The extent of upper-bound construals among different modified numerals

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Inferences and modified numerals

- Modified numerals give rise to wide variety of inferences
- Example 1: variation inferences (Nouwen, 2015)

  (1) The CNN crew got that bit of video, and everyone in the world has seen it at least twenty times.
  \[\rightarrow\text{there is no specific } n \text{ such that everyone has seen the video } n \text{ many times}\]
Inferences and modified numerals

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- Example 1: variation inferences (Nouwen, 2015)

1. The CNN crew got that bit of video, and everyone in the world has seen it at least twenty times.
   → there is no specific \( n \) such that everyone has seen the video \( n \) many times

2. A: According to a random sample every bag contains at least 22 sweets.
   B: ?Do they all contain the same number of sweets?
   Alexandropoulou (to appear)
Inferences and modified numerals

Example 2: scalar inferences (Krifka, 1999; Fox and Hackl, 2006)

(3) John has three children.
→ John doesn’t have four children.
Inferences and modified numerals

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(3) John has three children.
    → John doesn’t have four children.

(4) John has more than three children.
    ↳ John doesn’t have more than four children.
Inferences and modified numerals

Example 2: scalar inferences (Krifka, 1999; Fox and Hackl, 2006)

(3) John has three children.  
   \[\rightarrow\text{John doesn't have four children.}\]

(4) John has more than three children.  
   \[\not\rightarrow\text{John doesn't have more than four children}\]

(5) I can say with certainty that John has more than three children.  
   \[\rightarrow\text{I cannot say with certainty that John has more than four children}\]
Inferences and modified numerals

▶ Another factor: granularity/distance (Cummins et al., 2012)

(6) John’s birthplace has more than 1000 inhabitants.  
\[ \neg \neg \] John’s birthplace doesn’t have more than 1001 inhabitants.  
\[ \rightarrow \] John’s birthplace doesn’t have more than a million inhabitants.
Inferences and modified numerals

- Not all modified numerals give rise to the same kinds of inferences
- Class A/B distinction (Nouwen, 2010a): class B numeral modifiers give rise to obligatory ignorance inferences
Inferences and modified numerals

- Not all modified numerals give rise to the same kinds of inferences
- Class A/B distinction (Nouwen, 2010a): class B numeral modifiers give rise to obligatory ignorance inferences

(7)  **Class A**
I know exactly how much memory my laptop has, and it’s { more than / less than / under / over } 4GB.

(8)  **Class B**
#I know exactly how much memory my laptop has, and it’s { at least / at most / minimally / maximally / up to } 4GB.
The bounds of modified numerals

- Focus of our study: differences among class B modifiers

NPI licensing data suggest that up to is different from other class B modifiers that set an upper bound (Schwarz, Buccola, & Hamilton, 2012):

\[(9) \{\text{At most} / *\text{up to}\} \text{five students have ever been in this cave.}\]

\[(10) \{\text{At most} / *\text{up to}\} \text{three students give a damn about Pavarotti.}\]

This suggests at most is downward monotone, which is expected given the fact that it sets an upper bound.

What about up to?
The bounds of modified numerals

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- This suggests *at most* is downward monotone, which is expected given the fact that it sets an upper bound
- What about *up to*?
The bounds of modified numerals

- Blok (SALT 2015): Schwarz et al.’s findings extend to directional numeral modifiers crosslinguistically

(11) Greek: *mehri*

a. Perpatisame *mehri* tin akri tis limnis.
   We walked *MEHRI* the edge of the lake.
   ‘We walked up to the edge of the lake.’

b. Ston anelkistira khorane mehri 5 atoma.
   In the elevator *fit* *MEHRI* 5 people.
   ‘Up to 5 people can fit in the elevator.’
The bounds of modified numerals

- Blok (2015): there are two additional differences between directional numeral modifiers and expressions like *at most*:
  1. Directional numeral modifiers have a cancellable upper bound
  2. Directional numeral modifiers set a non-cancellable lower bound
The bounds of modified numerals

- The upper bound of directional numeral modifiers can be cancelled:

(12)  
  a. #At most ten people died in the crash, perhaps even more.  
  b. Up to ten people died in the crash, perhaps even more.

(13)  
  a. #Leftovers keep in the refrigerator for at most one week or more.  
  b. Leftovers keep in the refrigerator for up to one week or more.
The bounds of modified numerals

The lower bound of directional numeral modifiers cannot be cancelled:

(14)   a. At most three students will show up to the lecture, if any.
     b. #Up to three students will show up to the lecture, if any.
The bounds of modified numerals

Summary of the data:

- Directional numeral modifiers do not license NPIs; expressions like *at most* do.
The bounds of modified numerals

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The bounds of modified numerals

Summary of the data:

- Directional numeral modifiers do not license NPIs; expressions like *at most* do
- Directional numeral modifiers have a cancellable upper bound; expressions like *at most* have a non-cancellable upper bound
- Directional numeral modifiers have a non-cancellable lower bound; expressions like *at most* do not
An implicature-based account

Central proposal (Blok, SALT 2015):

- Directional numeral modifiers assert a lower bound
- Directional numeral modifiers only implicate an upper bound
An implicature-based account

- Directional numeral modifiers convey that the degree predicate they combine with holds for an interval on a scale.
- Directional numeral modifiers assert a lower bound: the lowest number on the scale it quantifies over cannot be 0.
- There is no maximality operator or other mechanism that sets an upper bound in the semantics.

(15) conveys that for every number on a scale \([1...10]\), the speaker considers it possible that that many people died in the crash — without excluding any other possibilities.

(15) Up to ten people died in the crash.
An implicature-based account

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How can this account for the data?

- As directional numeral modifiers assert a lower bound an implicate an upper bound, the cancellation facts follow straightforwardly from the account.
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- As directional numeral modifiers assert a lower bound an implicate an upper bound, the cancellation facts follow straightforwardly from the account.
- The fact that directional numeral modifiers are upward entailing is compatible with the fact that they do not license NPIs.
An implicature-based account

Additional evidence: the interaction with evaluative adverbs

- Evaluative adverbs target the assertion of an utterance rather than its implicature (Nouwen, 2006)

(16)  
  a. Fortunately, some students attended the wedding.
  b. Fortunately, the soup is warm.
An implicature-based account

Additional evidence: the interaction with evaluative adverbs

▶ Evaluative adverbs target the assertion of an utterance rather than its implicature (Nouwen, 2006)

(16)  
  a. Fortunately, some students attended the wedding.  
  b. Fortunately, the soup is warm.

▶ This also holds for *up to* and *at most*

(17)  
  a. Fortunately, up to 100 people will attend my wedding.  
  b. Fortunately, at most 100 people will attend my wedding.
An implicature-based account

Related notion: *directivity* (Nouwen, 2010b)

(18)  

a. In the airplane crash, \{few / not quite all / at most ten\} passengers were killed, which is a good thing.  
b. In the airplane crash, \{a few / almost all / up to ten\} passengers were killed, which is a good thing.
An implicature-based account

Related notion: *directivity* (Nouwen, 2010b)

(18)  a. In the airplane crash, \{few / not quite all / at most ten\} passengers were killed, which is a good thing.
    b. ?In the airplane crash, \{a few / almost all / up to ten\} passengers were killed, which is a good thing.

(19)  [In a commercial]
    a. Get a discount of up to 50%!
    b. ?Get a discount of at most 50%!
Questions

Research questions:

- Is it the case that the upper bound of directional numeral modifiers is cancellable, which would support an implicature-based account?
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▶ Is there a contrast between where the lower bound of expressions like *at most* and directional numeral modifiers start?
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▶ Does distance play a role?
Questions

Research questions:

➤ Is it the case that the upper bound of directional numeral modifiers is cancellable, which would support an implicature-based account? (experiment 1 & 2)

➤ Is there a contrast between where the lower bound of expressions like *at most* and directional numeral modifiers start?

➤ Does distance play a role?
Questions

Research questions:

- Is it the case that the upper bound of directional numeral modifiers is cancellable, which would support an implicature-based account? (experiment 1 & 2)

- Is there a contrast between where the lower bound of expressions like *at most* and directional numeral modifiers start?

- Does distance play a role? (experiment 2)
Questions

Research questions:

▶ Is it the case that the upper bound of directional numeral modifiers is cancellable, which would support an implicature-based account? (experiment 1 & 2)

▶ Is there a contrast between where the lower bound of expressions like at most and directional numeral modifiers start?
  (future research)

▶ Does distance play a role?
  (experiment 2)
Experiments

- Compare **at most** vs. **up to**: cancellable upper bound
- Control: **fewer than**: asserted upper bound  (Hackl, 2000; Nouwen, 2010a)
Outline

Inferences and modified numerals

The bounds of modified numerals

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Questions

Experiments
  Experiment 1
  Experiment 2

General discussion

Appendix
Experiment 1

- Greek
- NM's:
  - _lighoteros/-i/-o’ apo_, adj, ‘fewer than’ / _lighotero apo_, adv., ‘less than’
  - _to poli_, _lit_. the much, ‘at most’
  - _mehri_: DNM, also used in spatial & temporal domains
Experiment 1
Coherence judgement task

Naturally occurring sentences adapted from HNC (Hellenic National Corpus)

Claim about a subset which is compatible or incompatible with the assertion in the 1st sentence

$m$: No real round number

Claim about a subset which is compatible or incompatible with the assertion in the 1st sentence

$m$: $m < n$ ('under') or $m > n$ ('over') ($m$ close to $n$)
Interns in advertisement companies get \( \{ \text{less than} \} \) \( n \) dollars per month; the interns in some of them are paid \( m \) dollars per month.

Is the underlined sentence a good continuation of the first sentence?

\[ -3 \quad -2 \quad -1 \quad 0 \quad 1 \quad 2 \quad 3 \]

very very bad good
Interns in advertisement companies get \( \{ \text{less than} \} \), \( \{ \text{at most} \} \), \( \{ \text{up to} \} \) \( n \) dollars per month; the interns in some of them are paid \( m \) dollars per month.

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1st sentence:
- Naturally occurring sentences adapted from *HNC (Hellenic National Corpus)* (2009)
- \( n \): No real round number
Experiment 1
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very very bad good

2nd sentence:

Claim about a subset which is compatible or incompatible with the assertion in the 1st sentence

\( m: m < n \) (‘under’) or \( m > n \) (‘over’) \( (m \text{ close to } n) \)
Experiment 1

Methods

- Modifier (lighotero(s) apo ‘less than/fewer than’, to poli ‘at most’, mehri ‘up to’) x Discrepancy ($m < n$ ‘under’, $m > n$ ‘over’)
- 12 items, rotated through 6 lists
- 14 fillers (7 coherent discourses & 7 contradictory discourses), all appearing in every list
- 143 native speakers of Greek*
- Filled in on-line (created on www.surveymonkey.com)

* 98 Female, 2 no gender info; Mean age: 32.8; Age range: 19–67
Experiment 1

Results

'Over' condition: Significantly higher coherence rates for up to than for fewer than and at most ($\beta = 0.188$, SE = 0.089, $p < 0.05$ and $\beta = 0.277$, SE = 0.09, $p < 0.01$, respectively)

'Under' condition: Significantly lower coherence rates for up to than for fewer than and at most ($\beta = -0.215$, SE = 0.088, $p < 0.05$ and $\beta = -0.266$, SE = 0.088, $p < 0.001$, respectively)

No difference between fewer than and at most ($p > 0.05$)
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Conclusions

- Differences in ‘over’ condition:
  - The upper bound of *up to* in Greek is pragmatically derived (Note also: wider range of scores) → in favour of Blok’s (2015) account
  - The upper bound of *at most* in Greek is part of its lexical semantics → in favour of Blok (2015)

Interns in advertisement companies get up to 980 dollars per month; the interns in some of them are paid 950 dollars per month.
Experiment 1
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  - The upper bound of *at most* in Greek is part of its lexical semantics → in favour of Blok (2015)

- Differences in ‘under’ condition:
  - *Up to* associated with directivity: \( m < n \) → less felicitous

*Interns in advertisement companies get up to 980 dollars per month; the interns in some of them are paid 950 dollars per month.*
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Appendix
Experiment 2

- English
- Utterances with up to Num drawn from COCA Davies (2008)
Modifications in Experiment 2

- 2nd sentences as exceptions in discourse setting $\rightarrow$ different task
- Control for granularity: clearly non-round numbers
- $m$ close to $n$ $\rightarrow$ distance between $m$ and $n$ manipulated
CLAIM: Clarendon High School used its smart classrooms 50 times last year with \( \left\{ \begin{array}{l} \text{fewer than} \\ \text{at most} \\ \text{up to} \end{array} \right\} 39 \) students participating in this classroom environment.

FACT: On one occasion, the smart classroom was used at Clarendon High School last year, \( \left\{ \begin{array}{l} 10 \\ 37 \\ 41 \\ 68 \end{array} \right\} \) students participated.

How compatible is the CLAIM with the FACT?

-3  -2  -1  0  1  2  3

completely incompatible completely compatible
Experimental design

- Numeral modifier factor: fewer than / at most / up to
- \((n_{claim})\) vs. \((m_{fact})\) discrepancy conditions:
  - under \((m_{fact} < n_{claim})\):
    - under \((m_{fact} = n_{claim} \times 0.95)\)
    - way under \((m_{fact} = n_{claim} \times 0.25)\)
  - over \((m_{fact} > n_{claim})\):
    - over \((m_{fact} = n_{claim} \times 1.05)\)
    - way over \((m_{fact} = n_{claim} \times 1.75)\)
- Target items (N=28) rotated through lists
- 30 filler items with quantifiers (10 contradictions, 10 entailments, 10 implicatures)
- 45 participants on Amazon’s Mechanical Turk
Results

Differences between modifiers

▶ 'Over' condition: Significantly higher coherence rates for up to than for fewer than and at most ($\beta = .7879, SE = .1756, p < .01$) and $\beta = .639, SE = .17, p < .01$, respectively)

▶ 'Way over' condition: Higher coherence rates for up to than for fewer than (significantly) and at most (marginally) ($\beta = .41, SE = .176, p < .05$ and $\beta = .348, SE = .19, p = .07$, respectively)
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Results

Distance

rate for 'over' sig. higher than for 'way over' for each modifier, with the smallest effect for fewer than ($\beta = .69, SE = .170, p < .01$ vs. $\beta = .842, SE = .192, p < 0.01$ for at most and $\beta = .824, SE = .164, p < 0.01$ for up to)
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‘Under’ and ‘way under’ conditions: no differences between the modifiers and within each modifier
Conclusions

- Differences in ‘over’ and ‘way over’ conditions:
  - Blok (2015): at most provides an upper-bound entailment
  - Blok: up to’s upper bound is pragmatically-derived
    → over & way over conditions: up to better than at most and fewer than

- Differences wrt Distance:
  - Distance affects the upper bound construal
General findings

- Semantic vs. pragmatic upper bound in two different tasks → In favor of Blok’s pragmatic account
- Distance affects upper bound construal (Experiment 2)
- Up to associated with directivity, thus less compatible with a follow-up focussing on a subset (Experiment 1)
Up for discussion

- Effect of distance
  - Scalar/semantic distance – similar findings for other scalar terms (Beltrama and Xiang, 2013; Van Tiel et al., 2014): e.g., many/some $\sim\not\rightarrow$ not all $\succ$ many/some $\sim\not\rightarrow$ not most
Up for discussion

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  - Scalar/semantic distance – similar findings for other scalar terms (Beltrama and Xiang, 2013; Van Tiel et al., 2014): e.g.,
    - many/some ↝ not all > many/some ↝ not most
  - Distance in coherence rates may be mapped onto actual numeric distance → Effect in all MNs
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- Likert scale (vs. binary JT) $\rightarrow$ semantic $\neq$ pragmatic inferences (Cummins and Katsos, 2010; Katsos and Bishop, 2011)
  - A good metric?
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- Likert scale (vs. binary JT) → semantic ≠ pragmatic inferences (Cummins and Katsos, 2010; Katsos and Bishop, 2011)
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  - If so, greater range of ratings also a criterion (variation among speakers)?
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  - A good metric?
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- No difference between at most and fewer than – semantic identity or failure to find a difference?
Other points?
Thank you!


Blok, Dominique (2015), The semantics and pragmatics of directional numeral modifiers. SALT.


*HNC (Hellenic National Corpus)* (2009), Institute for Language and Speech Processing.


Bottom-of-the-scale effect

Schwarz et al. (2012) : *Up to* differs from expressions like *at most* and *maximally* in another way: it displays the *bottom-of-the-scale effect*

(20)  
a. At most ten people died in the crash. 
b. At most one person died in the crash.
Bottom-of-the-scale effect

- Schwarz et al. (2012) : *Up to* differs from expressions like *at most* and *maximally* in another way: it displays the *bottom-of-the-scale effect*

(20)  
a. At most ten people died in the crash.  
b. At most one person died in the crash.

(21)  
a. Up to ten people died in the crash.  
b. #Up to one person died in the crash.
Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect.
- All class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result.
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(22) a. #Up to one person died in the crash. $\{p_1\}$
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(22) a. #Up to one person died in the crash. \( \{ p_1 \} \)

(23) a. #At most zero people died in the crash. \( \{ p_0 \} \)
Bottom-of-the-scale effect

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\[(22)\]
\[
a. \ #\text{Up to one person died in the crash.} \quad \{p_1\}
\]
\[
b. \ \text{Up to two people died in the crash.} \quad \{p_1, p_2\}
\]

\[(23)\]
\[
a. \ #\text{At most zero people died in the crash.} \quad \{p_0\}
\]
Bottom-of-the-scale effect

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- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result.

(22)  
\( \begin{align*} 
\text{a. } & \text{Up to one person died in the crash.} \quad \{p_1\} \\
\text{b. } & \text{Up to two people died in the crash.} \quad \{p_1, p_2\} 
\end{align*} \)

(23)  
\( \begin{align*} 
\text{a. } & \text{At most zero people died in the crash.} \quad \{p_0\} \\
\text{b. } & \text{At most one person died in the crash.} \quad \{p_0, p_1\} 
\end{align*} \)
## Experiment 1: $n$ & $m$’s

<table>
<thead>
<tr>
<th>Item No</th>
<th>$n$</th>
<th>$m_{under}$</th>
<th>$m_{over}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
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<tr>
<td>2</td>
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<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>.8</td>
<td>1.2</td>
</tr>
<tr>
<td>8</td>
<td>43</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>9</td>
<td>152,000</td>
<td>150,000</td>
<td>152,700</td>
</tr>
<tr>
<td>10</td>
<td>980</td>
<td>950</td>
<td>1,000</td>
</tr>
<tr>
<td>11</td>
<td>249,000,000</td>
<td>242,000,000</td>
<td>249,300,000</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

- Not 100% round $n$’s, but small distance between $n$&$m_{over}$~⇒ possible granularity effects
- Same effects after excluding those items
Contradictory fillers (‘Bad fillers’)  

(24) The Panhellenic examinations started at the end of May; specifically, the examination of the first subject took place on the 10th of June.

Coherent fillers (‘Good fillers’)  

(25) Several countries have more than one official language; for example, Belgium has three official languages: Dutch, French and German.
Experiment 1: Targets vs. Good fillers

Results

Scores for Good fillers significantly higher than scores for ‘over’ condition for fewer than ($\beta = 1.224$, $SE = .181$, $p < .0001$), for up to ($\beta = 1.444$, $SE = .181$, $p < .0001$), and for at most ($\beta = 1.18$, $SE = .181$, $p < .0001$).
Experiment 1: Targets vs. Bad fillers

Results

Scores for Contradictions significantly lower than scores for ‘over’ condition for fewer than ($\beta = -1.32$, $SE = .2$, $p < .0001$), for up to ($\beta = -1.515$, $SE = .2$, $p < .0001$), and for at most ($\beta = -1.244$, $SE = .2$, $p < .0001$)
Experiment 2: Example filler items

All = implicature; some = entailment; none = contradiction

CLAIM: The community looked as peaceful as it had through the viewpoint’s telescope. Several of the houses on the near edge of town were holding yard sales.

FACT: \[
\begin{align*}
\text{All} & \quad \text{Some} & \quad \text{None} \\
\\text{of the houses on the near edge of town were holding yard sales.}
\end{align*}
\]

How compatible is the CLAIM with the FACT?

\[
\begin{array}{ccccccc}
-3 & -2 & -1 & 0 & 1 & 2 & 3 \\
\text{completely incompatible} & & & & & & \text{completely compatible}
\end{array}
\]
Experiment 2: Fillers

Results

Scores for ‘all’ (implicature) condition sig. higher than scores for ‘none’ (contradiction) condition ($\beta = -2.48$, $SE = .338$, $p < .01$)

Scores for ‘all’ (implicature) condition sig. lower than scores for ‘some’ (entailment) condition ($\beta = -2.00$, $SE = .306$, $p < .01$)
Scores for ‘all’ (implicature) condition sig. higher than scores for ‘over’ condition for at most ($\beta = -1.16$, $SE = .286$, $p < .01$) and for fewer than ($\beta = -1.52$, $SE = .269$, $p < .01$) but not for up to ($\beta = -.05$, $SE = .278$, $p = 0.843$)

Scores for ‘some’ sig. lower than score for ‘under’ for each modifier (fewer than: ($\beta = 2.65$, $SE = .357$, $p < .01$); at most: $\beta = 1.361$, $SE = .294$, $p < 0.01$; up to: $\beta = 1.93$, $SE = .313$, $p < 0.01$)