Analysis and Compensation of the Reaction Lag of Evaluators in Continuous Emotional Annotations

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Emotional Descriptors

- Emotional labels at sentence level
  - One descriptor assigned to a segment
    - sentence, turn, chunk, word
  - Long segments: variations are not captured
- Continuous labels
  - Track emotional content continuously over time
  - They capture localized emotional behaviors
  - Facilitate emotion analysis at different resolutions

Continuous Emotional Labels

- Record position of a cursor controlled by user
- Examples of these GUIs:
  - FEELTRACE [Cowie et al. 2000] and Gtrace [Cowie et al., 2012]
  - MoodSwings [Kim et al., 2008] and EmuJoy [Nagel et al., 2007]

Feeltrace - picture from Cowie et al. (2000)

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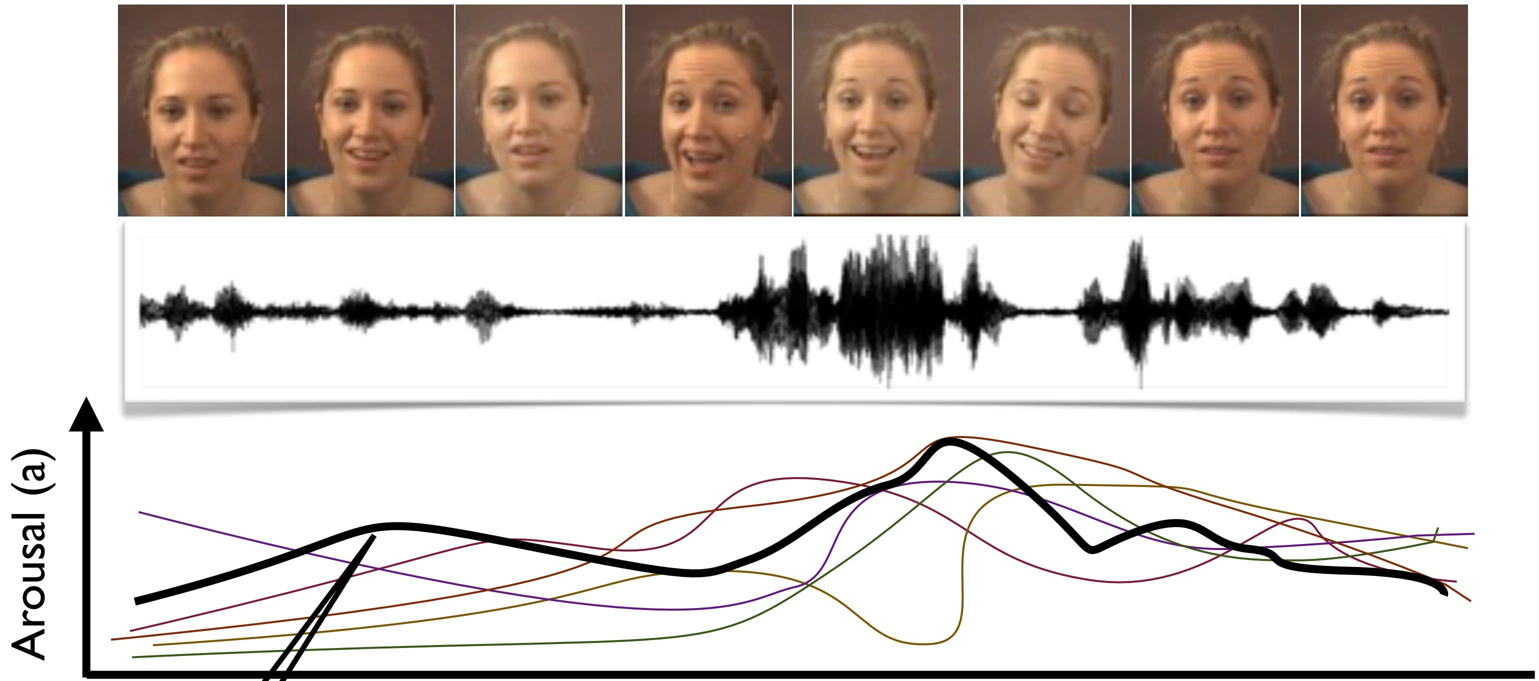
Discrete Classification Problem

- Approach: estimate mean across evaluators



Mean trajectory

$$\text{Segment} \in \begin{cases} \text{Class 1} & \text{if } \bar{a} < 0.5 \\ \text{Class 2} & \text{if } \bar{a} \geq 0.5 \end{cases}$$

(Or regression model)

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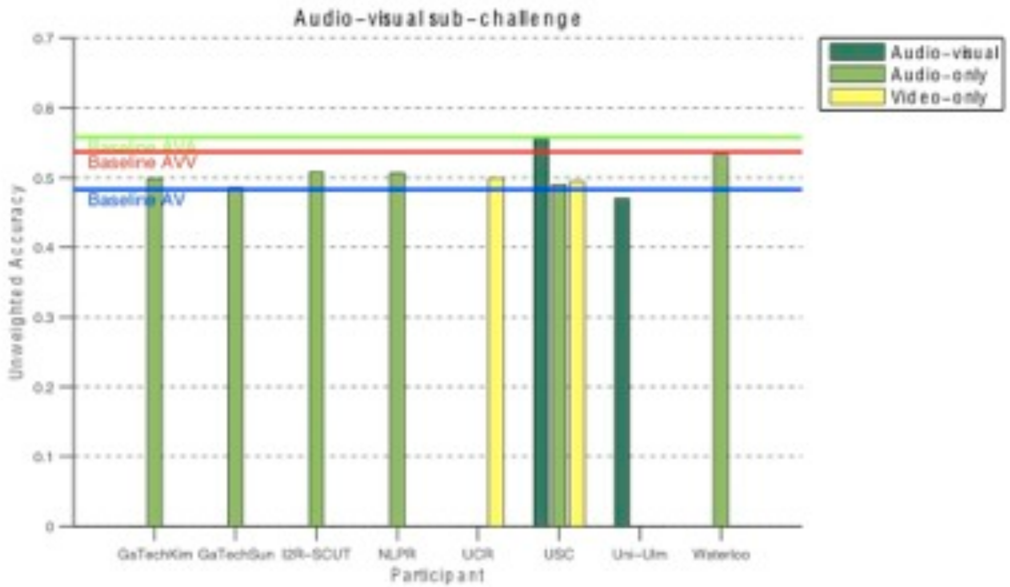
Motivation

- Emotional classification results in naturalistic database was very low - SEMAINE [McKeown et al., 2012]
    - Challenging task - spontaneous emotions

AVEC 2011

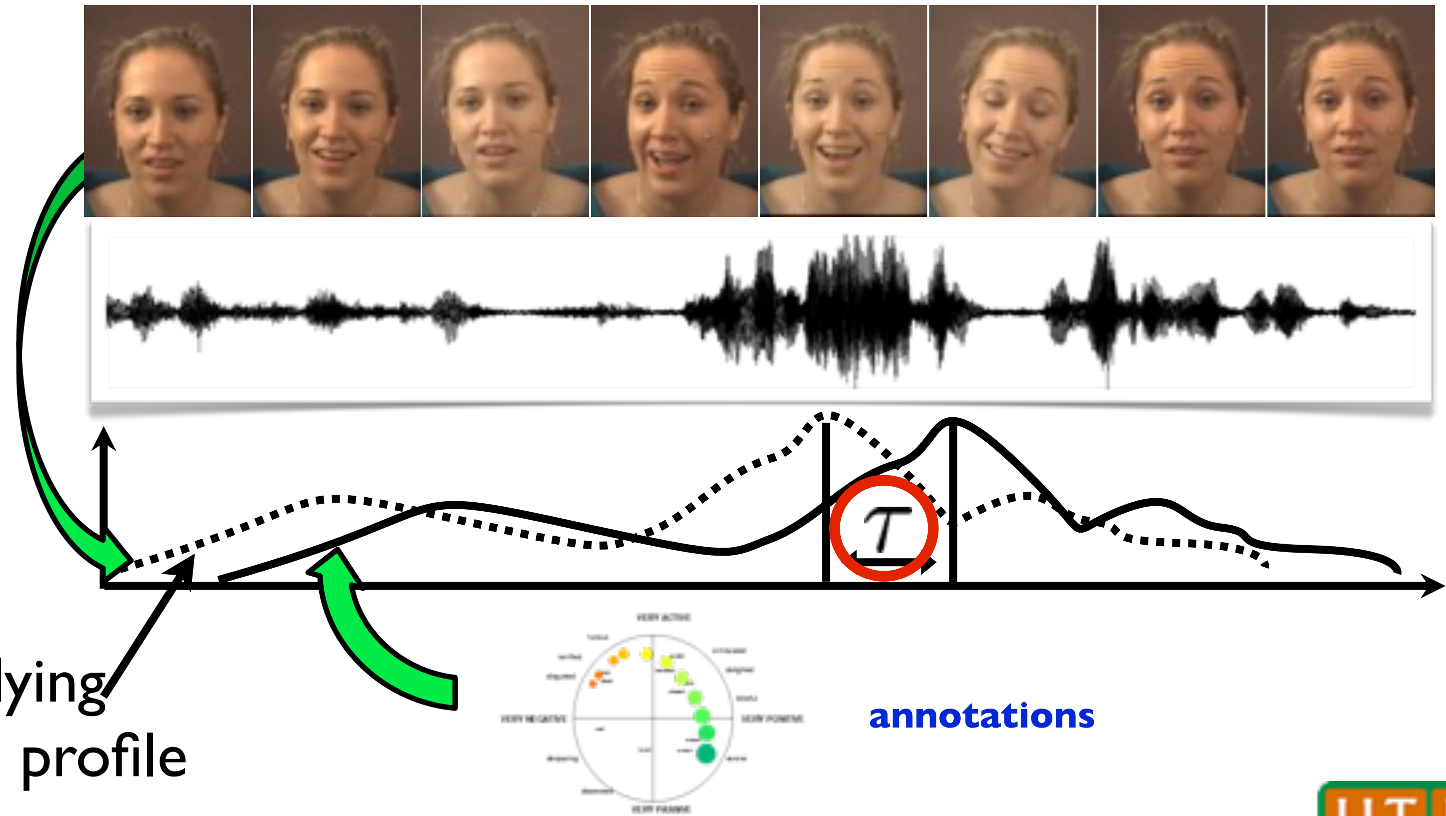


Is there any other reason for low performance?

Source: http://sspnet.eu/avec2011

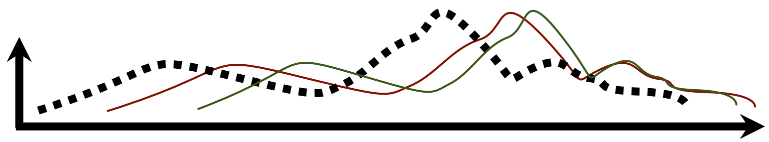
Evaluator Reaction Lag

- Emotion assessment
  - Sense the stimuli, appraise the emotional message, define their judgment, moving the cursor

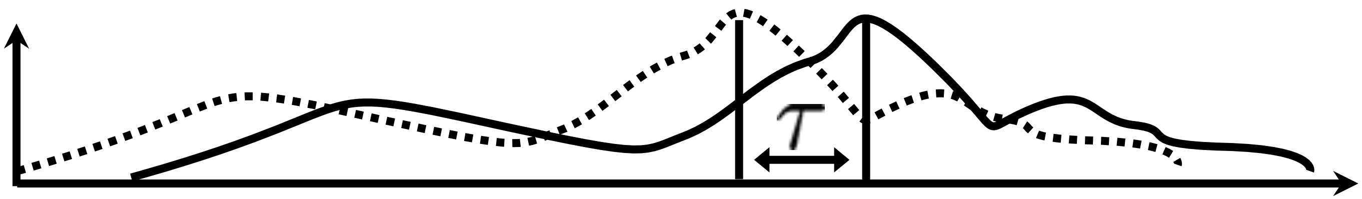


Problem Formulation

- How to formulate the estimation of the reaction lag?
  - Constant reaction lag or time-variant
  - Annotator-dependent or annotator-independent



- Assumptions in this work
  - Constant reaction lag across time
  - Annotator-independent (mean across evaluators)
    - Preliminary results on annotator-dependent

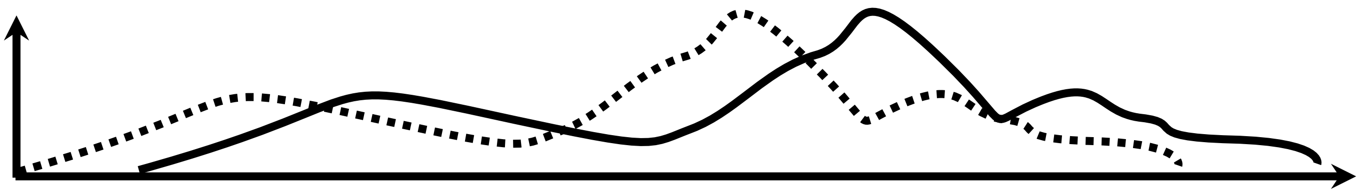


Estimating Reaction Lag

- Proposed approach based on mutual information (MI)
  - Capture the dependency between two random variables
- Find the optimal reaction lag

$$\hat{\tau} = \arg_{\tau} \max I[EMO; ANN^{\tau}]$$

  - EMO = emotional content of the stimulus
  - ANN^{τ} = shift version of emotional annotation



Estimation of Emotional Content

$$\hat{\tau} = \arg_{\tau} \max I[EMO; ANN^{\tau}]$$

- *EMO* represented by facial features capturing the deviations from neutral behaviors (EMO^F)
- Why acoustic features are not included?
  - During silence, speech features are not available
  - Single frame does not convey enough emotion cues
- Distributions are estimated with k-means
  - $P(EMO^F)$
  - $P(ANN^{\tau})$
  - $P(ANN^{\tau}, EMO^F)$

SEMAINE Database

Source: McKeown et al. (2012)

user

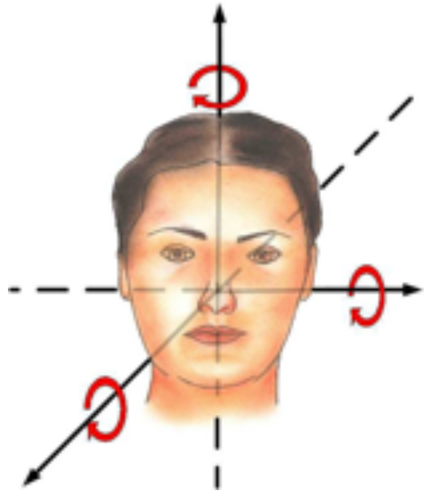
operator (stimulus)

- Emotionally colored interactions
- Annotations: FEELTRACE (activation, valence)
- 44 sessions, 9 unique speakers (users)
  - Sessions with annotations and correctly extracted facial features

Facial Features

- Facial features extracted with CERT [Bartlett et al. 2006]
  - Action Units from FACS (deviation from neutral faces)
  - Head rotation (Jaw, Yaw and Pitch)

AU	Description	AU	Description
AU 1	Inner Brow Raise	AU 15	Lip Corner Depressor
AU 2	Outer Brow Raise	AU 17	Chin Raise
AU 4	Brow Lower	AU 18	Lip Pucker
AU 5	Eye Widen	AU 20	Lip stretch
AU 6	Cheek Raise	AU 23	Lip Tightener
AU 7	Lids Tight	AU 24	Lip Presser
AU 9	Nose Wrinkle	AU 25	Lips Part
AU 10	Lip Raise	AU 26	Jaw Drop
AU 12	Lip Corner Pull	AU 28	Lips Suck
AU 14	Dimpler	AU 45	Blink/Eye Closure



- For EMO^F, we use $K \in \{2, 4, 6, 8, 10, 16, 20\}$ over the joint feature space

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$P(ANN^\tau)$

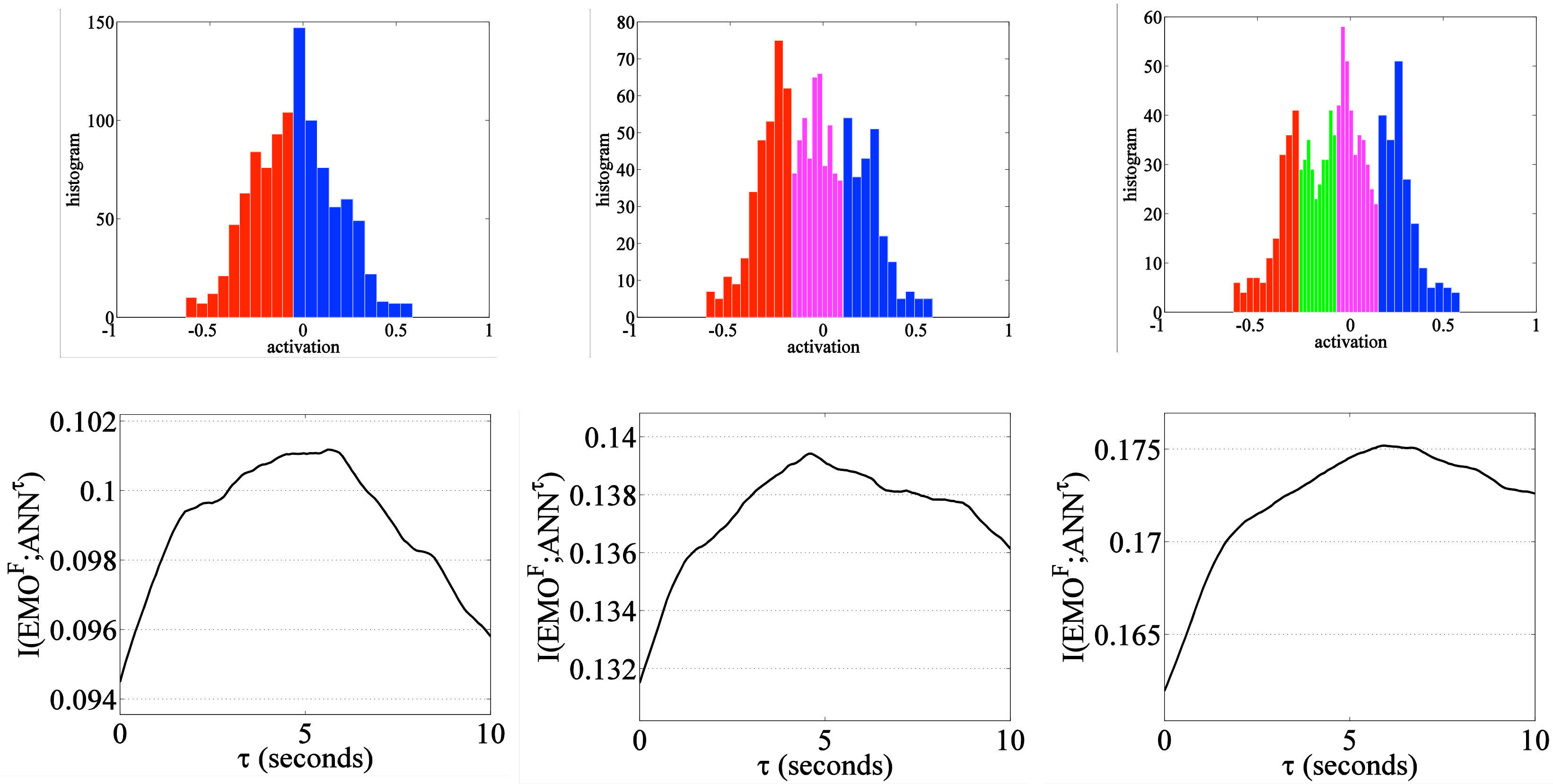
Analysis of the Reaction Lag

- Activation

K = 2 | K = 3 | K = 4

Clusters (ANN)

Lag analysis



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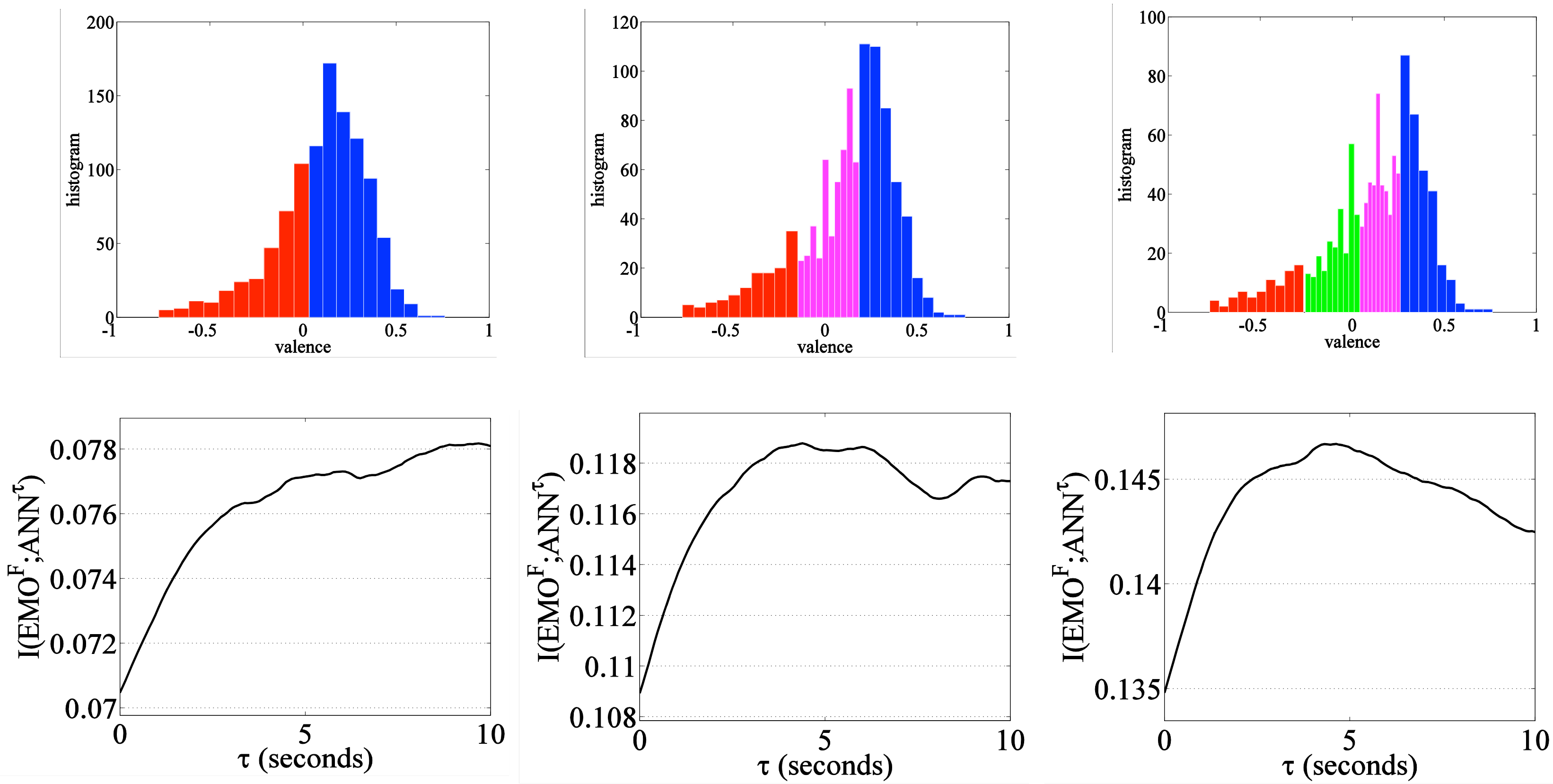
Analysis of the Reaction Lag

- Valence

K = 2 **K = 3** **K = 4**

Clusters (ANN)

Lag analysis



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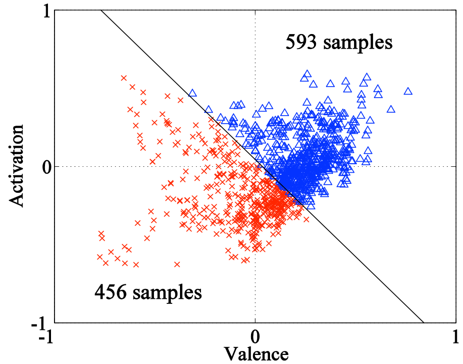
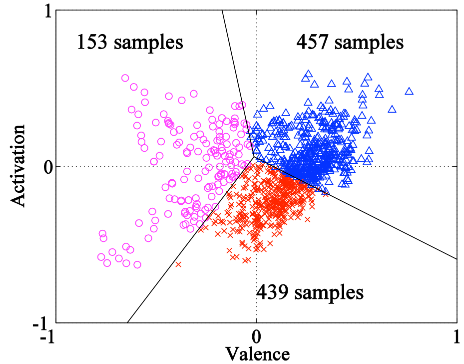
Analysis of the Reaction Lag

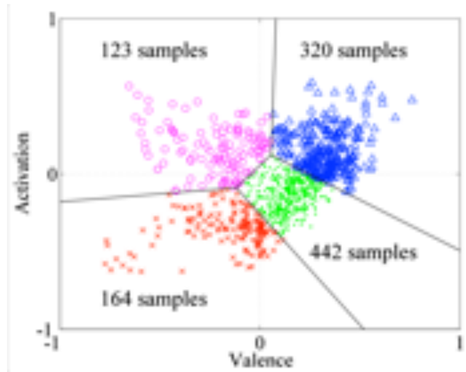
- [Activation, Valence]

K = 2 **K = 3** **K = 4**

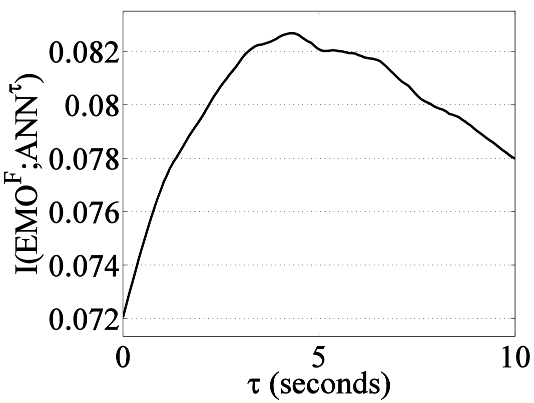
Clusters (ANN)

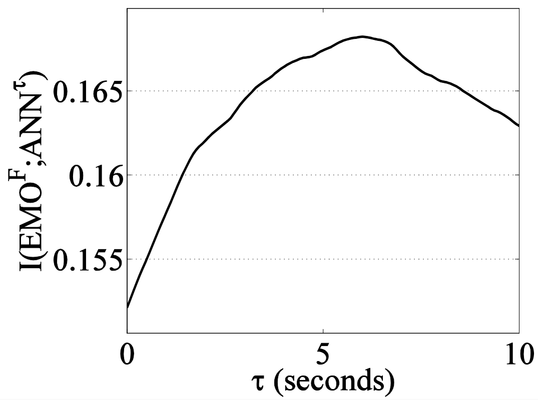


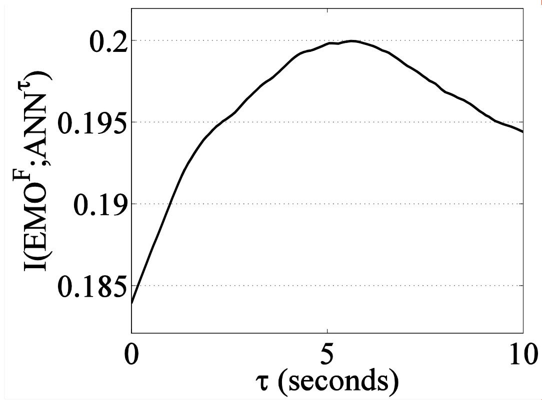




Lag analysis



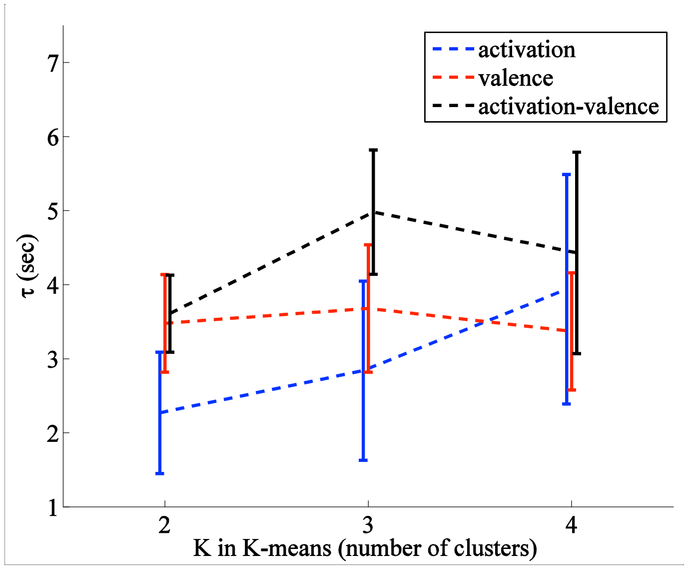




Experimental Setting

- The optimal delay is defined as the first time the mutual information does not increase
  - Priority to shorter reaction lag

Attribute	K=2		K=3		K=4	
	mean	std	mean	std	mean	std
Act	2.27	0.82	2.84	1.21	3.94	1.55
Val	3.48	0.66	3.68	0.86	3.37	0.79
Act-Val	3.61	0.52	4.98	0.84	4.43	1.36



Validation with Emotion Recognition

- 1049 turns (at least 300ms long) - 9 subjects
- SVM with 9-fold speaker independent cross-validation
- Evaluation settings
  - Activation, valence, and [activation, valence]
  - Discrete emotional labels with K=2, 3,4 classes
  - Reaction lag: 0, 1, 2 and 3 sec + optimal delay
- Facial features
  - [AUs+head] x 6 statistics (e.g., quantiles, mean and std)
- Acoustic features

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Acoustic Features

- openSMILE 4368 features [Eyben et al. 2010, Schuller et al. 2011]
  - Spectral

Rasta-style filtered auditory spectrum bands
MFCCs
Spectral energy 25-60Hz, 1k-4KHz
Spectral roll-off point 0.25 0.50 0.75 0.90
Spectral Flux, entropy, variance, skewness, kurtosis, slope

  - Energy

Sum of auditory spectrum (loudness)
Sum of Rasta-style filtered auditory spectrum
RMS Energy
Zero-Crossing Rate

  - Voice

F0
Probability of voicing
Jitter (local, delta)
Shimmer

- Feature selection with CFS (~ 99 features)

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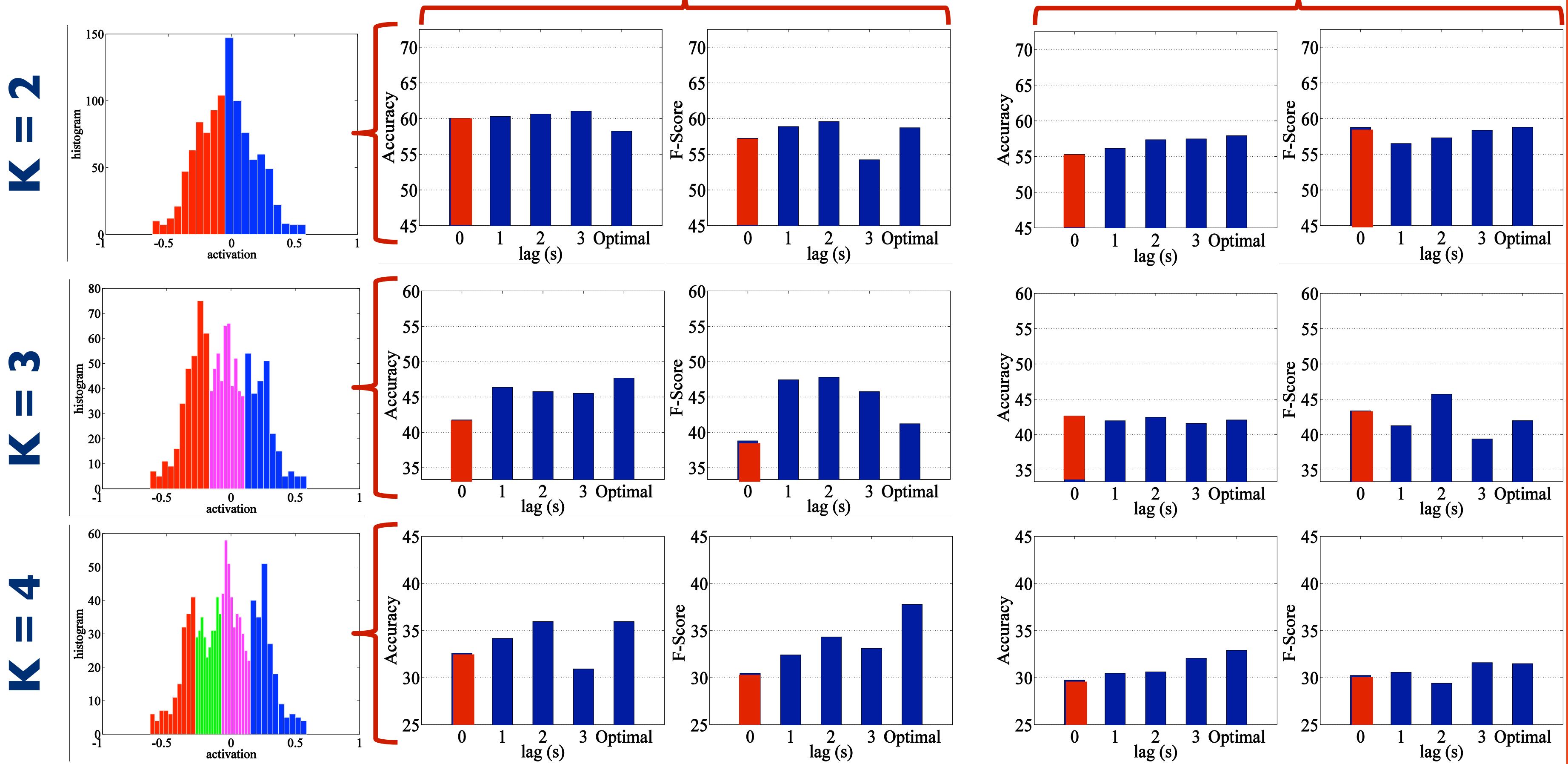
Recognition Experiments - Activation



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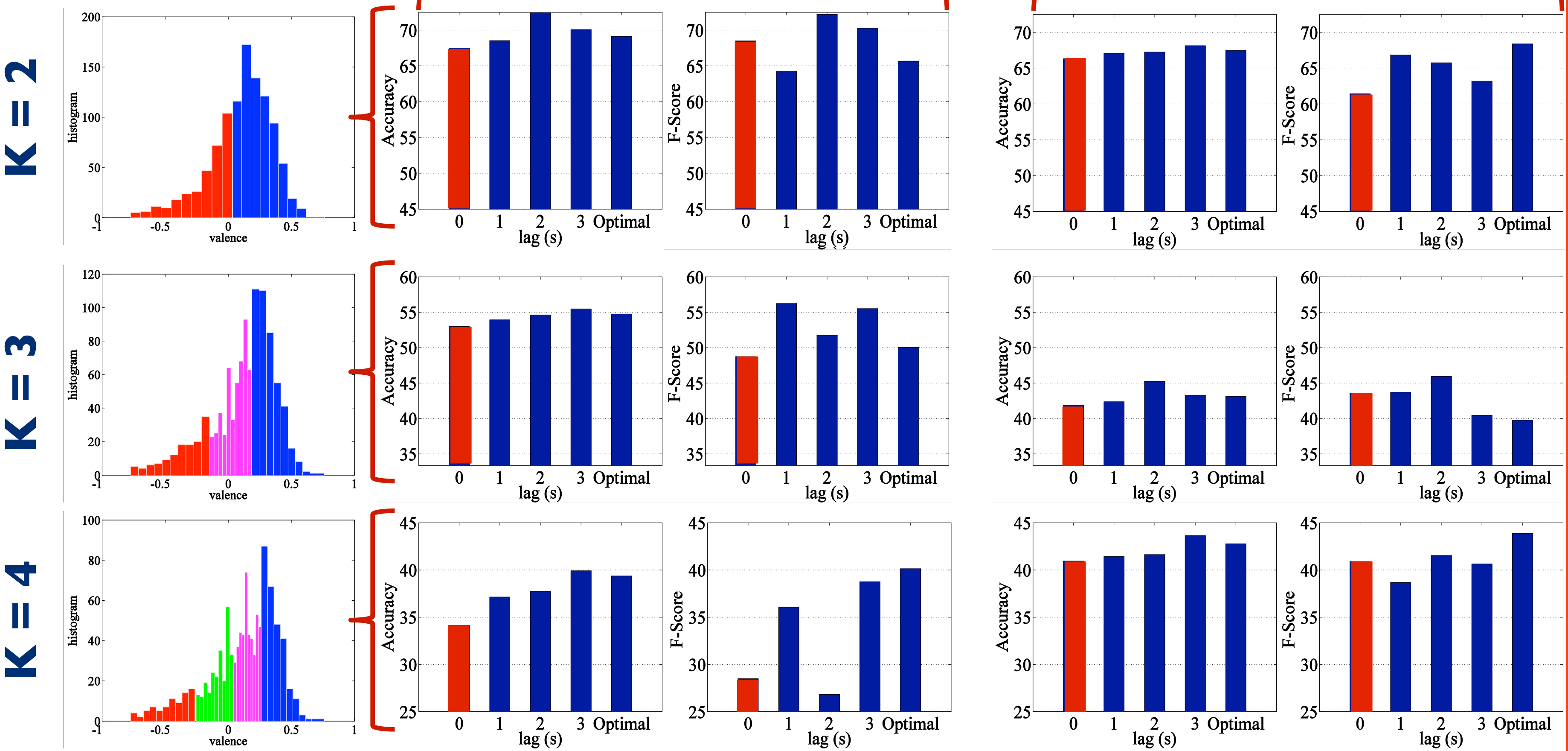
Recognition Experiments - Valence

Face

Speech



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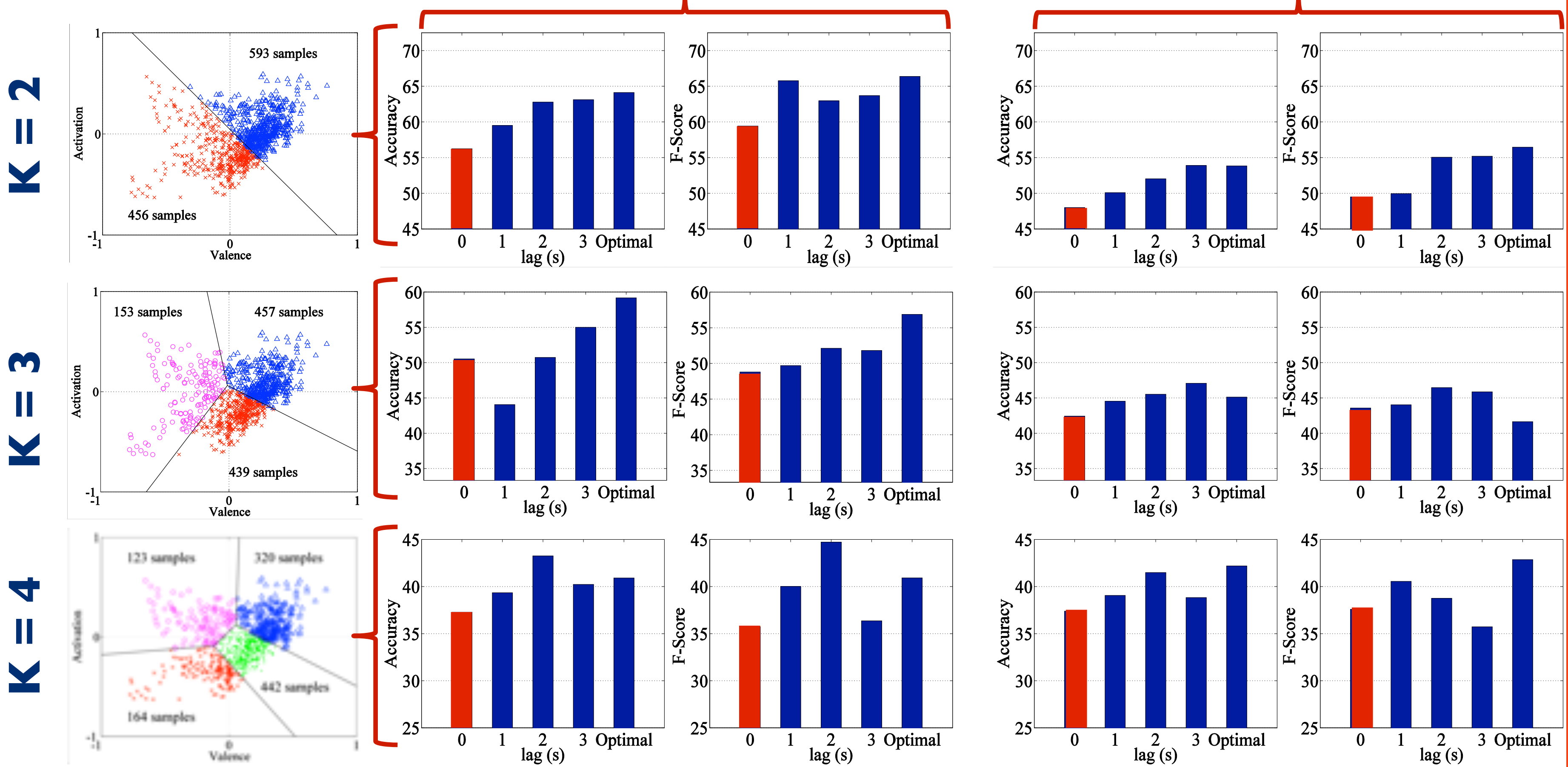
Recognition Experiments - [Act,Val]

Face

Speech



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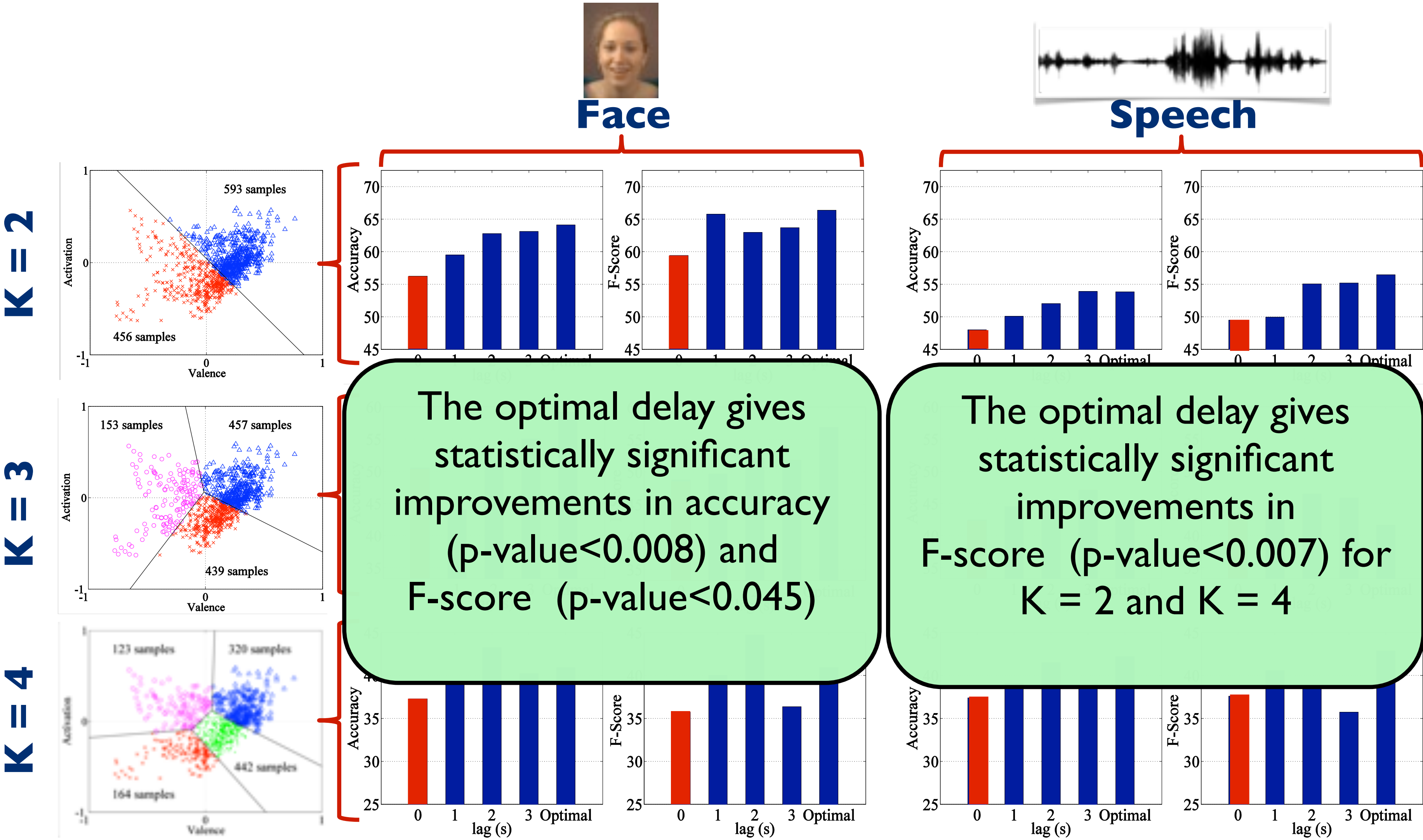
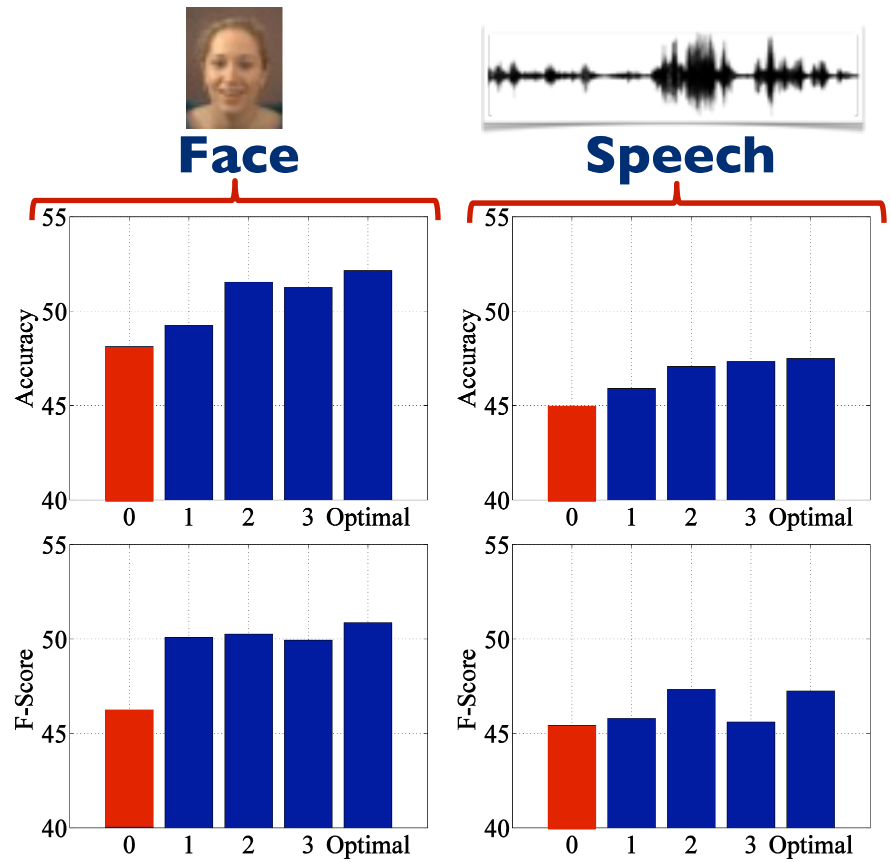
Recognition Experiments - [Act,Val]



Recognition Experiments - Average

- Across all settings
  - Act, Val, [Act-Val]
  - K = 2,3,4

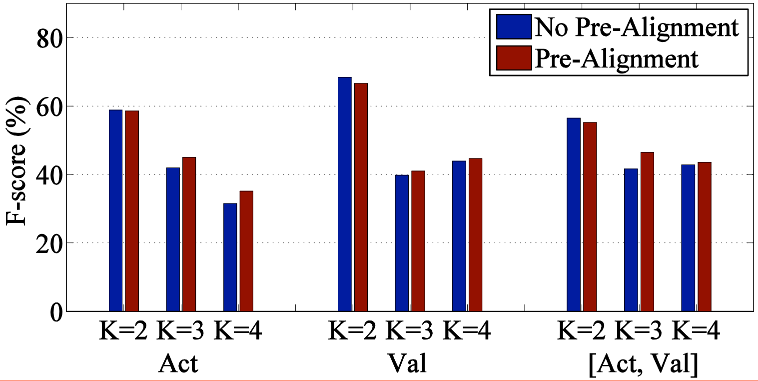


- Optimal delay estimated from training set yields the best performance across all settings on the test set

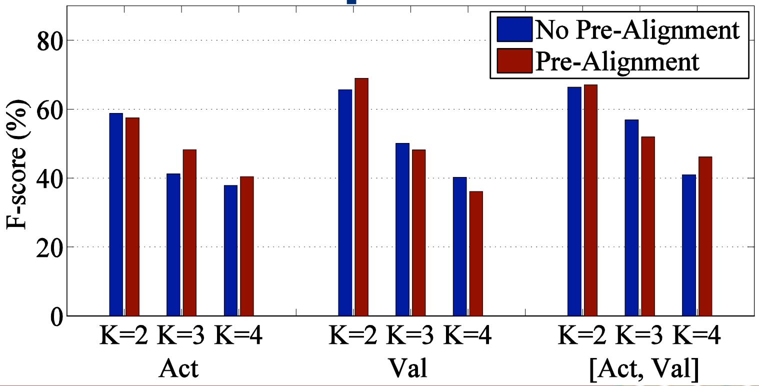
Experiments – Pre-Aligning the Annotations

- Evaluator dependent lag
  - Assumption: phase between two annotators is fixed and is less than 1 sec
  - Pre-Aligning the labels of multiple annotator to maximize the correlation between them within [-1, 1] seconds
  - F-score improves 1.06% (face) and 0.26% (speech)

Face



Speech



Conclusions

- The mutual information analysis unveils and quantifies the reaction lag with respect to facial features
- Compensating for the reaction lag improves the performance of both facial and vocal emotion recognition systems
  - Shift-delayed emotional annotations achieved statistically significant improvements

We are using the wrong labels!

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Future Work

- Reaction lag analysis with respect to speech features
- Reaction lag analysis in evaluator-dependent fashion
  - Find optimum delay per annotation
- Considering time-variant reaction lag
  - Time warping methods e.g., dynamic probabilistic canonical correlation with time warping (DPCTW) [Nicolaou et al., 2012]

Multimodal Signal Processing (MSP)

Thanks!

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