Ambiguous *than*-clauses and the mention-some reading

Linmin Zhang
(Joint work with Jia Ling)

Concordia University

zhanglinmin@gmail.com

May 12, 2017

Lucinda sentences

Context: This highway has a required minimum speed of 35 mph and a speed limit of 50 mph.

(1)   Lucinda was driving less fast than allowed.

'< **max**' reading

Lucinda was driving below the speed limit (50 mph).

⤳ Lucinda's speed was legal.

'< **min**' reading

Lucinda was driving below the required minimum (35 mph).

⤳ Lucinda's speed was illegal.

Rullmann (1995), Heim (2006b), Büring (2007), Beck (2013), Crnič (2016)

Other examples of ambiguous comparatives

Context: Chuck wants to be a fighter pilot. Air Force regulations require all pilots to be between 5′4″ and 6′5″ tall.

(2)   a.   Chuck is taller than he needs to be.
       b.   Chuck is taller than he has to be.
       c.   Chuck is taller than he is required to be.

'> **max**' reading

Chuck is taller than the upper bound (6′5″).

'> **min**' reading

Chuck is taller than the lower bound (5′4″).

Heim (2006a), Krasikova (2008), Beck (2010), Alrenga and Kennedy (2014).

Main goal of today's talk

- Modals expressing **permission**

(1) Lucinda was driving less fast than allowed.

$\rightsquigarrow$ The interval of permissible speed

(2) a. Chuck is taller than he needs to be.
     b. Chuck is taller than he has to be.
     c. Chuck is taller than he is required to be.

$\rightsquigarrow$ The interval of permissible height

Main goal

Accounting for the ambiguity of comparatives that contain **permission-related modals** in their *than*-clause.

Overview

1. We show that previous accounts based on scope interaction or the use of different silent operators cannot account for the ambiguity of Lucinda sentences.

2. We adopt a generalized interval-arithmetic-based recipe for computing the semantics of clausal comparatives (Zhang and Ling 2015, 2017, In prep.).

3. For comparatives containing permission-related modals in their *than*-clause, we locate the source of the ambiguity in their *than*-clause and show that permission-related modals lead to the mention-some/mention-all ambiguity.

Outline

1. Empirical challenges to previous accounts
   - Scopal interaction ⤳ under-generation
   - Different silent operators ⤳ over-generation

2. More empirical observations on the (un)ambiguity of comparatives

3. Proposal
   - The semantics of clausal comparatives: An interval-arithmetic approach
   - The semantics of than-clauses: Short answers to wh-questions
   - Mention-some answers

4. Concluding remarks and outlook

Heim (2006b)'s analysis:
Scopal interaction between *little* and modals

(1)   Lucinda was driving less fast than allowed.

- *less = little + more/-er*

'< max' reading

than [little [allowed [Lucinda drive ___ fast]]]   little + allowed = not allowed
How fast was Lucinda not allowed to drive?   – the speed limit (50 mph)

⤳ Lucinda was driving less fast than the speed limit.

'< min' reading

than [allowed [little [Lucinda drive ___ fast]]]   little + fast = slowly
How slowly was Lucinda allowed to drive? – the required minimum (35 mph)

⤳ Lucinda was driving less fast than the required minimum.

Under-generation:
more-comparatives can also be ambiguous.

Context: Chuck wants to be a fighter pilot. Air Force regulations require all pilots to be between $5'4''$ and $6'5''$ tall.

(2)   a.   Chuck is taller than he needs to be.
      b.   Chuck is taller than he has to be.
      c.   Chuck is taller than he is required to be.

'> **max**' reading

Chuck is taller than the upper bound ($6'5''$).

'> **min**' reading

Chuck is taller than the lower bound ($5'4''$).

Heim (2006a), Krasikova (2008), Beck (2010), Alrenga and Kennedy (2014); see also Beck (2013).

Crnič (2016)'s analysis:
Existential closure vs. Maximality

Existential closure

$$\llbracket \exists \rrbracket \stackrel{\text{def}}{=} \lambda I_{\langle\langle dt\rangle t\rangle}.\lambda I'_{\langle\langle dt\rangle t\rangle}.\exists i[I(i) \wedge I'(i)]$$

There exists an interval i that makes $I(i)$ and $I'(i)$ true.

Maximality

$$\llbracket \text{the} \rrbracket \stackrel{\text{def}}{=} \lambda I_{\langle\langle dt\rangle t\rangle}.\iota i[I(i) \wedge \forall i'[I(i') \rightarrow {}^{\wedge}I(i) \subseteq {}^{\wedge}I(i')]]$$

i is the maximally informative i that makes $I(i)$ true.

Crnič (2016)'s analysis:
Existential closure vs. Maximality

(1) Lucinda was driving less fast than allowed.

Existential closure: '< **max**' reading

There is a speed interval i such that Lucinda was allowed to drive i fast.
Lucinda was driving less fast than i.

⤳ Lucinda was driving less fast than the speed limit.

Maximality: '< **min**' reading

The maximally informative interval i such that Lucinda was allowed to drive i fast, i.e., [speed$_{\diamond min}$(Lucinda), speed$_{\diamond max}$(Lucinda)]
Lucinda was driving less fast than i.

⤳ Lucinda was driving less fast than the required minimum.

Over-generation:
Lack of ambiguity with nominal quantifiers

(3)   Lucy was driving less fast than a/some boy did.

Existential closure: '< **max**' reading

There is a speed interval i such that some boy drove i fast.
Lucinda was driving less fast than i.

⤳ Lucinda was driving less fast than the fastest boy did.

Maximality: '< **min**' reading   unattested

The maximally informative interval i such that any boy drove i fast, i.e.,
the interval that includes every boy's speed.
Lucinda was driving less fast than i.

⤳ Lucinda was driving less fast than the slowest boy did.

Črnič (2016)

Outline

1. Empirical challenges to previous accounts
   - Scopal interaction ⤳ under-generation
   - Different silent operators ⤳ over-generation

2. More empirical observations on the (un)ambiguity of comparatives

3. Proposal
   - The semantics of clausal comparatives: An interval-arithmetic approach
   - The semantics of than-clauses: Short answers to wh-questions
   - Mention-some answers

4. Concluding remarks and outlook

More empirical observations

Comparatives that contain nominal or modal quantifiers in their
than-clause are in general unambiguous.

- Universal modals
- Nominal universal quantifiers
- Existential modals
- Nominal existential quantifiers
- Modals + exhaustifiers

Nominal universal quantifiers

(4)   *every*

    a.   John is **taller** than every girl is.   ✓ > tallest, # > shortest

    b.   John is **less tall** than every girl is.   # < tallest, ✓ < shortest

Universal modals

Context: Because of his height, John cannot be a fighter pilot. Air Force regulations require all pilots to be between 5′4″ and 6′5″ tall.

(5) *should*

    a.   John is **taller** than he should be.   ✓ > max, # > min

    b.   John is **less tall** than he should be.   # < max, ✓ < min

(6) *supposed to*

    a.   John is **taller** than he is supposed to be.   ✓ > max, # > min

    b.   John is **less tall** than he is supposed to be. # < max, ✓ < min

Nominal existential quantifiers

(7)   *some*

    a.   John is **taller** than some girl is.   \# > tallest, ✓ > shortest

    b.   John is **less tall** than some girl is.   ✓ < tallest, \# < shortest

Existential modals

Context: The range of sound frequencies audible to John has an upper bound and a lower bound.

(8)   *can*

    a.   The sound that the whistle produces is **higher** than John can hear.   ✓ > upper bound, # > lower bound

    b.   The sound that the bird produces is **less high** than John can hear.   # < upper bound, ✓ < lower bound

See also Rullmann (1995), Beck (2013)

Permission-related modals + exhaustifiers

Context: This highway has a required minimum speed of 35 mph and a speed limit of 50 mph.

(9) *allowed + any*

    a. Lucinda drove faster than **anyone was allowed to**.

                                                                  ✓ > max, # > min

    b. Lucinda drove less fast than **anyone was allowed to**.

                                                                 # < max, ✓ < min

Generalization

- Comparatives that contain nominal or modal quantifiers in their *than*-clause are in general **unambiguous**.
  In general, (when there are no overt differential expressions,)

    - For *more*-comparatives, the comparative subjected is compared with the **upper bound** of the comparative standard.
    - For *less*-comparatives, the comparative subjected is compared with the **lower bound** of the comparative standard.

- Comparatives containing permission-related modals in the *than*-clause are special.

Outline

1. Empirical challenges to previous accounts
   - Scopal interaction ⤳ under-generation
   - Different silent operators ⤳ over-generation

2. More empirical observations on the (un)ambiguity of comparatives

3. **Proposal**
   - The semantics of clausal comparatives: An interval-arithmetic approach
   - The semantics of than-clauses: Short answers to wh-questions
   - Mention-some answers

4. Concluding remarks and outlook

The semantics of clausal comparatives: An interval-arithmetic approach

Here we use a generalized, interval-arithmetic-based recipe that captures the generalization that (when there are no overt differential expressions,)

- For *more*-comparatives, the comparative subjected is compared with the **upper bound** of the comparative standard.
- For *less*-comparatives, the comparative subjected is compared with the **lower bound** of the comparative standard.

The semantics of clausal comparatives

The semantics of comparatives is analyzed as a relation among three degree-related expressions:

- The comparative subject
- The comparative standard (expressed by the *than*-clause)
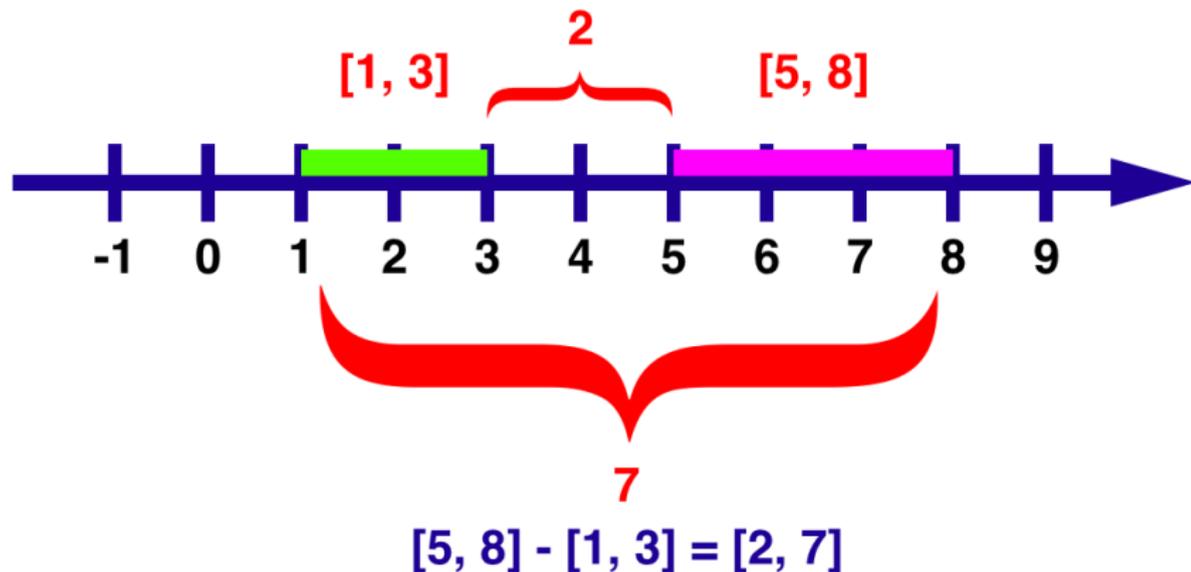- The differential between them (expressed by *more* or *less*)

These three degree-related expressions can all be considered **intervals**.
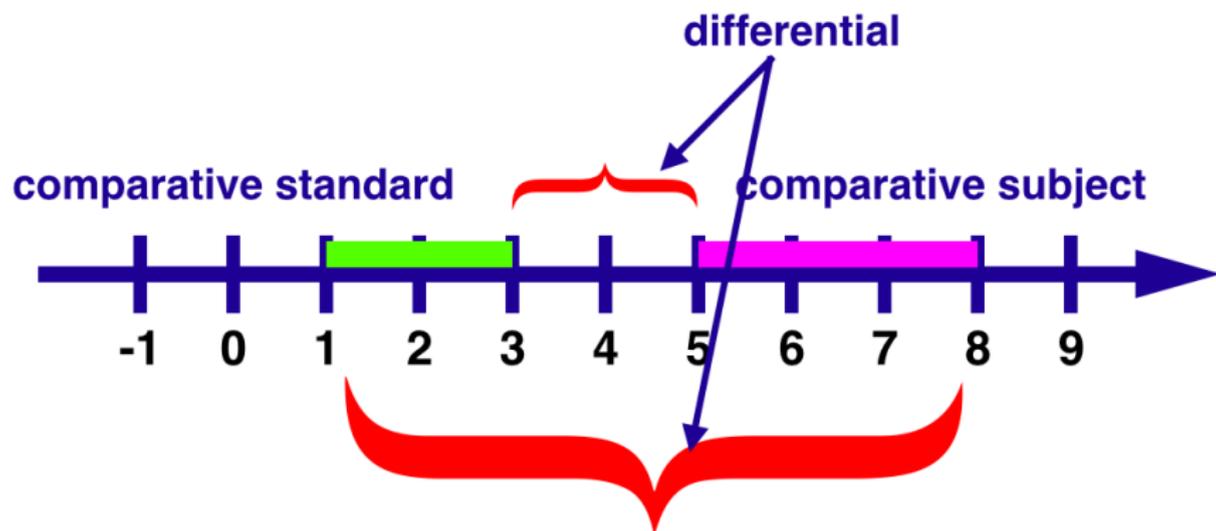
See also Schwarzchild and Wilkinson (2002).

Subtraction between two points on a scale
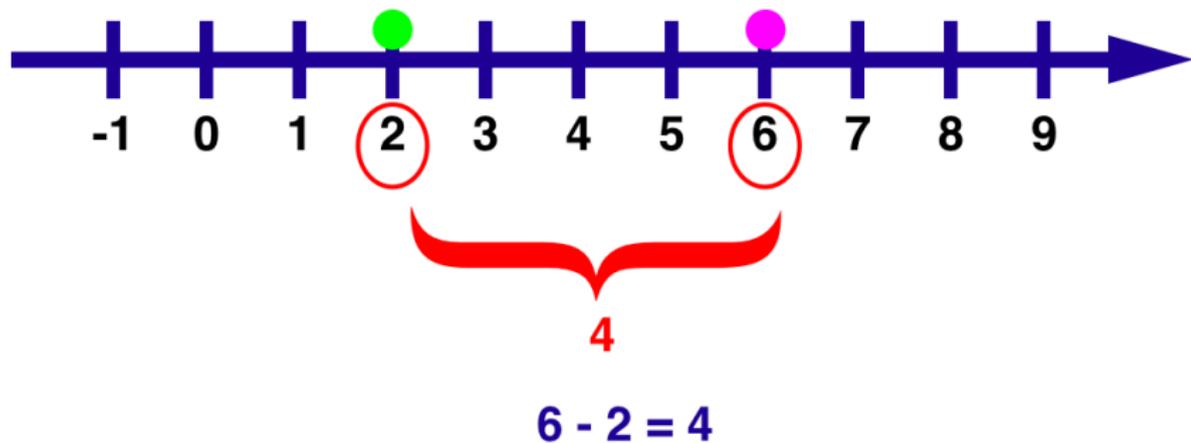
Subtraction between two intervals on a scale

[5, 8] - [1, 3] = [2, 7]

Moore (1979)

Illustrating the semantics of comparatives:
The relation among three intervals

comparative subject - comparative standard = differential

An interval-arithmetic approach to the semantics of comparatives

Comparative subject - comparative standard = differential

- Given the values of the comparative subject and the comparative standard,

  $\text{differential}_{\text{upper-bound}}$

  $= \text{comparative-subject}_{\text{upper-bound}}$ - $\text{comparative-standard}_{\text{lower-bound}}$

  $\text{differential}_{\text{lower-boud}}$

  $= \text{comparative-subject}_{\text{lower-bound}}$ - $\text{comparative-standard}_{\text{upper-bound}}$

- Given the values of the comparative standard and the differential,

  $\text{comparative-subject}_{\text{upper-bound}}$

  $= \text{comparative-standard}_{\text{lower-bound}}$ + $\text{differential}_{\text{upper-bound}}$

  $\text{comparative-subject}_{\text{lower-boud}}$

  $= \text{comparative-standard}_{\text{upper-bound}}$ + $\text{differential}_{\text{lower-boud}}$

An interval-arithmetic approach to the semantics of comparatives

more vs. less

- $[\![\text{more/-er}]\!] \stackrel{\text{def}}{=} (0, +\infty)$
- $[\![\text{less}]\!] \stackrel{\text{def}}{=} [\![\text{little}]\!][\![\text{more/-er}]\!] = (-\infty, 0)$

- comparative-subject$_{\text{upper-bound}}$
  = comparative-standard$_{\text{lower-bound}}$ + differential$_{\text{upper-bound}}$
- comparative-subject$_{\text{lower-boud}}$
  = comparative-standard$_{\text{upper-bound}}$ + differential$_{\text{lower-boud}}$

An interval-arithmetic approach to the semantics of comparatives: two examples

- $\llbracket \text{fast} \rrbracket_{\langle dt, et \rangle} \stackrel{\text{def}}{=} \lambda I_{\langle dt \rangle}.\lambda x_e.\text{speed}(x) \subseteq I$
- $\llbracket \text{(th)-an} \rrbracket_{\langle dt, \langle dt, dt \rangle \rangle} \stackrel{\text{def}}{=} \lambda I_{\text{stdd}}.\lambda I_{\text{diff}}.\iota I[I - I_{\text{stdd}} = I_{\text{diff}}]$

Lucinda was faster than every boy was.

$\text{speed}(\text{Lucinda}) \subseteq \iota I[I - \llbracket \text{the} \rrbracket [\lambda I'.[\forall x[\text{boy}(x) \rightarrow \text{speed}(x) \subseteq I']] = (0, +\infty)]]]$

($\llbracket \text{the} \rrbracket [\lambda I'.[\forall x[\text{boy}(x) \rightarrow \text{speed}(x) \subseteq I']]$ can be written as

$[I_{\text{every-boy's-speed-lower-bound}}, I_{\text{every-boy's-speed-upper-bound}}])$

$\text{speed}(\text{Lucinda}) \subseteq (I_{\text{every-boy's-speed-upper-bound}}, +\infty)$

Lucinda was less fast than every boy was.

$\text{speed}(\text{Lucinda}) \subseteq \iota I[I - \llbracket \text{the} \rrbracket [\lambda I'.[\forall x[\text{boy}(x) \rightarrow \text{speed}(x) \subseteq I']] = (-\infty, 0)]]]$

$\text{speed}(\text{Lucinda}) \subseteq (-\infty, I_{\text{every-boy's-speed-lower-bound}})$

The semantics of than-clauses: Short answers to wh-questions

- The meaning of a *than*-clauses is analyzed as a definite description, e.g., *than John is (tall)* is analyzed as a value indicating **the height of John** (see also Heim 2006a).

- Or in other words, it can be considered the **short answer to its corresponding wh-question**.

The semantics of than-clauses:
Short answers to wh-questions

(10)   John is taller than Bill is.
        Meaning: John's height exceeds Bill's height.

$[\![$th-(an) Bill is$]\!]$ = Bill's height

$[\![$th-(an) Bill is (tall)$]\!]$ = $[\![$the$]\!][\lambda I.\text{height}(\text{Bill}) \subseteq I]$
I.e., the maximally informative answer to the question *how tall is Bill*?

Depending on context, it can be as precise as $[6'1'', 6'2'']$ or
$[6'1.5'', 6'1.8'']$, etc.

Short answers to wh-questions

Context: Mary ate an apple; Sue ate a banana; Kate ate a peach.

(11)   What did every girl eat?

    a.   An apple, a banana, or a peach.   ⤳ A fruit

    b. #An apple, a banana, and a peach.

(12)   Mary is taller than every boy is.

(12')   How tall is every boy?

    a.   At least 6′.

    b.   6′.   ⤳ Every boy is of the same height.

    c.   Between 6′ and 6′5″.

⟦th-(an) every boy is⟧ means a range of possible values.

I.e., an **interval**, or a **convex set of degrees**.

⤳ The maximally informative interval that includes the height of every boy

⟦the⟧[$\lambda I'.[\forall x[\text{boy}(x) \rightarrow \text{height}(x) \subseteq I']$]], i.e.,

[$I_{\text{every-boy's-height-lower-bound}}$, $I_{\text{every-boy's-height-upper-bound}}$]

Mention-some answers

Fox (2013), Xiang (2016): The use of certain modals in a *wh*-question often leads to a mention-some / mention-all ambiguity for their answerhood. We call these questions 'mention-some questions'.

Mention-some questions

(13)   Where can we get gas in Cambridge?

(14)   How fast was Lucinda (still) allowed to drive?

(15)   a.   (At least) how tall does Chuck need to be?
           b.   (At least) how tall does Chuck have to be?
           c.   (At least) how tall is Chuck required to be?

Mention-some vs. mention-all answers

(13) Where can we get gas in Cambridge?

   a. X   Specify one location

   b. X, Y, or Z   Specify all locations with a disjunctive form

   c. X, Y, and Z   Specify all locations with a conjunctive form

(14) How fast was Lucinda (still) allowed to drive?

   a. The speed limit (50 mph).   Mention-some answer

   b. Between 35 mph and 50 mph. Disjunctive mention-all answer

(15) a. (At least) how tall does Chuck need to be?

   b. (At least) how tall does Chuck have to be?

   c. (At least) how tall is Chuck required to be?

     (i) 5′4″.   Mention-some answer

     (ii) Between 5′4″ and 6′5″. Disjunctive mention-all answer

Accounting for the semantics of ambiguous comparatives

(1)   Lucinda was driving less fast than allowed

⟦than allowed⟧ = the answer to 'how fast was Lucinda allowed to drive'

- The speed limit (50 mph).   Mention-some answer
  $\mathrm{Speed}(\mathrm{Lucinda}) \subseteq \iota I[I - [50\mathrm{mph}, 50\mathrm{mph}] = (-\infty, 0)]$
  $\Leftrightarrow \mathrm{Speed}(\mathrm{Lucinda}) \subseteq (-\infty, 50\mathrm{mph})$ '< max' reading

- Between 35 mph and 50 mph.   Disjunctive mention-all answer
  $\mathrm{Speed}(\mathrm{Lucinda}) \subseteq \iota I[I - [35\mathrm{mph}, 50\mathrm{mph}] = (-\infty, 0)]$
  $\Leftrightarrow \mathrm{Speed}(\mathrm{Lucinda}) \subseteq (-\infty, 35\mathrm{mph})$ '< min' reading

Accounting for the semantics of ambiguous comparatives

(2)   a.   Chuck is taller than he needs to be.
      b.   Chuck is taller than he has to be.
      c.   Chuck is taller than he is required to be.

⟦than he needs/has/is required to be⟧ = the answer to 'how tall does Chuck need/have to be'

- $5'4''$.   Mention-some answer
  height(Chuck) $\subseteq \iota I[I - [5'4'', 5'4''] = (0, +\infty)]$
  $\Leftrightarrow$ height(Chuck) $\subseteq (5'4'', +\infty)$ '> min' reading

- Between $5'4''$ and $6'5''$.   Disjunctive mention-all answer
  height(Chuck) $\subseteq \iota I[I - [5'4'', 6'5''] = (0, +\infty)]$
  $\Leftrightarrow$ height(Chuck) $\subseteq (6'5'', +\infty)$ '> max' reading

Outline

1. Empirical challenges to previous accounts
   - Scopal interaction ⤳ under-generation
   - Different silent operators ⤳ over-generation

2. More empirical observations on the (un)ambiguity of comparatives

3. Proposal
   - The semantics of clausal comparatives: An interval-arithmetic approach
   - The semantics of than-clauses: Short answers to wh-questions
   - Mention-some answers

4. Concluding remarks and outlook

Summary

- We have shown that previous accounts based on scope interaction or the use of different silent operators cannot account for the ambiguity of Lucinda sentences.

- We have adopted a generalized interval-arithmetic-based recipe for computing the semantics of clausal comparatives (Zhang and Ling 2015, 2017, In prep.).

- For comparatives containing permission-related modals in their *than*-clause, we have attributed their ambiguity to the ambiguous mention-some / mention-all answerhood.

Outlook

- What are short answers to *wh*-questions?
  - ▶ What is the cognitive significance of summarizing clausal pair-list answers into short answers? In general, how to formalize this?

- What are the conditions that license mention-some answerhood?
  - ▶ Van Rooy (2004)'s view on answerhood: utility.
  - ▶ Fox (2013), Xiang (2016)'s view on answerhood: maximal informativeness.
  - ▶ Barker (2010)'s view on permission: resource-sensitivity.
  - ▶ How can we further make use of linguistic expressions on measurement and gradability to study this issue? How to formalize our sensitivity with regard to necessity and sufficiency?

Thank you!

Selected references I

Alrenga, Peter, and Christopher Kennedy. 2014. *No more* shall we part: Quantifiers in English comparatives. *Natural Language Semantics* 22:1–53.

Barker, Chris. 2010. Free choice permission as resource-sensitive reasoning. *Semantics and Pragmatics* 3:10–1.

Beck, Sigrid. 2010. Quantifiers in *than*-clauses. *Semantics and Pragmatics* 3:1–72.

Beck, Sigrid. 2013. Lucinda driving too fast again – the scalar properties of ambiguous *than*-clauses. *Journal of Semantics* 30:1 – 63 (ffr011).

Büring, Daniel. 2007. Cross-polar nomalies. In *Proceedings of Semantics and Linguistic Theory 17*, ed. T. Friedman and M. Gibson, 37–52. Ithaca, NY: Cornell University.

Crnič, Luka. 2016. More on *less*. In *NELS 47*.

Fox, Danny. 2013. Mention-some readings of questions. MIT seminar notes.

Heim, Irene. 2006a. Remarks on comparative clauses as generalized quantifiers. Manuscript, MIT.

Heim, Irene. 2006b. *Little*. In *Proceedings of Semantics and Linguistic Theory 16*, ed. M. Gibson and J. Howell, 35–58. Ithaca, NY: Cornell University.

Krasikova, Sveta. 2008. Quantifiers in comparatives. In *Proceedings of Sinn und Bedeutung 12*, ed. Atle Grønn, 337–352. Oslo: ILOS 2008 (ISBN 978-82-92800-00-3).

Moore, Ramon E. 1979. *Methods and Applications of Interval Analysis*. SIAM.

Rullmann, Hotze. 1995. Maximality in the semantics of wh-constructions. Doctoral Dissertation, University of Massachusetts Amherst.

Selected references II

Schwarzchild, Roger, and Karina Wilkinson. 2002. Quantifiers in comparatives: A semantics of degree based on intervals. *Natural language semantics* 10:1–41.

Van Rooy, Robert. 2004. Utility of mention-some questions. *Research on Language and Computation* 2:401–416.

Xiang, Yimei. 2016. Interpreting questions with non-exhaustive answers. Doctoral Dissertation, Harvard University.

Zhang, Linmin, and Jia Ling. 2015. Comparatives Revisited: Downward-Entailing Differentials Do Not Threaten Encapsulation Theories. In *Proceedings of the 20th Amsterdam Colloquium*, ed. Thomas Brochhagen, Floris Roelofsen, and Nadine Theiler, 478 – 487.

Zhang, Linmin, and Jia Ling. 2017. LITTLE: Not a dichotomy-based negation operator, but a trivalence-based polar opposition operator. In *Proceedings of the 34th West Coast Conference on Formal Linguistics*, ed. Aaron Kaplan, Abby Kaplan, Miranda K. McCarvel, and Edward J. Rubin. Cascadilla Press.

Zhang, Linmin, and Jia Ling. In prep. The semantics of English clausal comparatives: An interval-arithmetic-based approach.