin{enumerate}
  \item \textbf{Parent}: Let’s see if you can finish eating the cookies in the jar.
  \item \textbf{Child}: I eat all three.
  \item \textbf{Parent}: Good job, you ate every cookie.
  \end{enumerate}

- Any weaker meaning would be pragmatically odd in this context:

  \begin{enumerate}
  \item \textbf{Parent}: Good job, you ate \textit{some} cookie.
  \end{enumerate}

- One approach to the oddness of the existential is based on the Neo-Gricean Maxim of Quantity (NGMQ)

- NMQ: a speaker shouldn’t utter $\phi$ if there’s a stronger alternative $\phi'$ that the speaker believes is true

- An algorithm for ruling out the weaker meaning using NMQ:

  - The sentence with SOME:

    \begin{enumerate}
    \item \textbf{Parent}: Good job, you ate SOME cookie.
    \end{enumerate}

  - Assumption #1: The child believes that her parent believes that she ate all cookies.
  - Assumption #2 (more on this assumption below): SOME has EVERY as an alternative.
  - Then the following is a stronger alternative to (32):

    \begin{enumerate}
    \item \textbf{Parent}: Good job, you ate EVERY cookie.
    \end{enumerate}

  - Inference: $[[\textit{every}]] = \textit{SOME} \implies$ violation of NMQ
• **Note:** if the child hadn’t acquired the lexical entry for the universal, then according to NGMQ it’s not an available alternative.

• Open question: access to non-lexical alternatives? (Deal, 2011; Buccola et al., 2016)

• What about the following alternative to Assumption #2?
  
  – Assumption #2’: SOME has THREE as a lexical alternative.

• Following the same reasoning, \([\text{every}] = \text{SOME} \implies \text{violation of NGMQ}\)

• **Tentative conclusion:** Conditions for using the context as evidence for rejecting a weaker meaning Q, assuming NGMQ:

  1. The child can use NGMQ
  2. The child can hold beliefs regarding other speakers’ beliefs
  3. **Either:**
     
     (i) The child had acquired lexical alternatives that are contextually stronger than Q
  
  **Or:**

  (ii) Alternatives to Q that are contextually stronger (e.g., the universal quantifier) are available regardless of lexicalization.

• Need to say a bit more to derive oddness. Is the conclusion different for other approaches to oddness?

• Examples like (24) are systematically available in the corpus.

  – Preliminary analysis: 400 of the 793 every-utterances in the Manchester Corpus
  
  – 10.5% of the utterances were used in contexts where the child has grounds to believe that the parent believes that the stronger alternative holds

(34) Context: The child is asking the parent to get his toys out from the toy chest. He lists the things he wants one by one.³

  a. Child: Clothes for the doll
     
     Mother: There you go
     
     Child: oh pig.
     
     Mother: oh
     
     Child: pig here.
     
     ...
     
     Mother: There. Now you’ve got everything out.
     
     Mother: Is there anything in particular you’d like to play with?

  {Manchester Corpus, Dominic, Age 2;4

  ³We assume here that both the child and the mother has the relevant information about the domain of quantification, the toys in the child’s toy chest.
• **Children and SIs:** Previous acquisition research suggests that children are more accepting of sentences that violate MQ in comprehension tasks (Noveck 2001 and many others since). More recently, it has been proposed that children’s difficulties stem from their inability to retrieve the relevant lexical alternatives (Barner, Brooks and Bale, 2011). If this proposal is on the right track, these sorts of data may not be helpful for the child even if she has acquired the requisite lexical alternatives.

2.2.2 Questions

• The pragmatics of questions is another source of evidence against weaker meanings

(35) Context: somebody has already arrived
  a. Is everybody here?
  b. #Is anybody here?

• Pragmatic constraint on questions: Do not question what is in the Common Ground

• The context entails the answer to the question with the weaker meaning

• Preliminary analysis of the Manchester Corpus. Questions used in contexts that seemed to entail an answer to the existential counterpart were coded as informative
  – 400 of the 793 every-utterances
  – 42.5% were questions
  – 9% (21% of the questions) were informative questions

(36) Context: Pretend play: mother is shopkeeper and child is customer. Child has listed a series of things she is buying.
  a. Mother: Have you got everything?

  *Anne, Age 2;7*

2.2.3 Relevance

• Weaker meanings can yield trivial claims

(37) a. Mother: why don’t you put the things away? you’ve got everything in one spot
  b. Child: where?
  c. Mother: there.

• The utterance conveys that multiple things are in the same place. If every meant SOME, the mother’s utterance would have meant that something is in one spot, a claim that is trivially true
2.2.4 Causality

- Environments that express properties like causality require propositions of sufficient strength, making them incompatible with weaker alternatives. Consider the connectives so and because:

\[(38)\]
- a. I ate all of the apples, so there aren’t any apples left
- b. #I ate some of the apples, so there aren’t any apples left
- c. I ate all of the apples and there aren’t any apples left

\[(39)\]
- a. There aren’t any apples left because I ate all of them
- b. #There aren’t any apples left because I ate some of them
- c. There aren’t any apples left and I ate all of them

- The connectives in the (b) examples are infelicitous because their consequents do not follow from their prejacents

- The prejacents with every are strong enough to imply the consequents, while the variants with some are too weak to do so

\[(40)\] Context: the child wants to listen to the tape recorder again. The mother explains that they have already heard the entire recording
- a. Mother: it said everything that we said, so there wasn’t anything left for it to say
- b. Child: what?
- c. Mother: there wasn’t anything left for it to say, because it said everything that we said already

2.2.5 Intermediate summary: pragmatic evidence

- Informative pragmatic evidence was quite common: MQ and questions themselves provided a total of around 20% informative examples (around 80/400)

- If children can use this evidence early enough, the subset problem would disappear

- Conclusion: the input is rich enough to systematically rule out weaker meanings using pragmatic evidence

3 Logically stronger alternatives

- We construct a class of quantifiers that have the following properties:

\[(41)\] Properties:
- 1. Logically stronger than every
- 2. Consistent with occurrences of every in the data
- 3. Obey some familiar universal constraints on quantifiers (Conservativity, Isomorphy, Extension)
(42)  a. \([\text{every}] = \lambda P. Q \subseteq Q \land |P| > 2\)
    b. \([\text{every}]'' = \lambda P. Q \subseteq Q \land (m < |P| < n)\)
    c. \([\text{every}]''' = \lambda P. Q \subseteq Q \land (|P| = 3 \lor |P| = 5 \lor |P| = 6 \lor ...)\)

• Consider the following entry for every:

(43) \([\text{every}] = \lambda P. Q \subseteq Q \land |P| > 2\)

• every has been claimed to have an anti-duality implicated presupposition, so the conjunct
  \((|P| > 2)\) will be satisfied in contexts where the implicated presupposition is generated (given
  the English entry for every)

• This entry for every is incorrect: it predicts, for example, that the following sentence would
  be judged as true

(44) Context: there is one book. Mary read it
    It’s not the case that Mary read every book

• Is there evidence in the input against this entry?

• Examples where the implicated presupposition is not generated are quite complicated

(45) every person in Boston vaccinated every child of his

• In downward-entailing environments, utterances with every would be weaker with the
  complex entry than with EVERY. Can pragmatic considerations rule out the complex
  entry?

• Are these quantifiers learnable? This could be tested experimentally

• Note: these quantifiers pose a potential ‘superset problem’ for acquisition: if they are in the
  hypothesis space, restrictiveness-only biases like the Subset Principle would fail

4 Conclusion

• Systematic truth-conditional evidence for ruling out logically weaker meanings does not
  seem to be available. Obvious candidates for providing such evidence like the direct rejection
  of a child’s utterance and the use of quantifiers in downward-entailing environments were
  either absent from most corpora or consistent with weaker meanings

• Pragmatic evidence for ruling out logically weaker meanings seems to be systematically
  available. If children can use this contextual evidence early enough, then logically weaker
  meanings would be incompatible with the input

• If the logically stronger alternatives we constructed are in the child’s hypothesis space, and
  are consistent with the input, then converging on adult meanings would require non-trivial
  induction