Analysis of the Occurrence of Laughter in Meetings

Kornel Laskowski\textsuperscript{1,2} & Susanne Burger\textsuperscript{2}

\textsuperscript{1}interACT, Universität Karlsruhe
\textsuperscript{2}interACT, Carnegie Mellon University

August 29, 2007
Introduction

• primary motivation: meeting understanding
primary motivation: meeting understanding
Introduction

• primary motivation: meeting understanding

- verbal
  - words
  - word fragments
- vocalization
primary motivation: meeting understanding

vocalization

verbal

words

word fragments

statements

questions
primary motivation: meeting understanding

- verbal
- words
- word fragments
  - statements
  - questions
  - backchannel
  - disruption
  - floor grabbers

vocalization
primary motivation: meeting understanding
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- verbal
  - words
  - word fragments
- non-verbal
  - statements
  - questions
  - backchannel
  - disruption
  - floor grabbers
- propositional content
- interaction management
primary motivation: meeting understanding

vocalization

- verbal
  - words
  - word fragments
- non-verbal
  - laughter
  - other

interaction-management

- propositional
  - content
- interaction
  - management

Kornel Laskowski & Susanne Burger
INTERSPEECH 2007, Antwerpen, Belgium
primary motivation: meeting understanding

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interaction−managing

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propositional content

interaction management
primary motivation: meeting understanding
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propositional content

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propositional content
interaction management
emotion-relevant
primary motivation: meeting understanding
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laughter detection is particularly important for understanding both interaction and emotion if laughter occurs frequently
primary motivation: meeting understanding

laughter detection is particularly important for understanding both interaction and emotion if laughter occurs frequently

to date, for meetings, it is not known

1 how much laughter there actually is

2 when it tends to occur
Text-Independent Modeling of Multi-Participant Meetings

To find interaction, model participants jointly.
Text-Independent Modeling of Multi-Participant Meetings

To find interaction, model participants *jointly*.

- essentially monologue
To find interaction, model participants **jointly**.

- “multi-logue”
To find interaction, model participants **jointly**.

- “multi-logue” with more participant involvement
Text-Independent Modeling of Multi-Participant Meetings

To find interaction, model participants **jointly**.

- a mathematical artifact (the Haar wavelet basis)
Text-Independent Modeling of Multi-Participant Meetings

To find interaction, model participants \textit{jointly}.

- “multi-logue”
Text-Independent Modeling of Multi-Participant Meetings

To find interaction, model participants **jointly**.

- “multilogue” with **laughter**
  - participants tend to wait to speak
  - participants do not wait to laugh
Three Questions of Interest

1. What is the quantity of laughter, relative to the quantity of speech?
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2. How does the durational distribution of episodes of laughter differ from that of episodes of speech?
Three Questions of Interest

1. What is the quantity of laughter, relative to the quantity of speech?
2. How does the durational distribution of episodes of laughter differ from that of episodes of speech?
3. How do meeting participants appear to affect each other in their use of laughter, relative to their use of speech?
Laugh Bouts vs Talk Spurts

- we will contrast the occurrence of laughter $L$ with that of speech $S$
Laugh Bouts vs Talk Spurts

- we will contrast the occurrence of laughter $\mathcal{L}$ with that of speech $\mathcal{S}$

**talk spurts** contiguous per-participant intervals of speech (Shriberg et al, 2001), containing pauses no longer than 300 ms (as in NIST RT-06s SAD)
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**$\mathcal{S}/\mathcal{L}$ islands** contiguous per-group intervals in which at least one participant talks/laughs
Laugh Bouts vs Talk Spurts

- we will contrast the occurrence of laughter $\mathcal{L}$ with that of speech $\mathcal{S}$
The ICSI Meeting Corpus

- naturally occurring project-oriented conversations with varying number of participants
The ICSI Meeting Corpus

- naturally occurring project-oriented conversations with varying number of participants
- the largest such corpus available

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<thead>
<tr>
<th>type</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>mod</td>
</tr>
<tr>
<td>Bed</td>
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<td>6</td>
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<tr>
<td>Bmr</td>
<td>29</td>
<td>7</td>
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- rarely, meetings contain additional, uninstrumented participants (we ignore them)
- we use all 75 meetings: 66.3 hours of conversation
Identifying Laughter in the ICSI Corpus

- laughter is already annotated with rich XML-style mark-up
Identifying Laughter in the ICSI Corpus

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1. orthographic, time-segmented transcription of speaker contributions (.stm)

Bmr011 me013 chan1 3029.466 3029.911 Yeah.
Bmr011 mn005 chan3 3030.230 3031.140 Film-maker.
Bmr011 fe016 chan0 3030.783 3032.125 <Emphasis> colorful. </Emphasis>
Bmr011 me011 chanB 3035.301 3036.964 Of beeps, yeah.
Bmr011 fe008 chan8 3035.714 3037.314 <Pause/> of m- one hour of - ...
Bmr011 mn014 chan2 3036.030 3036.640 Yeah.
Bmr011 me013 chan1 3036.280 3037.600 <VocalSound Description="laugh"/>
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Sample VocalSound Instances

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<tr>
<th>Freq Rank</th>
<th>Token Count</th>
<th>VocalSound Description</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11515</td>
<td>laugh</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>7091</td>
<td>breath</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4589</td>
<td>inbreath</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2223</td>
<td>mouth</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>970</td>
<td>breath-laugh</td>
<td>✓</td>
</tr>
<tr>
<td>11</td>
<td>97</td>
<td>laugh-breath</td>
<td>✓</td>
</tr>
<tr>
<td>46</td>
<td>6</td>
<td>cough-laugh</td>
<td>✓</td>
</tr>
<tr>
<td>63</td>
<td>3</td>
<td>laugh, &quot;hmmph&quot;</td>
<td>✓</td>
</tr>
<tr>
<td>69</td>
<td>3</td>
<td>breath while smiling</td>
<td>✓</td>
</tr>
<tr>
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- laughter is by far the most common non-verbal VocalSound
- idem for Comment instances
Segmenting Identified Laughter Instances

- found 12570 non-farfield VocalSound laughs
Segmenting Identified Laughter Instances

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  - 11845 were adjacent to a time-stamped utterance boundary or lexical item: endpoints were derived automatically
  - 725 needed to be segmented manually
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- manual segmentation performed by one annotator, checked by at least one other annotator
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Manual segmentation performed by one annotator, checked by at least one other annotator

Merging immediately adjacent VocalSound and Comment instances, and removing transcribed instances for which we found counterevidence, resulted in **13259 bouts**
Speech vs Laughter by Time

- 13259 laugh bouts
Speech vs Laughter by Time

- 13259 laugh bouts
- 110790 talk spurts
Speech vs Laughter by Time

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- by personal time:
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  - 442.6 hours total recorded audio
Speech vs Laughter by Time

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- by personal time:
  - 442.6 hours total recorded audio
  - 55.2 hours spent in talk spurts ($S$), $\equiv 12.47\%$
Speech vs Laughter by Time

- 13259 laugh bouts
- 110790 talk spurts
- by personal time:
  - 442.6 hours total recorded audio
  - 55.2 hours spent in talk spurts ($S$), $\equiv$ 12.47%
  - 5.6 hours spent in laugh bouts ($L$), $\equiv$ 1.27%
Speech vs Laughter by Time, by Participant
Talk Spurt Duration vs Laugh Bout Duration

![Graphs showing talk spurt and laugh bout durations](image-url)
# Vocalization Overlap

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<tr>
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<tbody>
<tr>
<td></td>
<td>per part per meet</td>
<td>1 2 3 ≥4</td>
</tr>
<tr>
<td>$S$</td>
<td>55.2 50.8</td>
<td>46.7 3.8 0.27 0.02</td>
</tr>
<tr>
<td>$L$</td>
<td>5.6 3.3</td>
<td>2.0 0.7 0.31 0.27</td>
</tr>
<tr>
<td>$S \cap L$</td>
<td>0.2 0.2</td>
<td>0.2 0.0 0.0 0.0</td>
</tr>
<tr>
<td>$S \cup L$</td>
<td>60.3 52.0</td>
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- in $S$ only, 84.6% of vocalization is not overlapped
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- In $L$ only, 35.7% of vocalization is not overlapped.
### Vocalization Overlap

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<th>Vocalizing Time, hrs per meet</th>
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<td></td>
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- the proportion of “laughed speech” is negligible
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- there is $\geq 3$ times as much 3-participant overlap when considering $S \cup L$ as opposed to $S$ only.
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<td>0.2</td>
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<td>S ∪ L</td>
<td>60.3</td>
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- there is $\approx 25$ times as much 4-participant overlap when considering $S \cup L$ as opposed to $S$ only
Overlap Dynamics

- does laughter differ from speech in the way in which overlap arises and is resolved?
Overlap Dynamics

- does laughter differ from speech in the way in which overlap arises and is resolved?
- look at transition probabilities under a first-order Markov assumption
Overlap Dynamics

- does laughter differ from speech in the way in which overlap arises and is resolved?
- look at transition probabilities under a first-order Markov assumption
  - discretize $L$ and $S$ segmentations using non-overlapping analysis frames
does laughter differ from speech in the way in which overlap arises and is resolved?

look at transition probabilities under a first-order Markov assumption

1. discretize $L$ and $S$ segmentations using non-overlapping analysis frames

2. train an Extended Degree-of-Overlap (EDO) model on the discretized $L$ and $S$ segmentations

\[ P(\{A\} \rightarrow \{A, B\}) \]
\[ P(\{A, B\} \rightarrow \{A\}) \]
\[ P(\{A\} \rightarrow \{B\}) \]

etc.
Overlap Dynamics

1. does laughter differ from speech in the way in which overlap arises and is resolved?
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   - discretize $L$ and $S$ segmentations using non-overlapping analysis frames
   - train an Extended Degree-of-Overlap (EDO) model on the discretized $L$ and $S$ segmentations
     - $P(\{A\} \rightarrow \{A, B\})$
     - $P(\{A, B\} \rightarrow \{A\})$
     - $P(\{A\} \rightarrow \{B\})$
     - etc.
3. compare inferred probabilities for $L$ and $S$
## Overlap Dynamics: Results

<table>
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<tr>
<th>Select EDO Transitions from ( (at \ t) ) to ( (at \ t + 1) )</th>
<th>500ms frames ( S )</th>
<th>( L )</th>
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<tbody>
<tr>
<td>{A} → {A}</td>
<td>82.94</td>
<td>57.96</td>
</tr>
<tr>
<td>{A} → {A, B}</td>
<td>6.21</td>
<td>8.43</td>
</tr>
<tr>
<td>{A} → {A, B, C, \ldots}</td>
<td>0.39</td>
<td>2.39</td>
</tr>
<tr>
<td>{A, B} → {A}</td>
<td>45.49</td>
<td>26.37</td>
</tr>
<tr>
<td>{A, B} → {A, B}</td>
<td>40.88</td>
<td>46.93</td>
</tr>
<tr>
<td>{A, B} → {A, B, C, \ldots}</td>
<td>4.46</td>
<td>13.65</td>
</tr>
<tr>
<td>{A, B, C, \ldots} → {A}</td>
<td>19.24</td>
<td>6.69</td>
</tr>
<tr>
<td>{A, B, C, \ldots} → {A, B}</td>
<td>40.94</td>
<td>17.45</td>
</tr>
<tr>
<td>{A, B, C, \ldots} → {A, B, C, \ldots}</td>
<td>29.44</td>
<td>71.04</td>
</tr>
</tbody>
</table>
## Overlap Dynamics: Results

<table>
<thead>
<tr>
<th>Select EDO Transitions</th>
<th>500ms frames</th>
</tr>
</thead>
<tbody>
<tr>
<td>from (at $t$) to (at $t + 1$)</td>
<td>$S$</td>
</tr>
<tr>
<td>${A} \rightarrow {A}$</td>
<td>82.94</td>
</tr>
<tr>
<td>${A} \rightarrow {A, B}$</td>
<td>6.21</td>
</tr>
<tr>
<td>${A} \rightarrow {A, B, C, \ldots}$</td>
<td>0.39</td>
</tr>
<tr>
<td>${A, B} \rightarrow {A}$</td>
<td>45.49</td>
</tr>
<tr>
<td>${A, B} \rightarrow {A, B}$</td>
<td>40.88</td>
</tr>
<tr>
<td>${A, B} \rightarrow {A, B, C, \ldots}$</td>
<td>4.46</td>
</tr>
<tr>
<td>${A, B, C, \ldots} \rightarrow {A}$</td>
<td>19.24</td>
</tr>
<tr>
<td>${A, B, C, \ldots} \rightarrow {A, B}$</td>
<td>40.94</td>
</tr>
<tr>
<td>${A, B, C, \ldots} \rightarrow {A, B, C, \ldots}$</td>
<td>29.44</td>
</tr>
</tbody>
</table>
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   - ie. 3-participant speech overlap is 2.5 times more likely than laughter to be resolved within 500 ms
We would like to thank:

- our annotators: Jörg Brunstein and Matthew Bell
- discussion: Alan Black and Liz Shriberg
- funding: EU CHIL