Characterizing Small Group Dynamics: classification and mining

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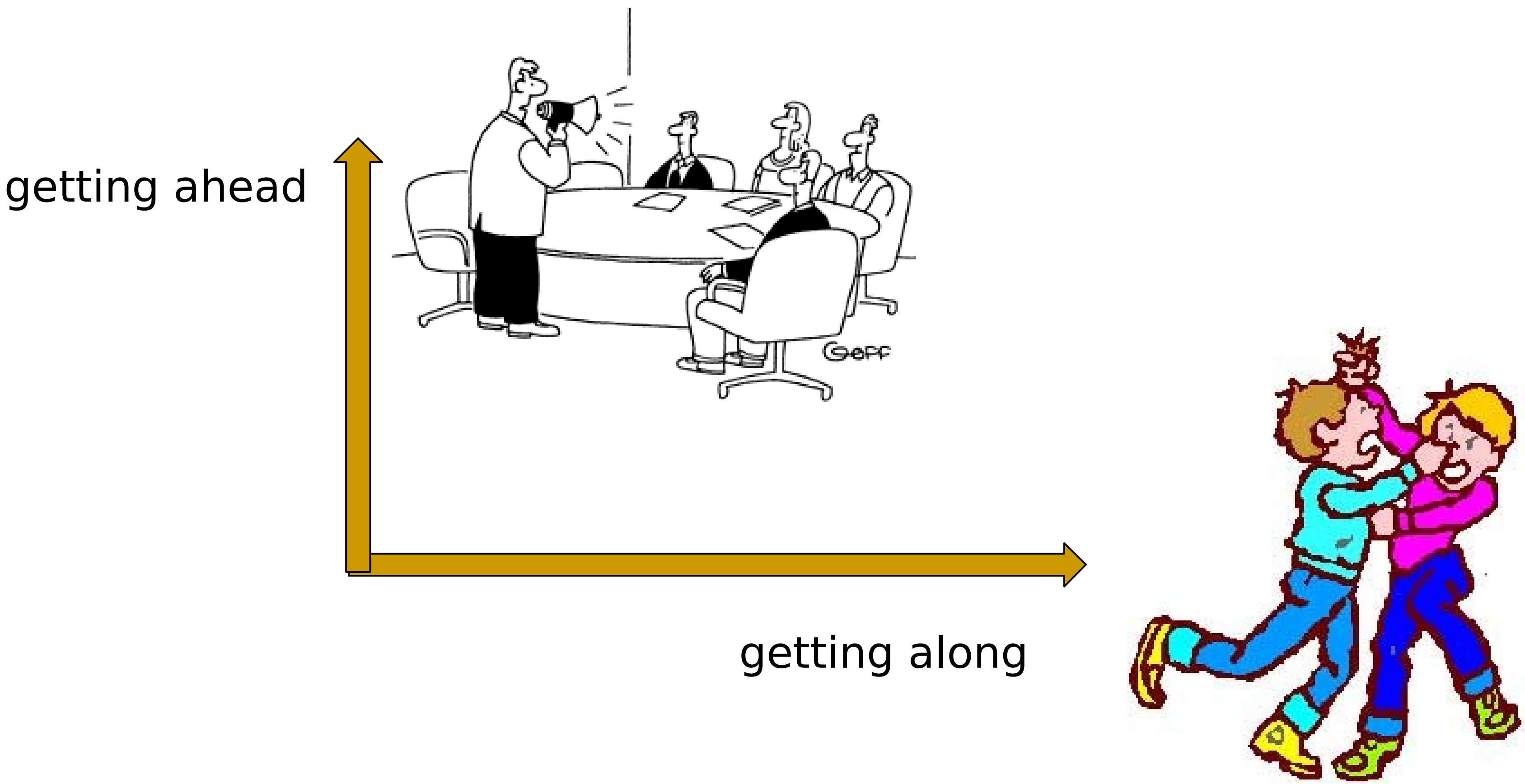
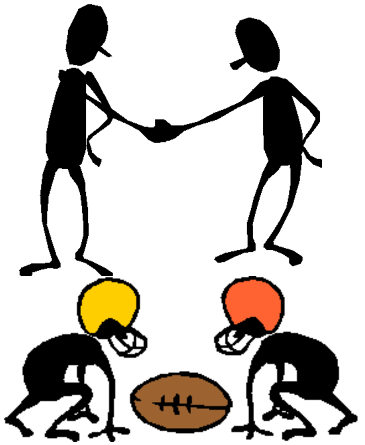
Related Work – small group, face-to-face

- Individual behaviour
  - Dominance and Status (Jayagopi et al. 2009)
  - Roles (Vinciarelli 2007)
  - Personality (Pianesi et al. 2008)
- Group behaviour
  - Small set of meetings – interactivity and centrality (Otsuka et al. 2006)
- Conversational analysis
  - Group meeting activities – monologue, discussion, presentation (Zhang et al 2005, Dielmann et al 2007)

Modeling - Individual or Group behaviour

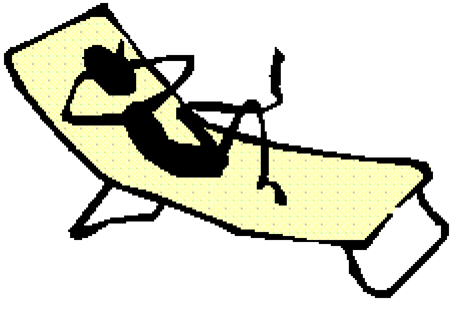


Applications: characterizing groups



Monitering team cohesiveness

Identify leadership skills



Identify irresponsible behaviour

Two different approaches

- Classification task
  - discriminative training
  - requires ground-truth
- Mining task
  - Clustering
  - does not require ground-truth

Two different approaches

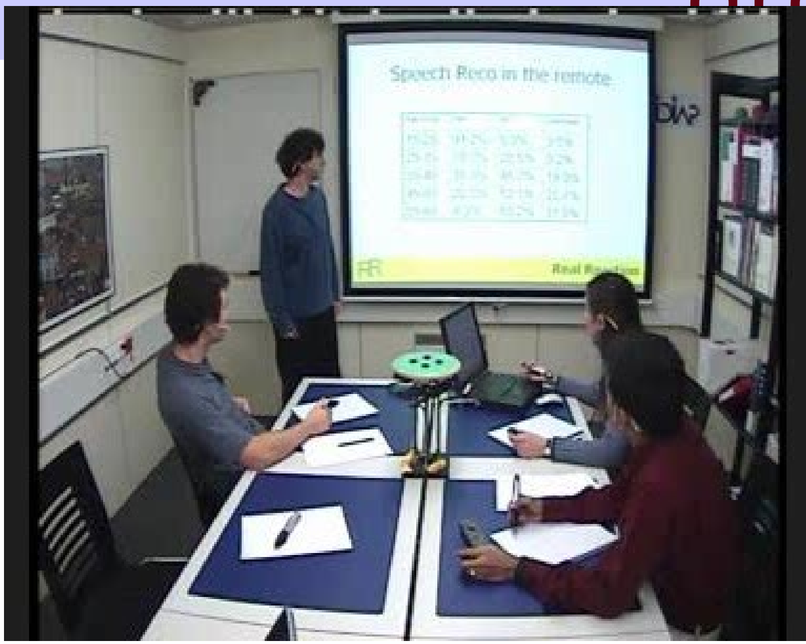
Classification task

- discriminative training
- requires ground-truth

Mining task

- Clustering
- does not require ground-truth

Samples – two very different groups



AMI meeting dataset:

To design a remote control together
Each participant had a role

COOPERATIVE

The Apprentice dataset:

To fire a participant
6th season of a TV show

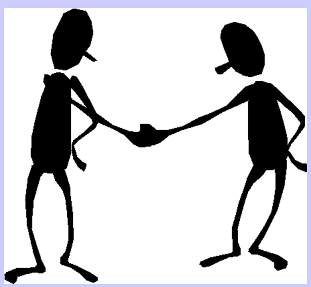
COMPETITIVE

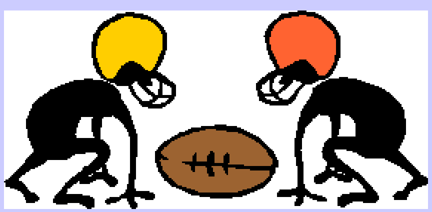
Motivation and hypotheses

Motivation

Objectives of a group => Group Dynamics (Mc Grath 1984)

Hypothesis 1



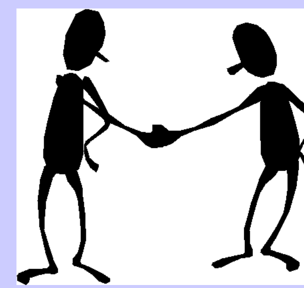


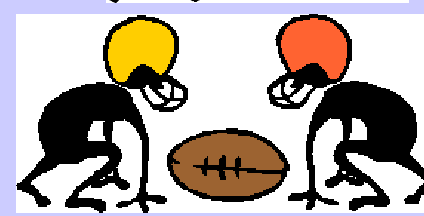
Group Dynamics

Hypothesis 2

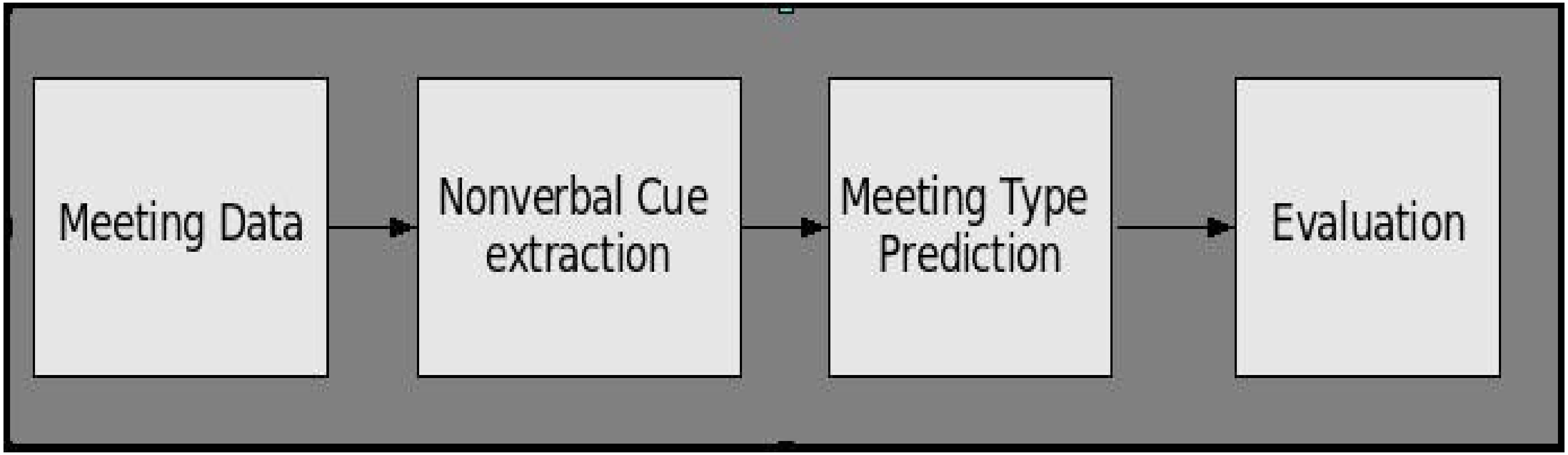
Nonverbal

Cues





Our Approach



Meeting Dataset

34 five-min meetings
4 participants

15 meetings
Average dur – 6 min
Participants median - 7

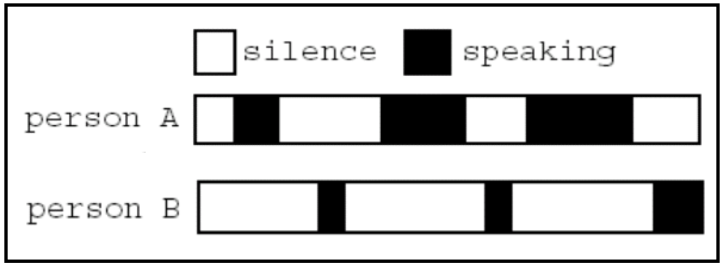
Nonverbal cues: speaking activity based

- from head set microphones

speech

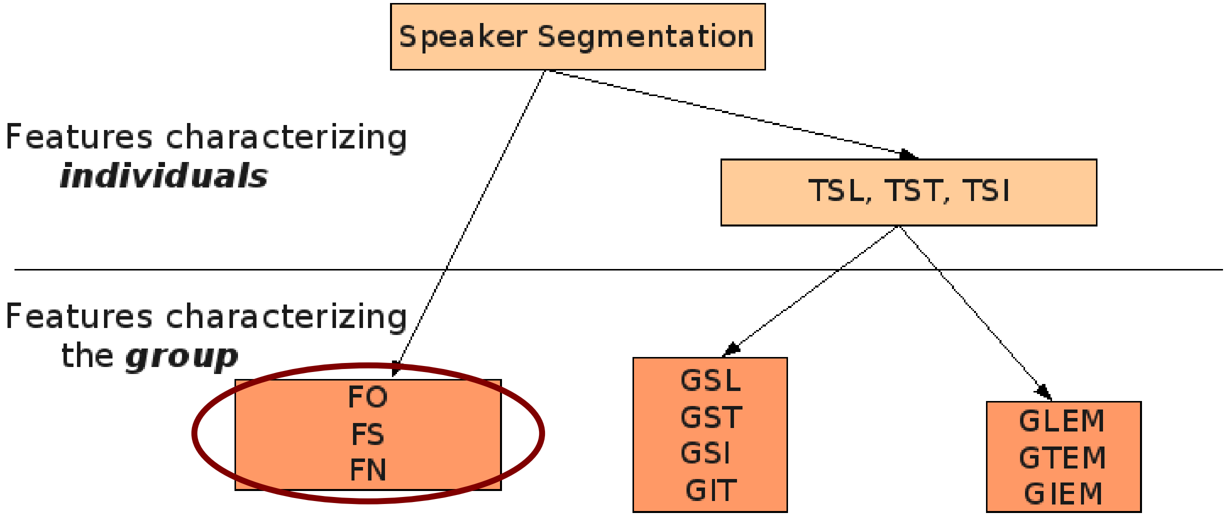
speaking-turn segmentation

- from speaking-turn segmentation
  - speaking length (TSL)
  - number of turns (TST)



  - number of successful interruptions (TSI)

Nonverbal cues: speaking activity based

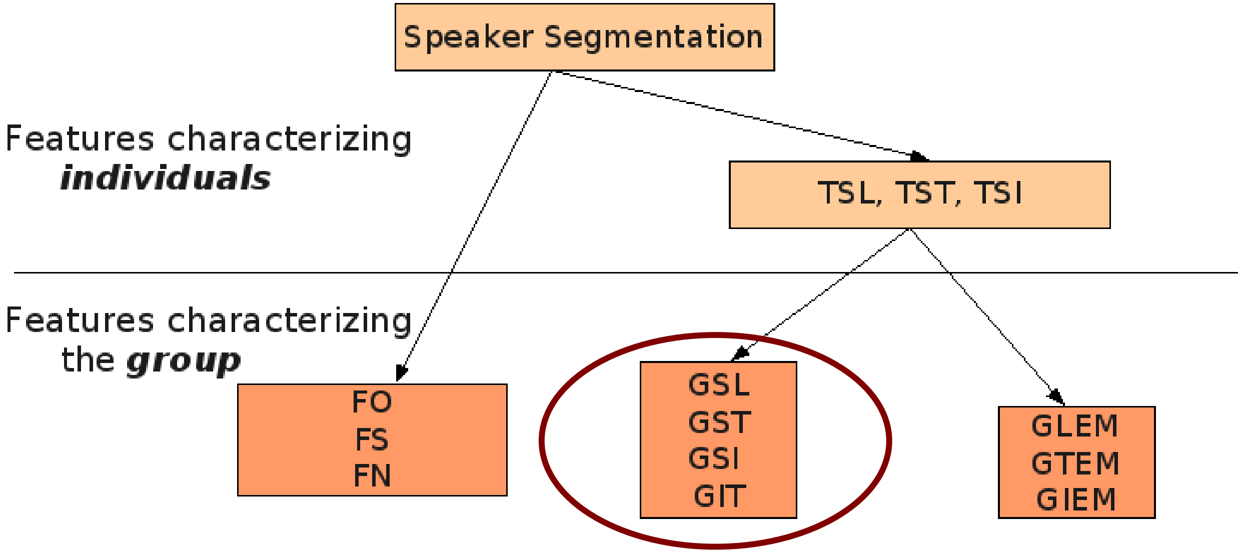


Fraction of Overlapped Speech $FO = \frac{O}{T}$

Fraction of Silence $FS = \frac{S}{T}$

Fraction of Non-overlapped Speech $FN = \frac{N}{T}$

Nonverbal cues: speaking activity based



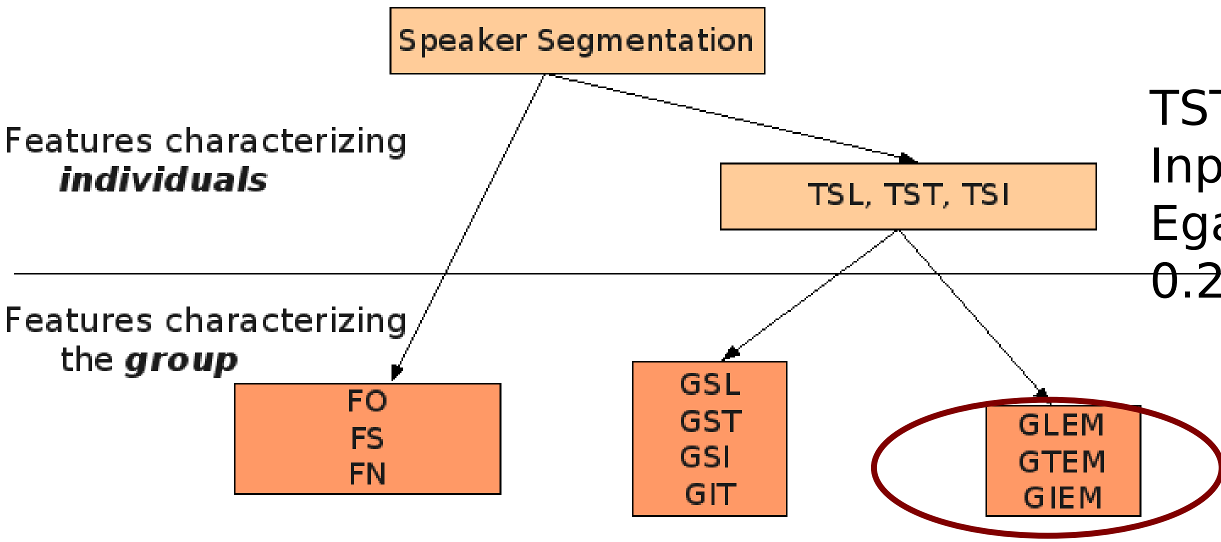
Group Speaking Length (GSL) $\sum_i TSL(i) \Big/ MeetingDuration$

Group Speaking Turns (GST) $\sum_i TST(i) \Big/ MeetingDuration$

Group Speaking Interruptions (GSI) $\sum_i TSI(i) \Big/ MeetingDuration$

Group Speaking Interruption-to-Turns Ratio (GIT) $\sum_i TSI(i) \Big/ \sum_j TST(j)$

Nonverbal cues: speaking activity based



TST – [20 15 10 5]
Input – [0.4 0.3 0.2 0.1]
Egal - [0.25 0.25 0.25 0.25]
GTEM = 0.17

Egalitarian measure – Bhatttacharya Distance
BD(input,egal. Vector)
0 if egalitarian

Group Speaking Length Egalitarian Measure

roup Speaking Turns Egalitarian Measure

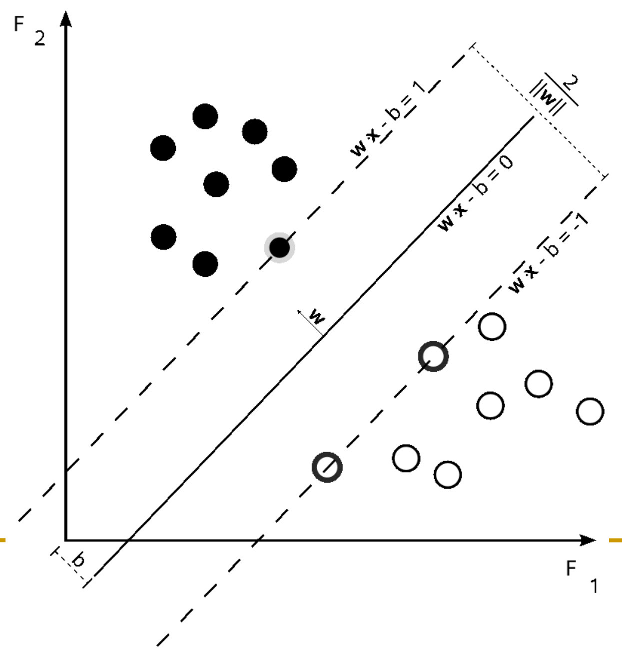
roup Speaking Interruptions Egalitarian Measure

Meeting Prediction using 2 classifiers

Using naive bayes classifier (likelihood ratio)

$$\log\left(\frac{P(A/(f_1, f_2, \ldots f_N))}{P(B/(f_1, f_2, \ldots f_N))}\right) \qquad \log\left(\frac{P(f_1/A).P(f_2/A)\ldots P(f_N/A).P(A)}{P(f_1/B).P(f_2/B)\ldots P(f_N/B).P(B)}\right)$$

Using SVM with quadratic kernel

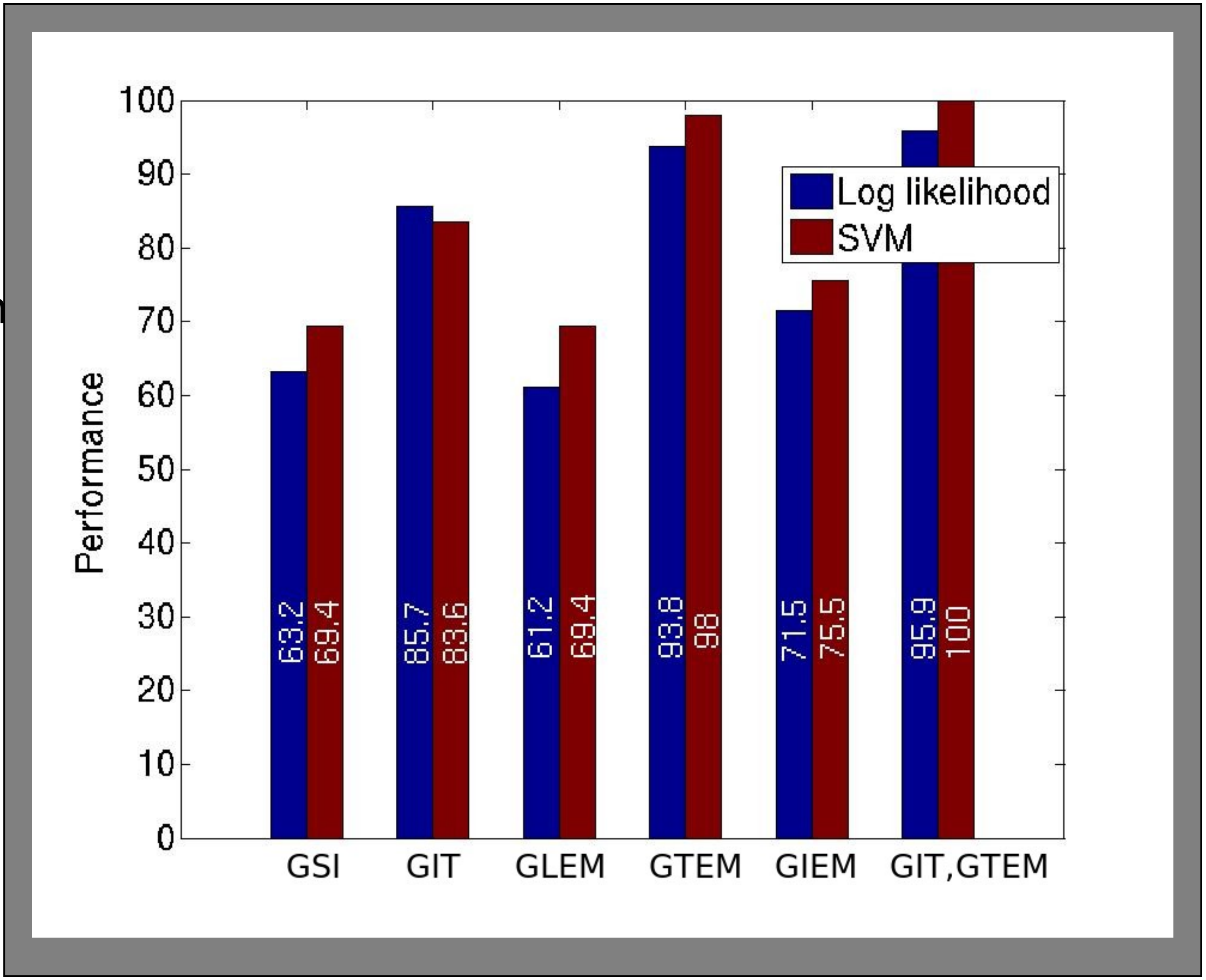


Results

•Group Interruption To Turn Ratio (GIT), Group Turn Egalitarian Measure (GTEM) Best single cues

-Combination of GIT and GTEM using an SVM classifies 100 % Correct

- Fraction of overlap, Group Speaking Ratio did not predict well



Conclusion: Classification

- Our two hypotheses – ‘competitive and cooperative meetings have different group dynamics’ and ‘nonverbal features capture this difference’ and was verified
- Characterization of entire group by the aggregation (both temporal and person-wise) of their nonverbal behaviour is promising
- GIT, GTEM are best single cues
- Combination of GIT, GTEM using an SVM – 100% accuracy
- The current limitation is the moderate size of dataset
- Future work would expand dataset, features and classification classes.

Two different approaches

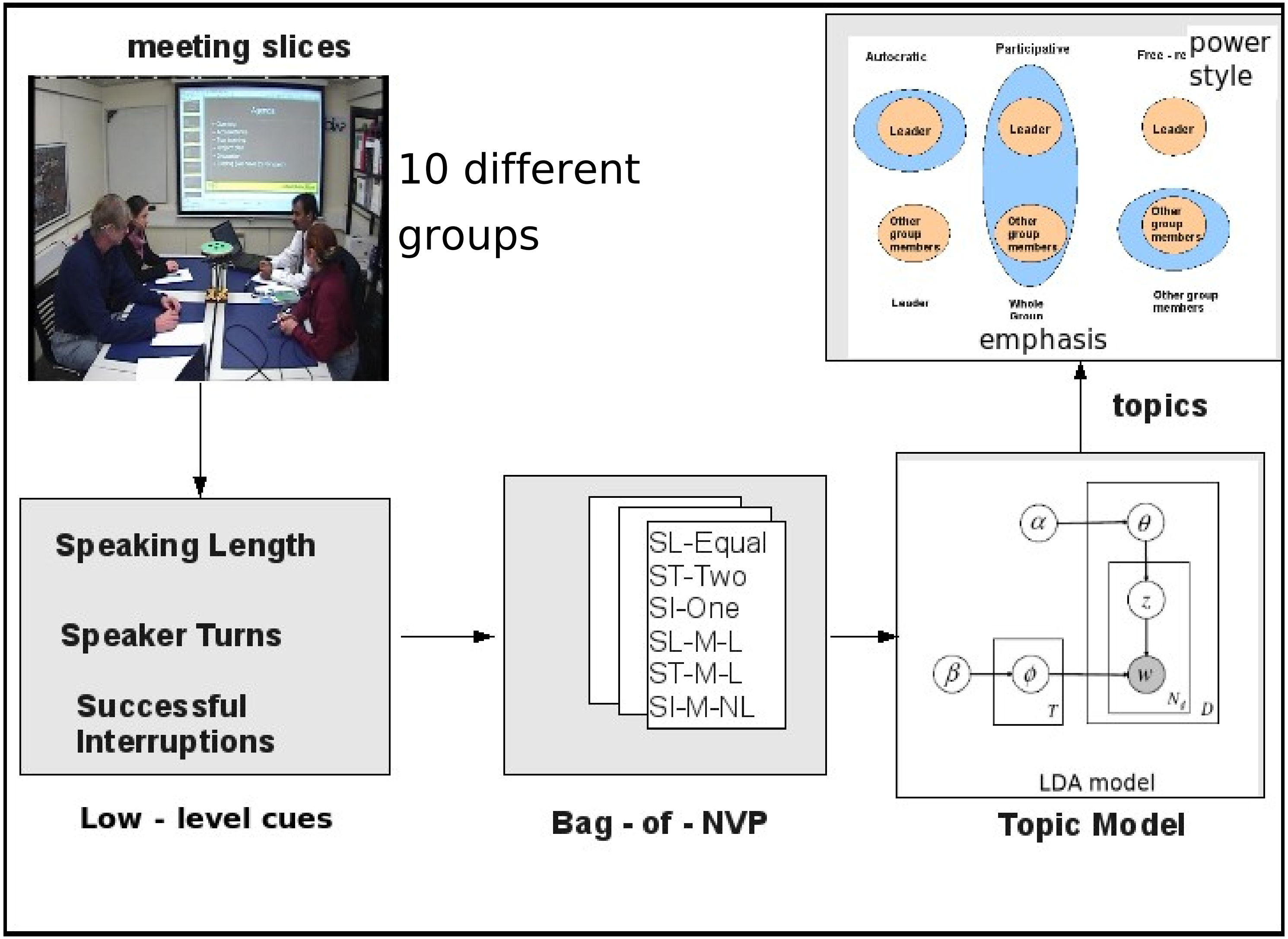
Classification task

- discriminative training
- requires ground-truth

Mining task

- Clustering
- does not require ground-truth

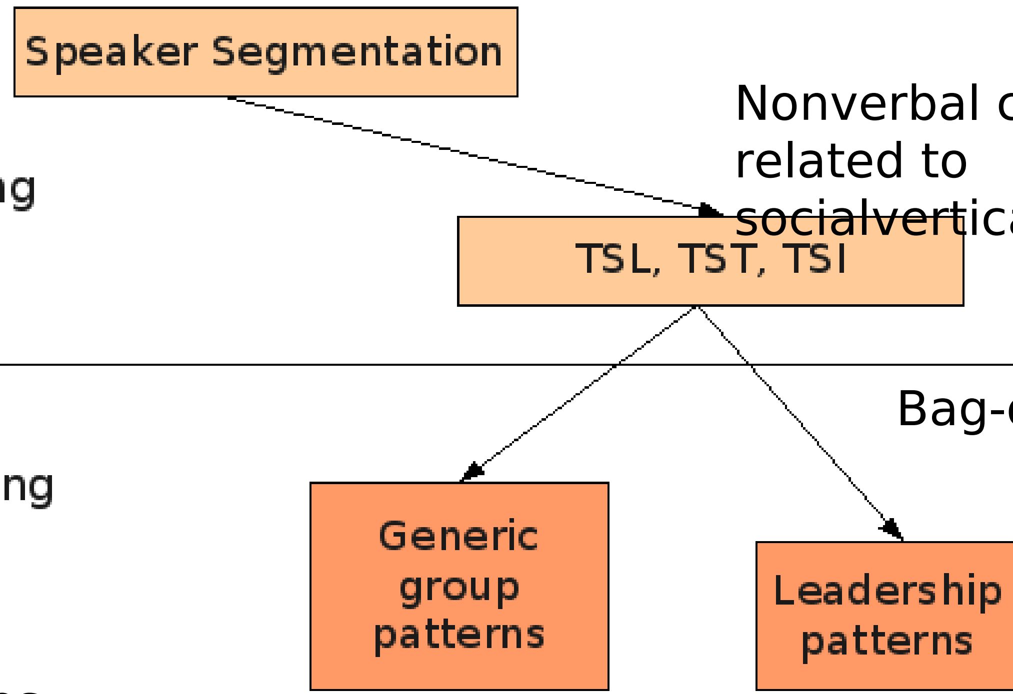
Mining task


meeting slices
10 different groups
power style
Autocratic
Participative
Leader
Other group members
Leader
Whole Group
Other group members
emphasis
topics
Speaking Length
Speaker Turns
Successful Interruptions
Low - level cues
SL-Equal
ST-Two
SI-One
SL-M-L
ST-M-L
SI-M-NL
Bag - of - NVP
LDA model
Topic Model

Features

Nonverbal cues
related to
socialverticality

Features characterizing
individuals



Bag-of-NVPs

Features characterizing
the ***group***

Bag-of-NVPs
-allows fusion of cues
-removes noise in the
features
-allows comparison of
groups
of different size

Quantize TSL, TST,
TSI into one of five
Classes (15 words)

Describe the
position of the
leader (6 words)

Generic group patterns - construction

TSL, TST, TSI

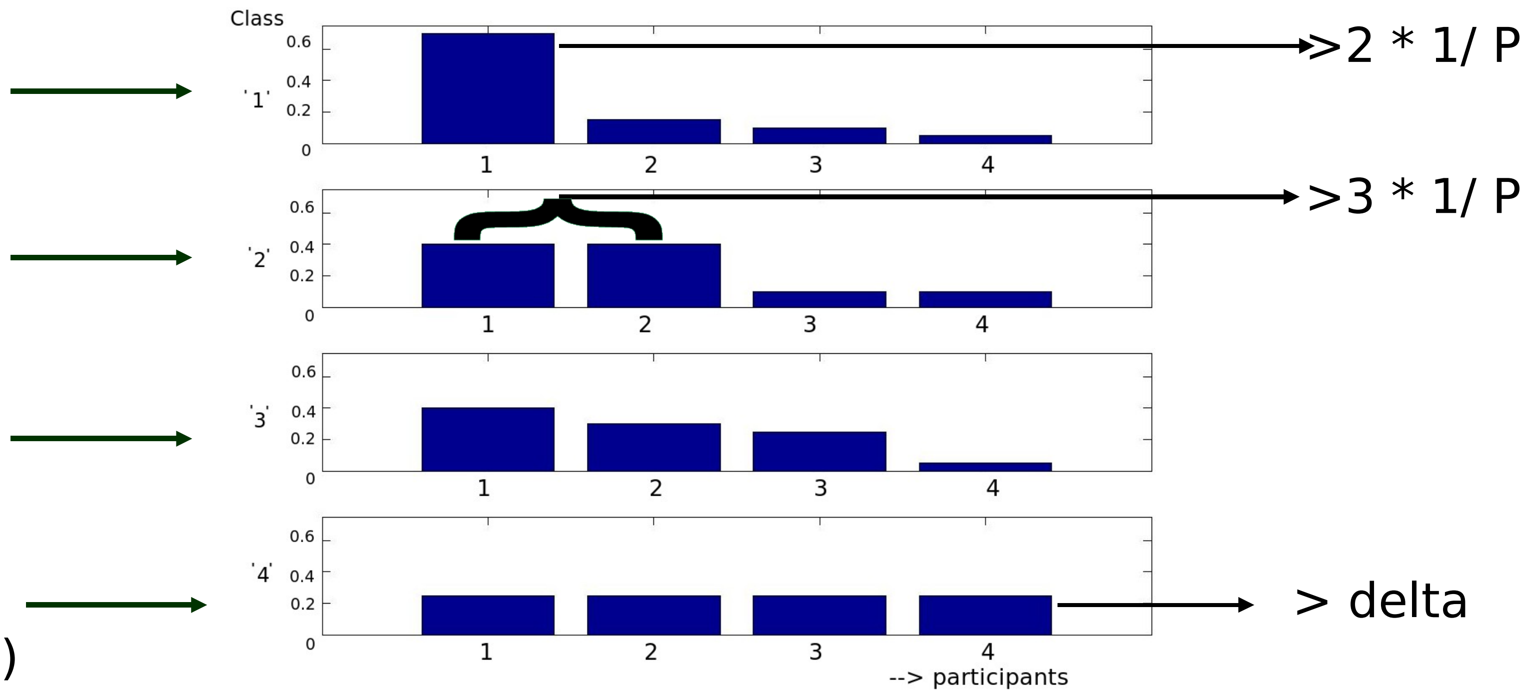
Silence (**0**)

One (**1**)

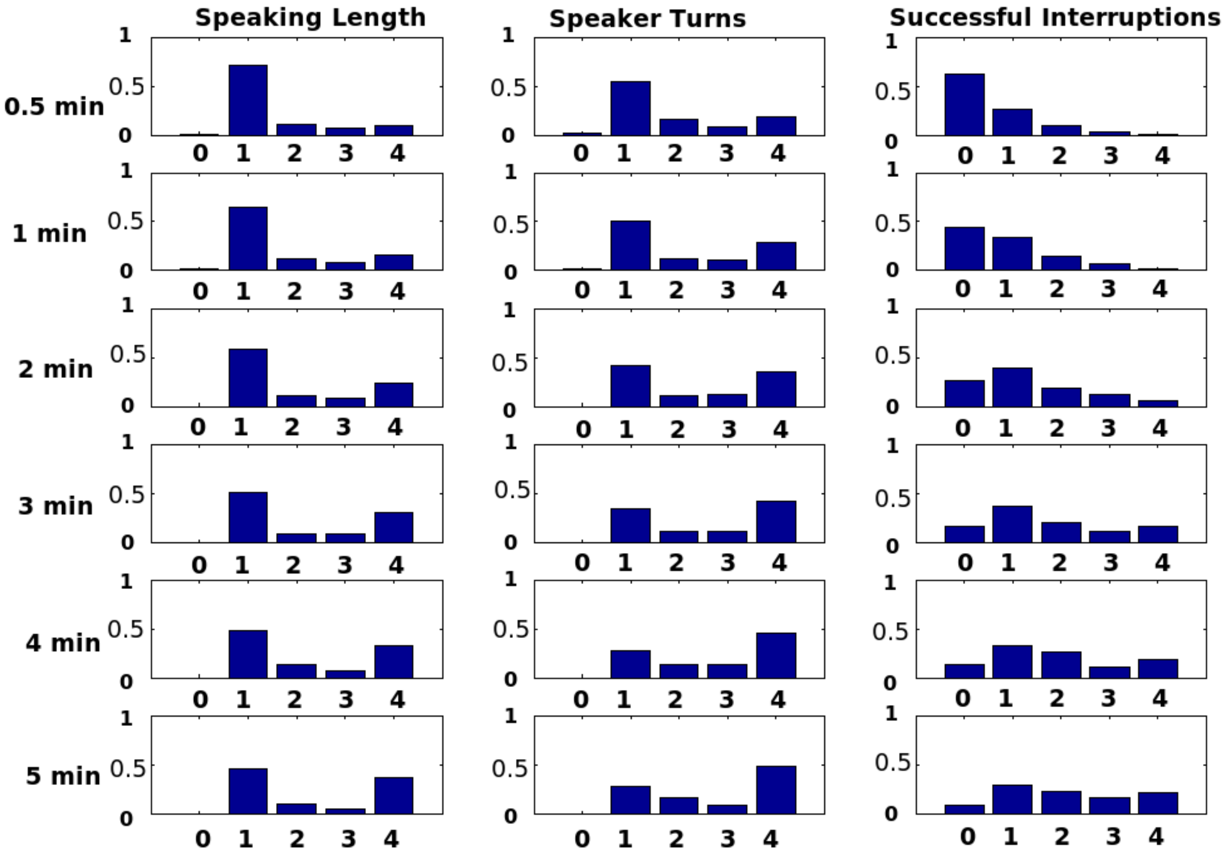
Two (**2**)

Rest (**3**)

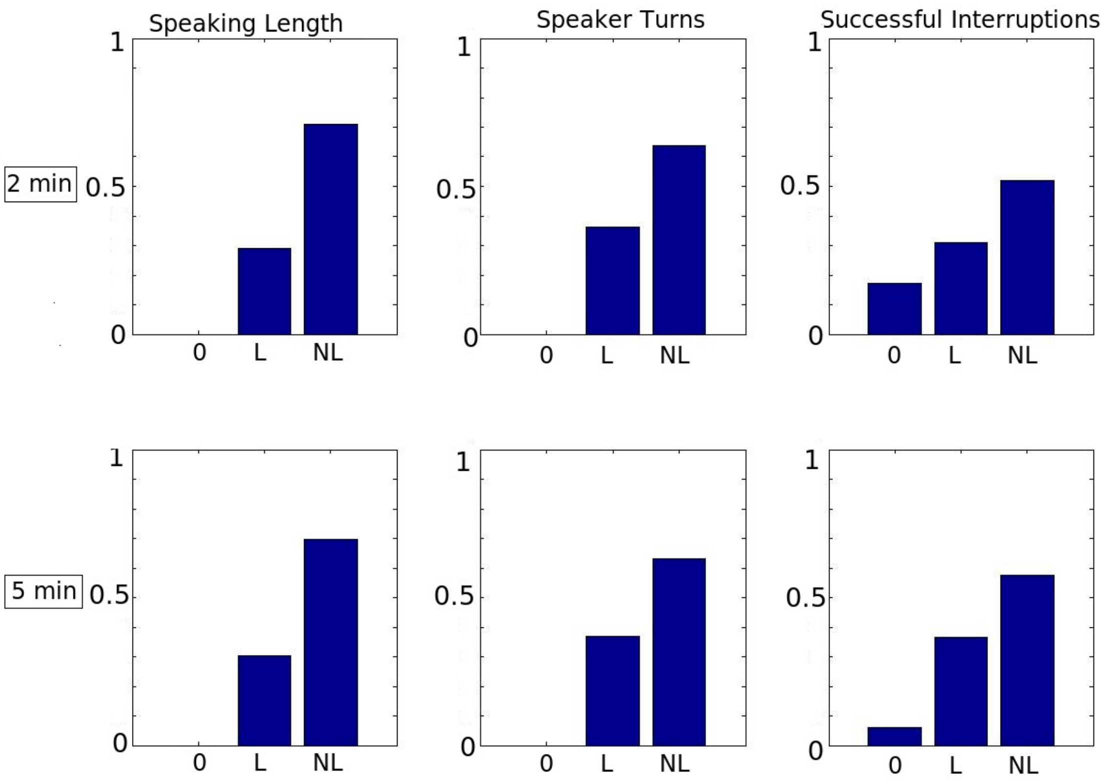
Equal (**4**)



Generic group patterns – at diff. scales



Leadership patterns – at diff. scales



Latent Dirichlet Allocation (LDA) model

$$P(w_i) = \sum_{t=1}^{T} P(w_i \mid z_i = t) P(z_i = t)$$

Input (example) :

SL-One
ST- Two
SI- Equal
SL-L
ST-L
SI-NL

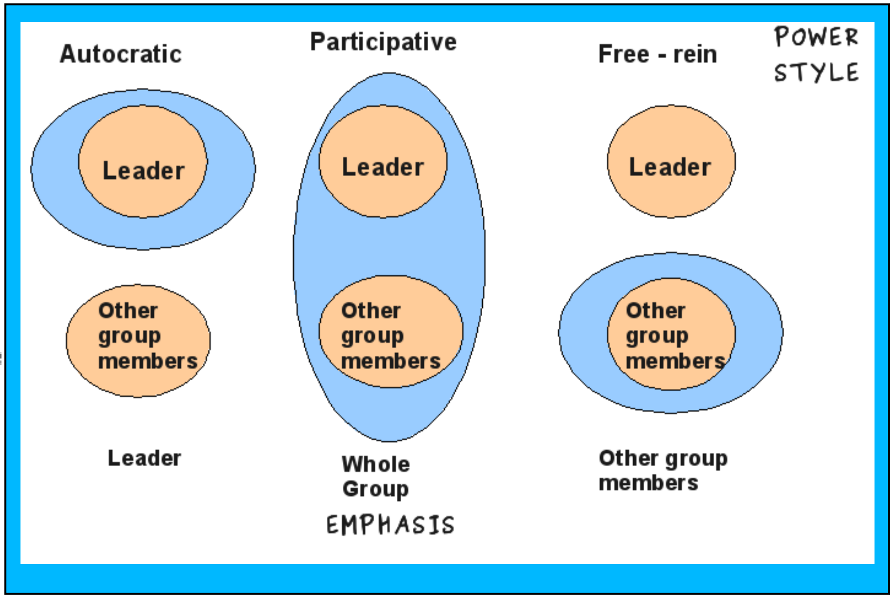
Say T = 3

5 min documents = 873 (overlapping)
2 min documents = 501 (non-overlapping)

LDA based discovery at 2 min & 5 min

Topic 1 - LDA		Topic 2 - LDA		Topic 3 - LDA	
$P(z) = 0.32$		$P(z) = 0.33$		$P(z) = 0.35$	
'Autocratic'		'Participative'		'Free-rein'	
Word	$P(w\|z)$	Word	$P(w\|z)$	Word	$P(w\|z)$
SL-L	0.2	ST-Equal	0.25	SL-One	0.22
ST-L	0.2	SL-Equal	0.18	SL-NL	0.19
SI-L	0.16	ST-NL	0.15	SI-One	0.16
SI-Two	0.11	SL-NL	0.15	SI-NL	0.16
SI-Rest	0.08	SI-NL	0.14	ST-NL	0.13
ST-Rest	0.07	SI-Equal	0.12	ST-One	0.12

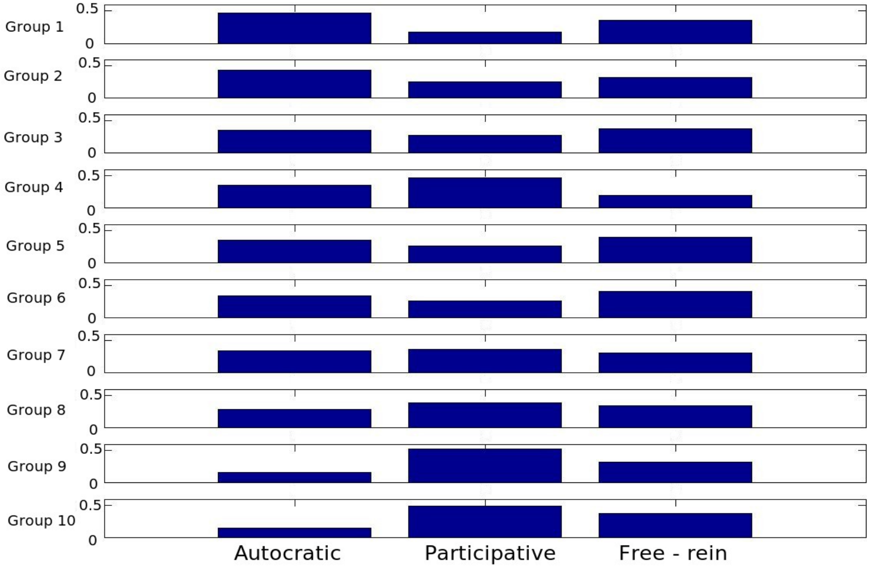
Table 1: LDA based discovery at 5-minute scale



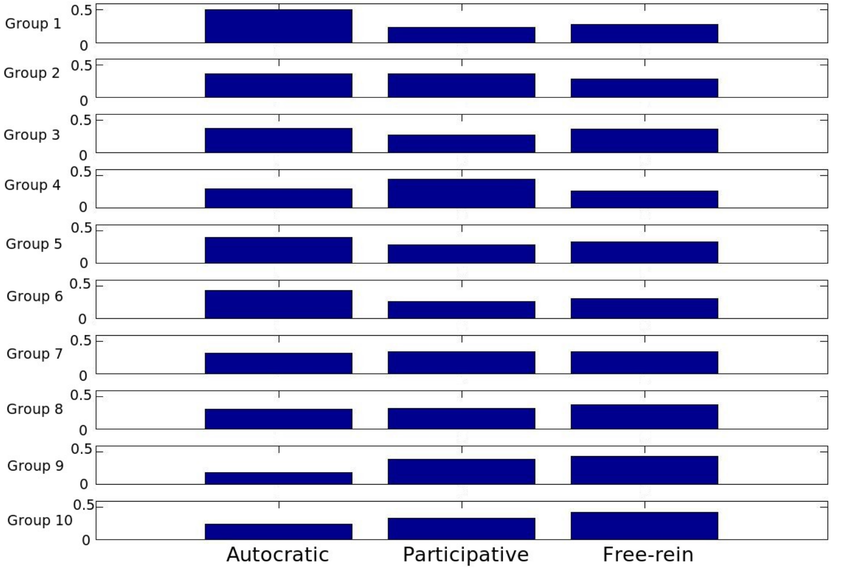
Topic 1 - LDA		Topic 2 - LDA		Topic 3 - LDA	
$P(z) = 0.31$		$P(z) = 0.35$		$P(z) = 0.34$	
'Autocratic'		'Participative'		'Free-rein'	
Word	$P(w\|z)$	Word	$P(w\|z)$	Word	$P(w\|z)$
ST-L	0.22	ST-Equal	0.19	SL-NL	0.30
SL-One	0.20	SI-L	0.16	SI-NL	0.19
SL-L	0.19	SL-Equal	0.12	ST-NL	0.18
ST-One	0.15	ST-NL	0.12	SI-One	0.16
SI-Silence	0.13	SI-Two	0.10	SL-One	0.11
ST-Two	0.06	ST-Rest	0.06	ST-One	0.07

Table 2: LDA based discovery at 2-minute scale

Average topic distribution over groups



5 min slices



2 min slices

Conclusion: Mining

- We investigated the problem of discovering nonverbal group patterns using topic models.
- We proposed a novel bag-of-NVPs approach to characterize groups.
- Generic group patterns – described the group and leadership patterns coded the position of the leader.
- Using an LDA model, the topics discovered fairly mimic well the three classic leadership styles of Lewin et al – autocratic, participative and free-rein.
- Future work – annotation to further validate our claims, expand the bag-of-NVPs, try author-topic model etc.

ACKNOWLEDGEMENTS

- Bogdan Raducanu

- Daniel Gatica-Perez