Classification of similar musical objects

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Sound and Music Technology
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Overview

- The challenge of music similarity
- Similarity
  - Why important?
  - What is tricky about similarity?
  - How to predict similarity?

Recap

- Segmentation
  - What cues do listeners use for segmentation?
  - Computational modeling of segmentation for melodies
    - Gestalt-based vs. Expectation-based (for modeling closure)
  - Basic principles of segmentation in audio domain
    - Repetition-based
    - Novelty-based
    - Homogeneity-based

Final reports on projects

- Deadline for submission: Sunday February 2nd
  - Use ISMIR-style template, around 6 pages
  - Submission via Blackboard
- Presentations in week 4
  - 10 minutes per group
  - Ask questions after each presentation
  - Students NOT presenting will have to give feedback via Google document
  - Hence: participation is mandatory on both days
  - Tuesday, 21 January: Projects A
  - Thursday, 23 January: Projects B and C

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Music similarity and variation

- Monkey Island: Each of the locations has a variation on a common melody. Upon entering the carpenter's shop, a nasal timbre is added to the score and plays a hornpipe variation, and when meeting the cartographer, an arpeggiated harp version of the same melody is heard. A rondo form is created as the main street is revisited between each sub-location. A game structure and a musical structure here concatenate. Some of these variations are even more elaborate: upon visiting Largo's hotel room, his theme is added to the hotel variation … and when sleeping pirates are awakened ... an accordion part is introduced (a further thematic variation) … The music seems to be emanating from the locations and characters within this world, closely synchronized to Threepwood's experience of the universe.

  - Understanding Video Game Music (Tim Summers, James Hannigan), 2016

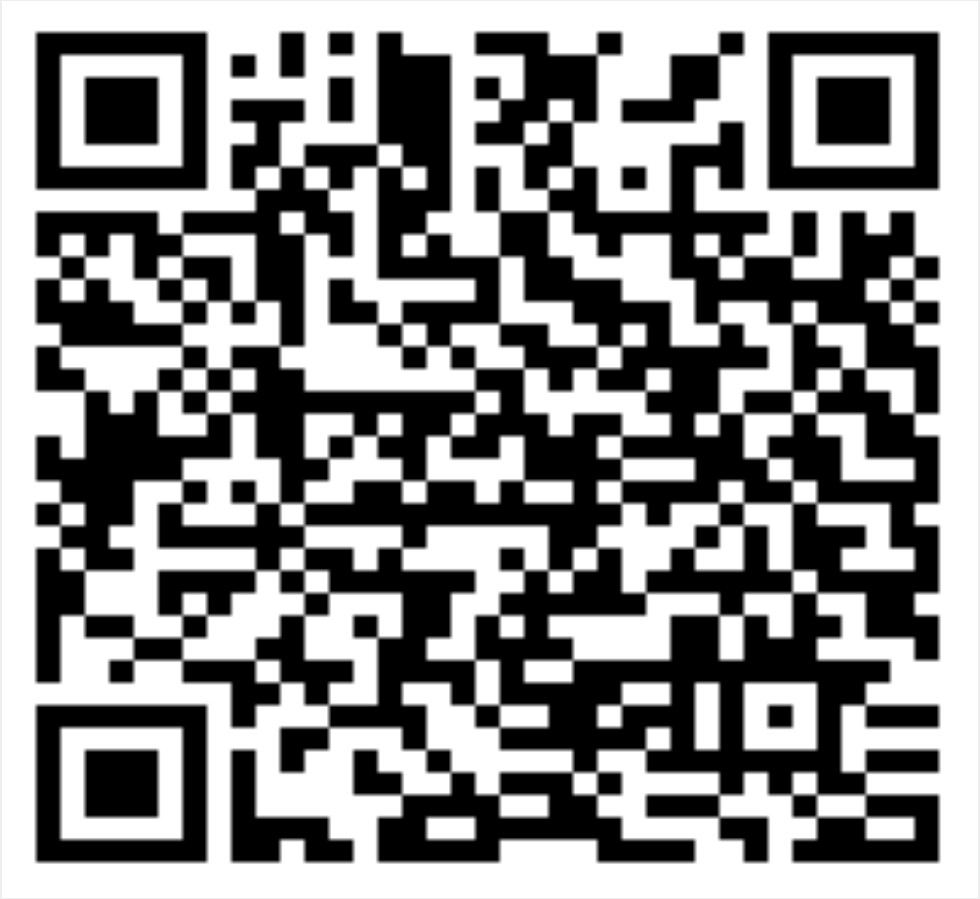
Music Information Retrieval

Music Information Retrieval seeks to ”make the worlds vast store of music accessible to all” (Downie, 2003)

enable users to search in large collections of digitized musical data

Musical similarity: central concept

Music similarity



Pair A

Pair B

Pair C

Pair D

http://bit.ly/1eNo2X7

Music similarity


Pair A


Pair B


Pair C


Pair D

http://bit.ly/1eNo2X7

Music similarity


Pair A


Pair B


Pair C


Pair D

Music similarity


Pair A


Pair B


Pair C


Pair D

Music similarity


Pair A


Pair B


Pair C


Pair D

Music similarity



Pair A



Pair B



Pair C



Pair D

Music similarity


Pair A

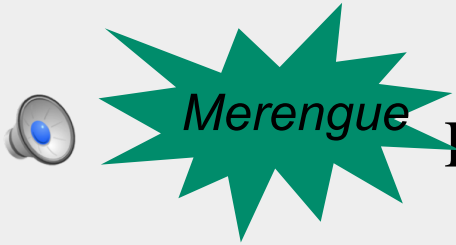

Pair B


Pair C

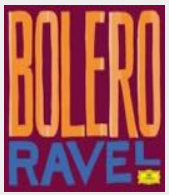

Pair D

bit.ly/1ntHusT

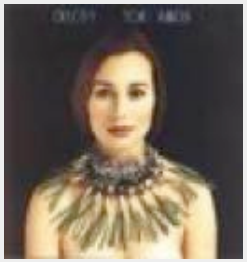
Music similarity



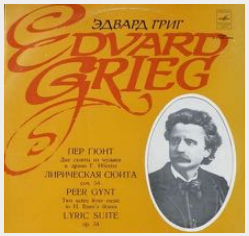
Pair A



Pair B



Pair C



Pair D

bit.ly/1ntHusT

Music similarity: What others said…

Hard to decide on **which factors** to rate

> Pair C had the same chords and lyrics, is that what you mean by similarity or how similar it sounds? Because it sounded very different due to the higher notes. **Not knowing what kind of similarity** we were looking for made it slightly difficult.

It's all extremely subjective, so it's hard to rate it.

> I did not think the pieces alike, and then I heard **a very tiny part that did seem very similar**. But how do you rate the **overall difference** in that case?

I compared the genre, tempo, vibe and sounds of each of the tracks. With that in mind I decided wich number I should pick.

> Most difficult would be to have to **weigh the different aspects** of the music, but since the pairs mostly differed in a single way, either superficially or structurally, it was quite easy.

Music similarity and MIR

according to free association among MIR-researchers:

Music similarity is …

… inherently an ill posed problem.
Slaney (2008)

… a fuzzy term.
Allamanche (2003), McFee (2010)

… an elusive concept.
Berenzweig (2003)

… a huge challenge.
Downie et al (2009)

… a cold start problem.
Wang et al (2011)

Information on similarity in MIR …

- Similarity information according to
  - High-level music content description (melody, harmony …)
  - Low-level audio features (MFCC, …)
  - Factual and cultural meta data
    - extra-musical information: such as artist, album, year of publication,
    - cultural metadata provide "subjective, culturally determined information" (mood, emotion, genre)
  - Information from collaborative filtering*
    - Preference rather than similarity

Casey et al (2008): Content-Based Music Information Retrieval: Current Directions and Future Challenges Proceedings of the IEEE, Vol. 96, No. 4, 668–696

*Goussevskaia et al. (2008): From Web to Map: Exploring the World of Music, Proceedings of IEEE/WIC/ACM, 242–248, 2008.

Types of music similarity in MIR …

- audio-based similarity
- structural similarity
- melodic similarity
- harmonic similarity
- tonal similarity
- rhythmic similarity
- artist similarity
- performance similarity

Does *music similarity* make sense at all?

Musicologists use it all the time!

Music similarity and musicologists

Musicology

Music analysis: paradigmatic analysis

…. **traditional music analysis**, by investing in **notions of repetition and the association between repeated units**, has **always drawn implicitly** on the descriptive domains of paradigm and syntagm. (Agawu, 2008)

Music similarity and musicologists

Musicology

Becoming a musical expert by distinguishing stylistic traits

Music similarity and musicologists

Musicology

Please compose in the “style of”!

Music similarity and the ordinary listener

Switching between radio programs: we are very good in distinguishing different styles of music

Similarity is everywhere …

Function of similarity in music:
Facilitate understanding of music

Musicology

- … similarity relationships give the listener the ***feeling that he understands*** … without having to study the compositional rules on which the music was based (L.B. Meyer)

- **Musical motives** show a similar amount of variation, and it is through **developing a notion of what they have in common** … that we begin to **comprehend** the musical organization of works (L. Zbikowski)

- While repetition is a feature of all music … **a high level of repetition** may be a specific mark of the "popular", enabling an ***inclusive rather than exclusive audience***. (R. Middleton)

Overview

- The challenge of music similarity in MIR
- Similarity
  - Why important?
  - What is tricky about similarity?
  - How to predict similarity?
- Music Similarity: variation principle

Similarity

- Similarity is one of the most central theoretical constructs in psychology (Medin et al 1993)
- Predicting, categorizing, learning, memorizing…

Similarity

- … our tendency to expect that similar causes will have similar effects.

(Quine, according to Goldstone & Son, 2005)

Similarity

- Example:

Appreciating the similarity between **crocodiles** and **alligators** is helpful … (Goldstone and Son, 2005)

Similarity

- ... when we do **not have specific knowledge** about a domain, we can use **similarity** as a default method to reason about it. (Goldstone & Son, 2005)

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Problem of researching similarity

- Nelson Goodman (1972) … called similarity "**invidious, insidious, a pretender, an imposter, a quack**" (p. 437).

Problem of similarity

- What is so difficult about similarity?

- subjectiv
- flexibel
- What determines it?

http://blueforestsoapbox.blogspot.nl/2008/11/family-resemblence.html

Problem of similarity

- "the **relative weighting of a feature** […] varies with the stimulus context and task" (Murphy and Medin, 1985)

- Similarity is assumed to be based on **matching and mismatching properties** or **predicates**. … **However, any two things share an arbitrary number of ways** (see Goodman, 1972, Watanabe, 1969)

Approach to the problem: Kinds of similarity

- The first of these concerns the question of **what kinds of similarity there are**. Is there only one kind, or are there more? If there is more than one kind of similarity, what distinguishes them? (Vosniadou and Ortony, 1989)

- … **perceptual similarity is not one thing but is of many interrelated kinds**. In brief, we seem to possess a complex system of perceptual relations, a complex system of kinds of similarity. (Smith 1989)

Kinds of similarity

- ***surface*** vs. ***deep*** **similarity**,
- ***globa****l* vs ***dimensional*** similarity,
- similarity based on object **attributes** vs. object **relations**

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- ***deep*** **similarity:** more central, core properties

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- ***surface*** **similarity**: based on readily accessible components
- ***deep*** **similarity:** more central, core properties
- Example: children sensitive to certain perceptual properties of objects; learn to differentiate between animate and nonanimate objects

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Models of similarity

Geometric models (Nonmetric multidimensional scaling)

Featural models (Tversky)

Alignment models

Transformational models

Models of similarity

Geometric models (Nonmetric multidimensional scaling)

$$dissimilarity(i,j) = \left[\sum_{k=1}^{n} \left|X_{ik} - X_{jk}\right|^{r}\right]^{\frac{1}{r}}$$

Featural models (Tversky)

Alignment models

Transformational models

Models of similarity

Geometric models (Multidimensional scaling)

- represent similarity relations between entities in terms of a geometric model
- geometric model consists of a set of points embedded in a dimensionally organized metric space

$$dissimilarity(i,j) = \left[\sum_{k=1}^{n} \left| X_{ik} - X_{jk} \right|^{r} \right]^{\frac{1}{r}}$$

r=2: Euclidean distance

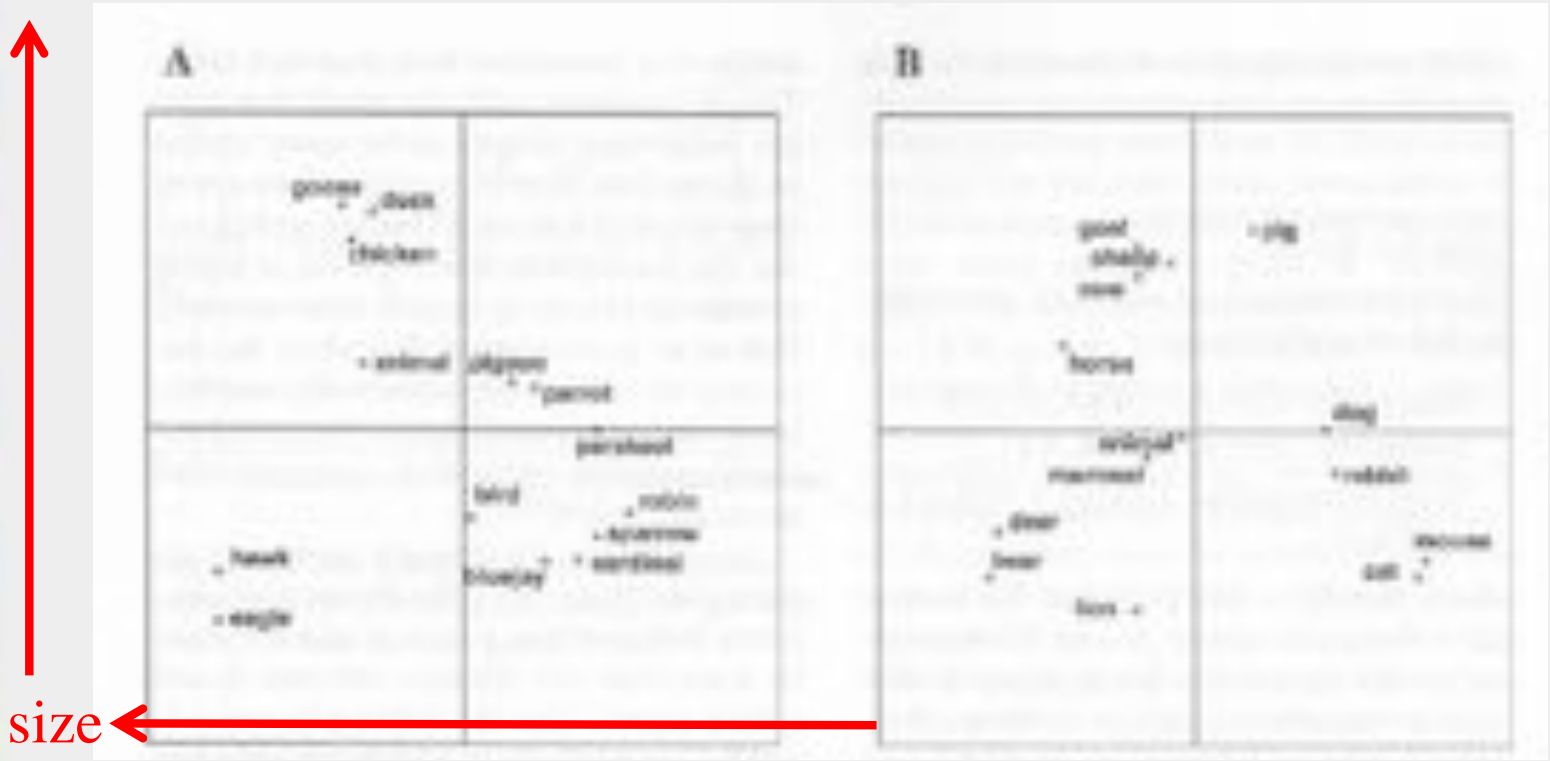
r=1: city block metric

Models of similarity

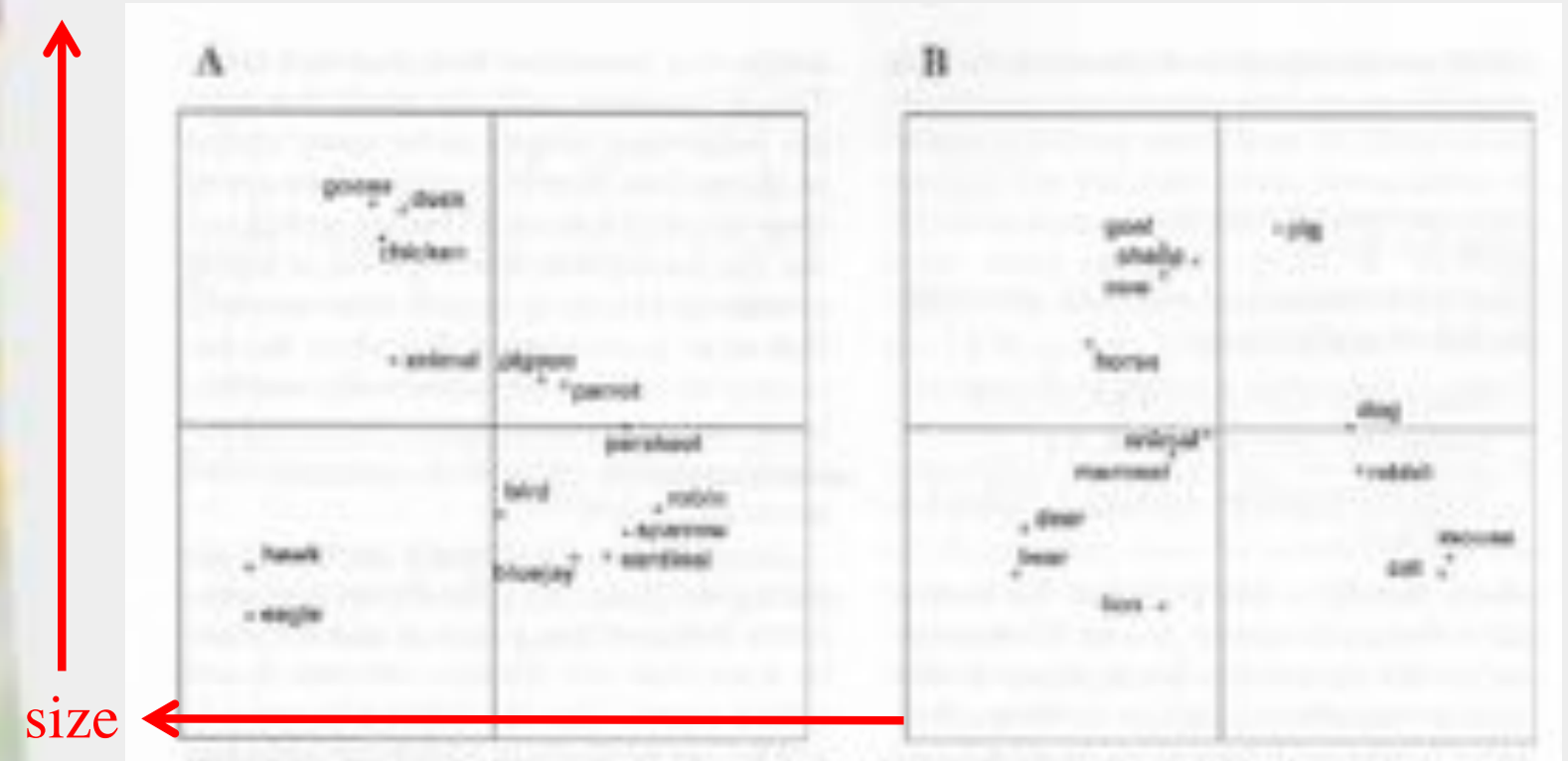
Geometric models (Multidimensional scaling)

- Idea: start with subjects' judgments of pair-wise object dissimilarity
- work backward to determine the dimensions and dimension values that subjects used in making their judgments

Models of similarity

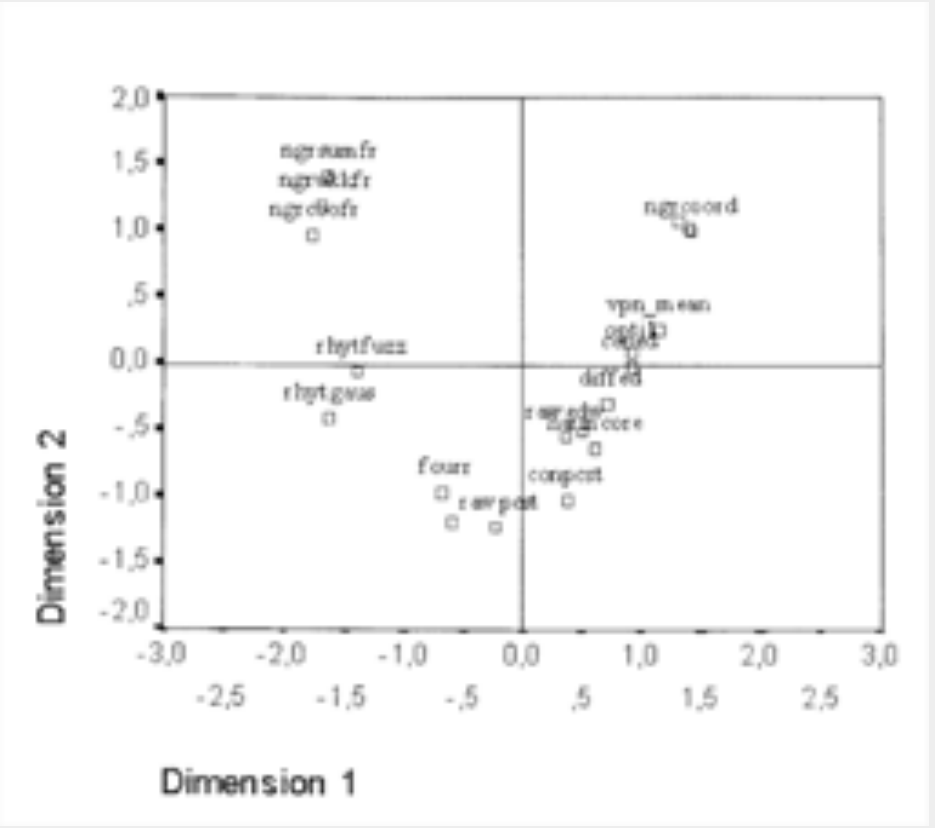


Models of similarity



Application: Melodic similarity

- Muellensiefen & Frieler (2007)
  - 14 algorithmic measures
  - Pairwise similarity rating of popular melodies
  - Dimension 1: degree of rhythmic information
  - Dimension 2: global vs. local information



Models of similarity

Geometric models (Nonmetric multidimensional scaling)

Featural models (Tversky)

$$S(A,B) = qf(A \cap B) - af(A-B) - bf(B-A)$$

Alignment models

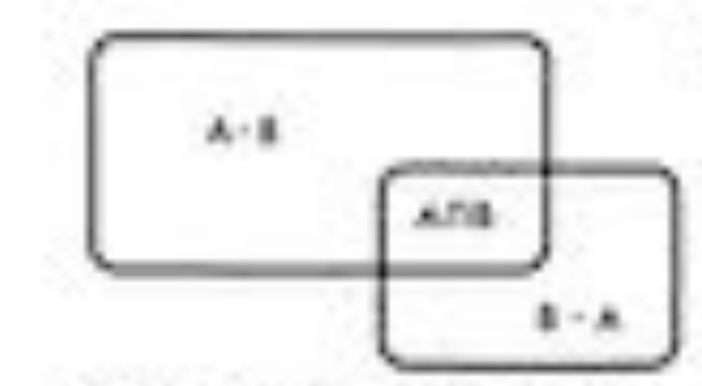
Transformational models

Models of similarity

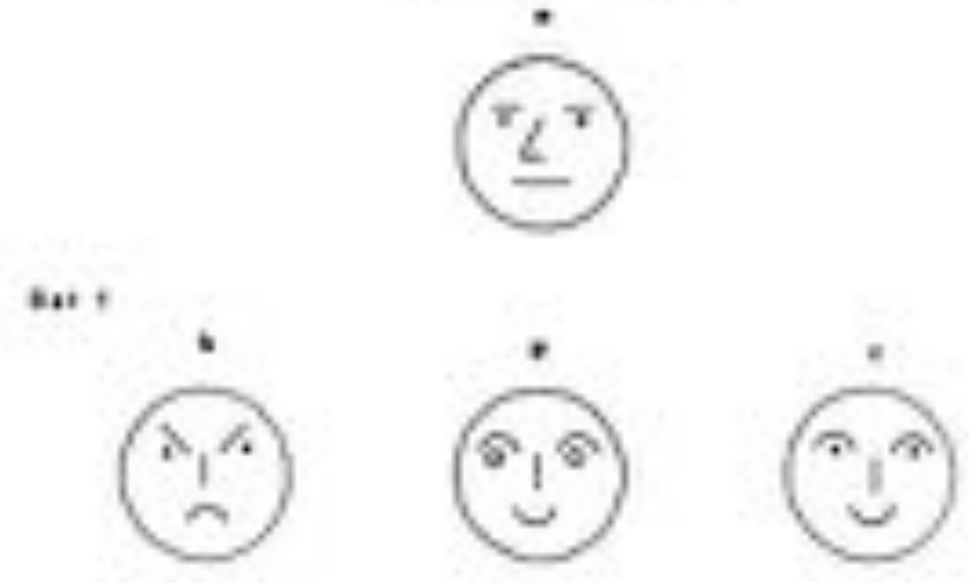
Featural models (Tversky)

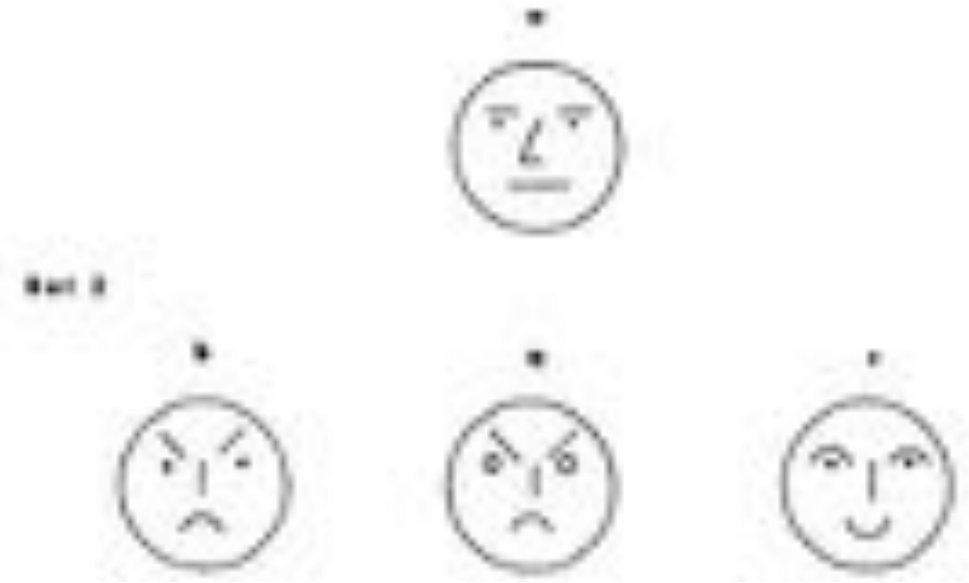
- Human judgment of similarity often not symmetric
- Triangle inequality often does not hold

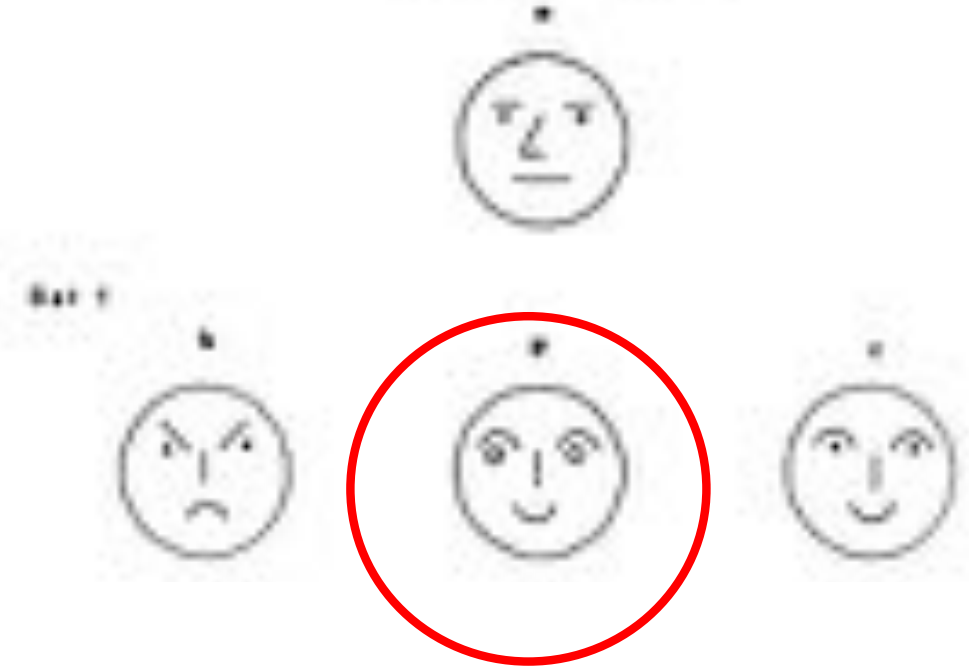
$$S(A,B) = qf(A \cap B) - af(A-B) - bf(B-A)$$

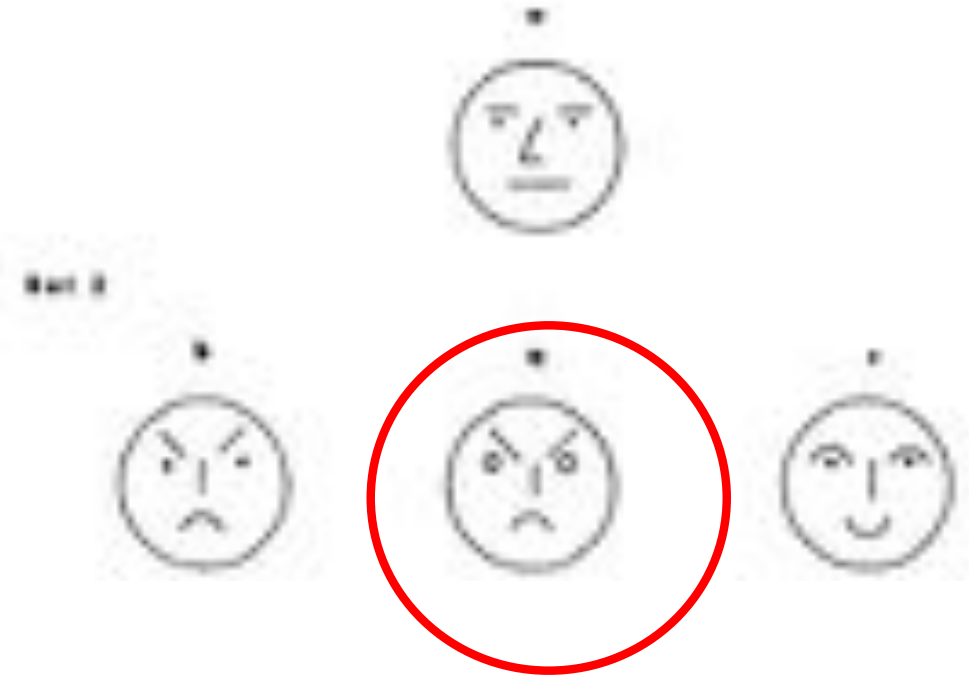


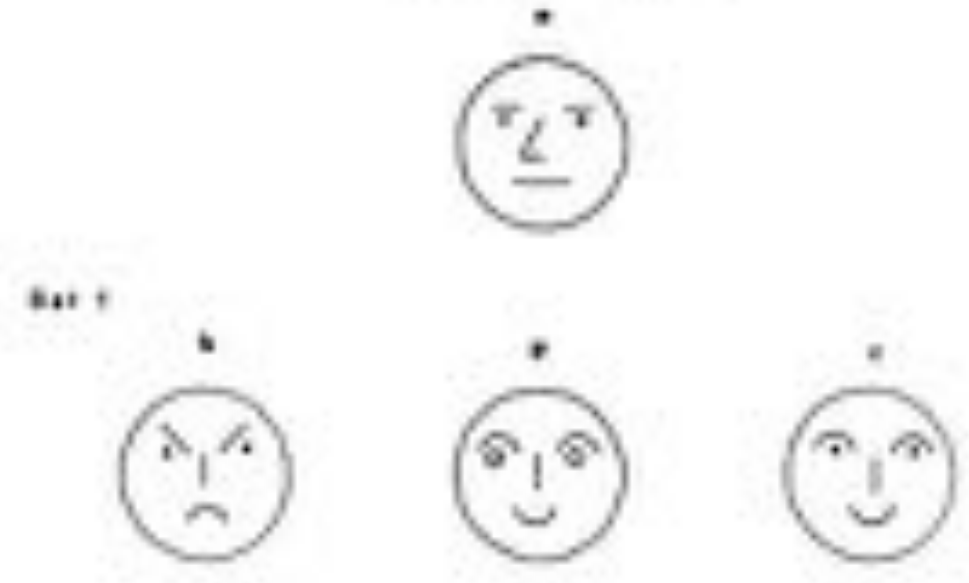
Statistical context information via psychological salience function f

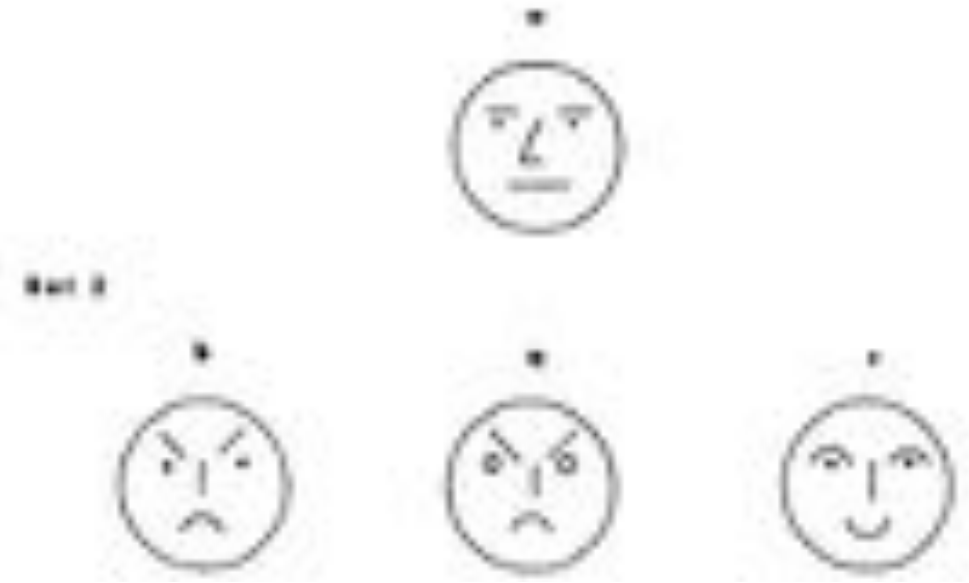


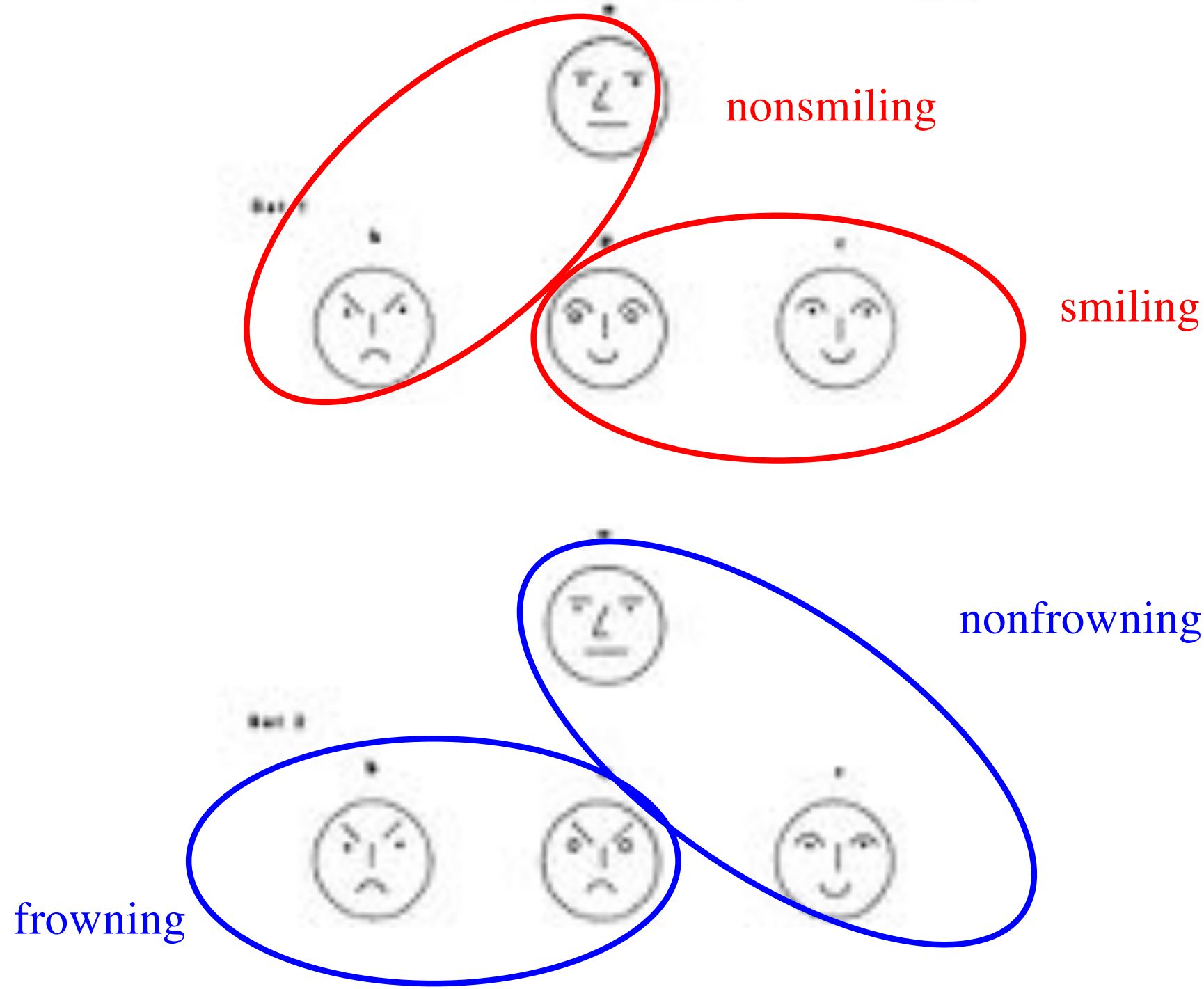


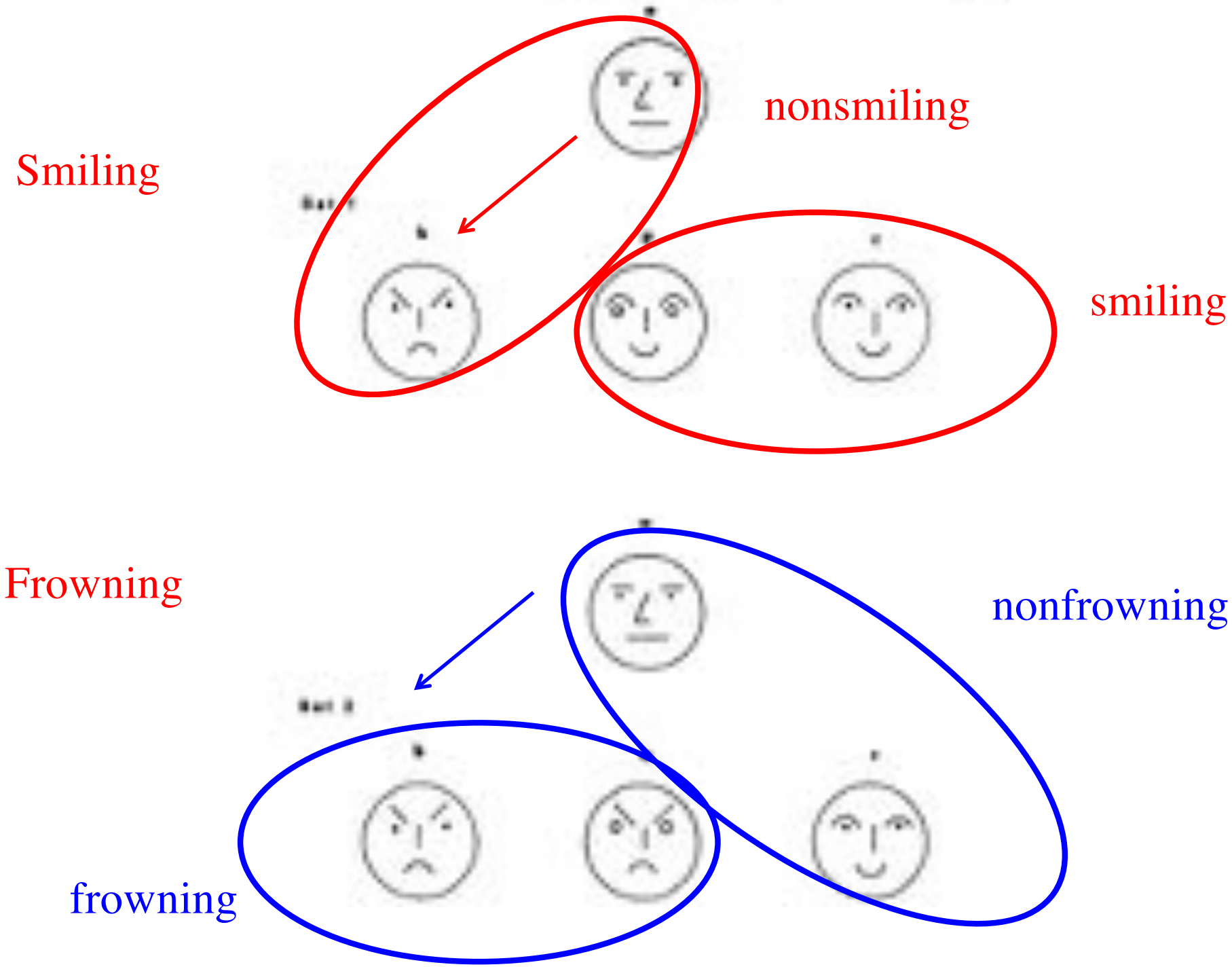









nonsmiling
smiling
nonfrowning
frowning


Smiling
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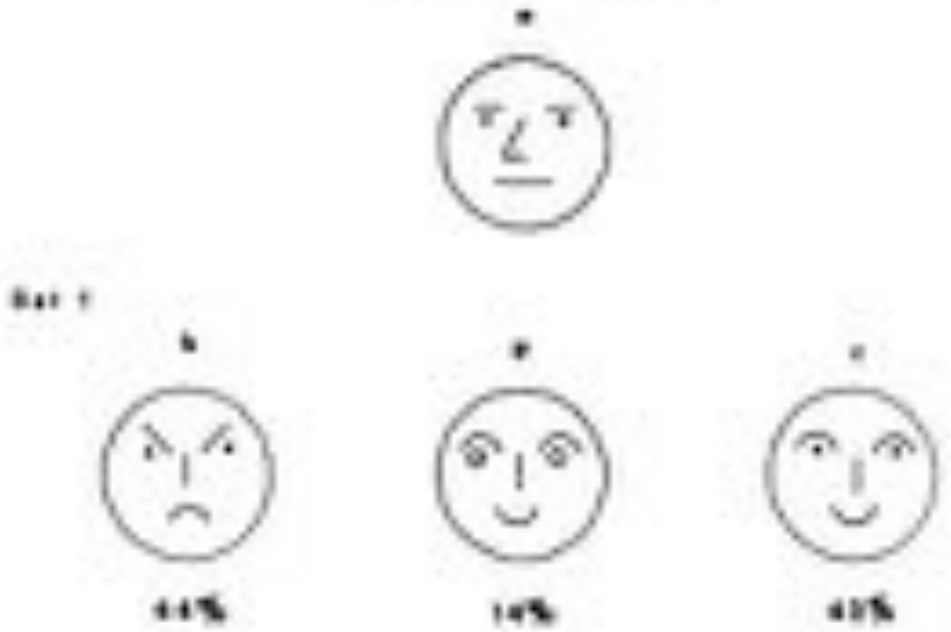
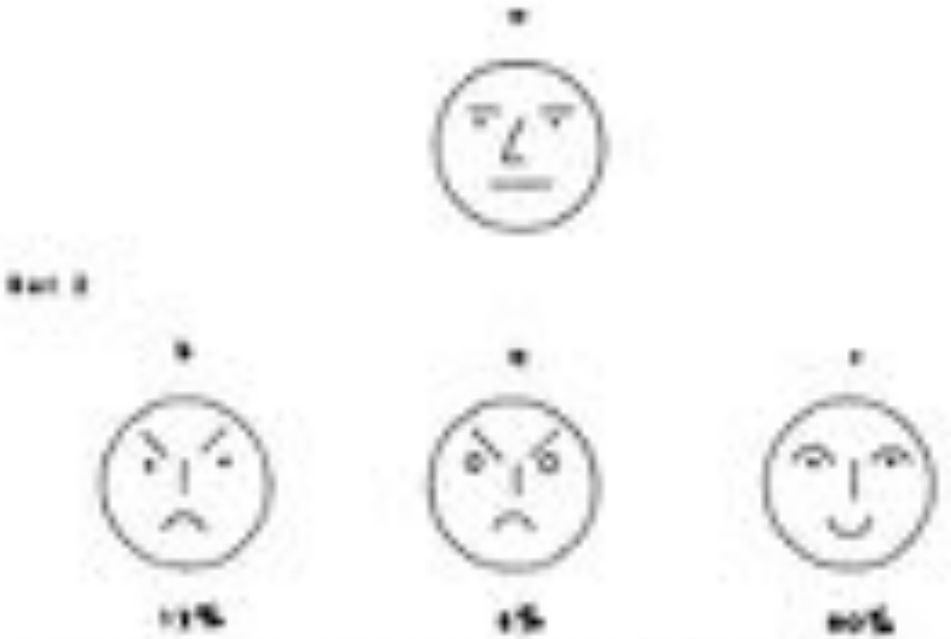
frowning



Please select the face that is most similar to face a !



Models of similarity

Geometric models (Nonmetric multidimensional scaling)

Featural models (Tversky)

Alignment models

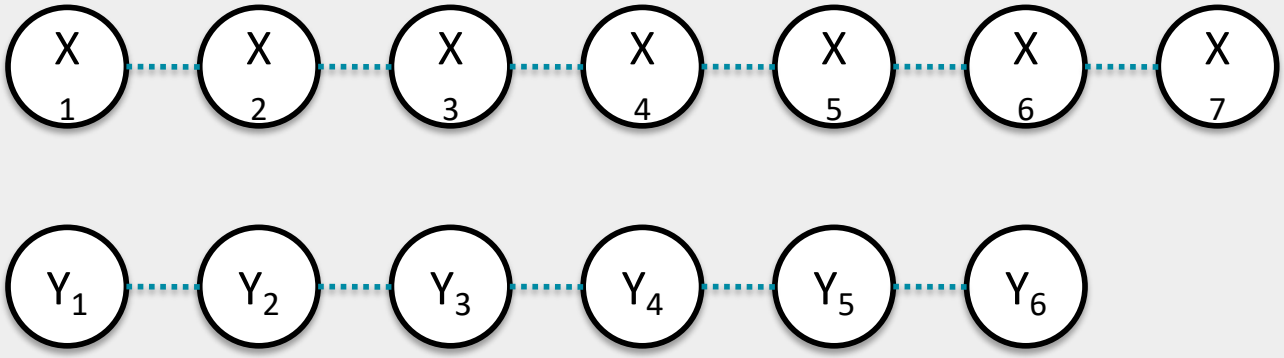
Transformational models

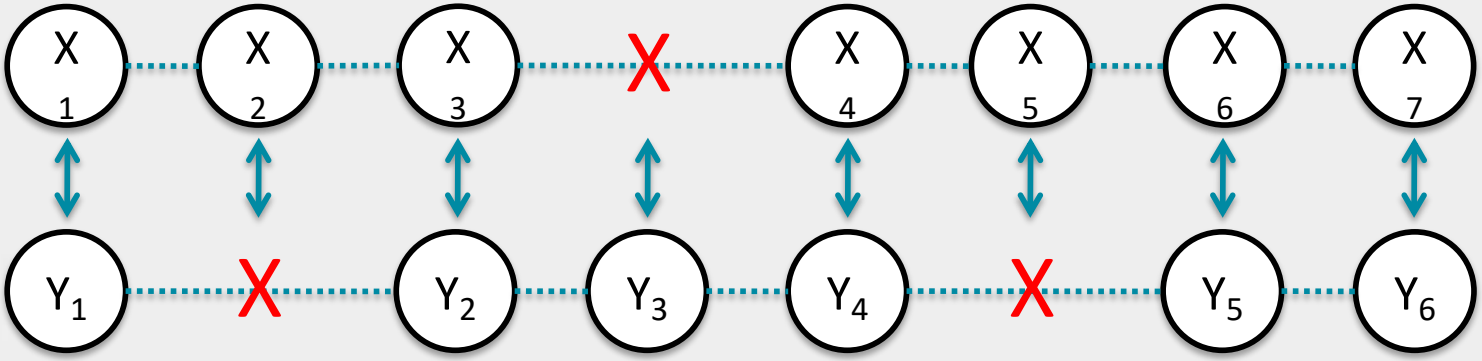
Alignment models

- Real-world objects are not just sets of features or coordinates in space
- Relations between elements within objects also important

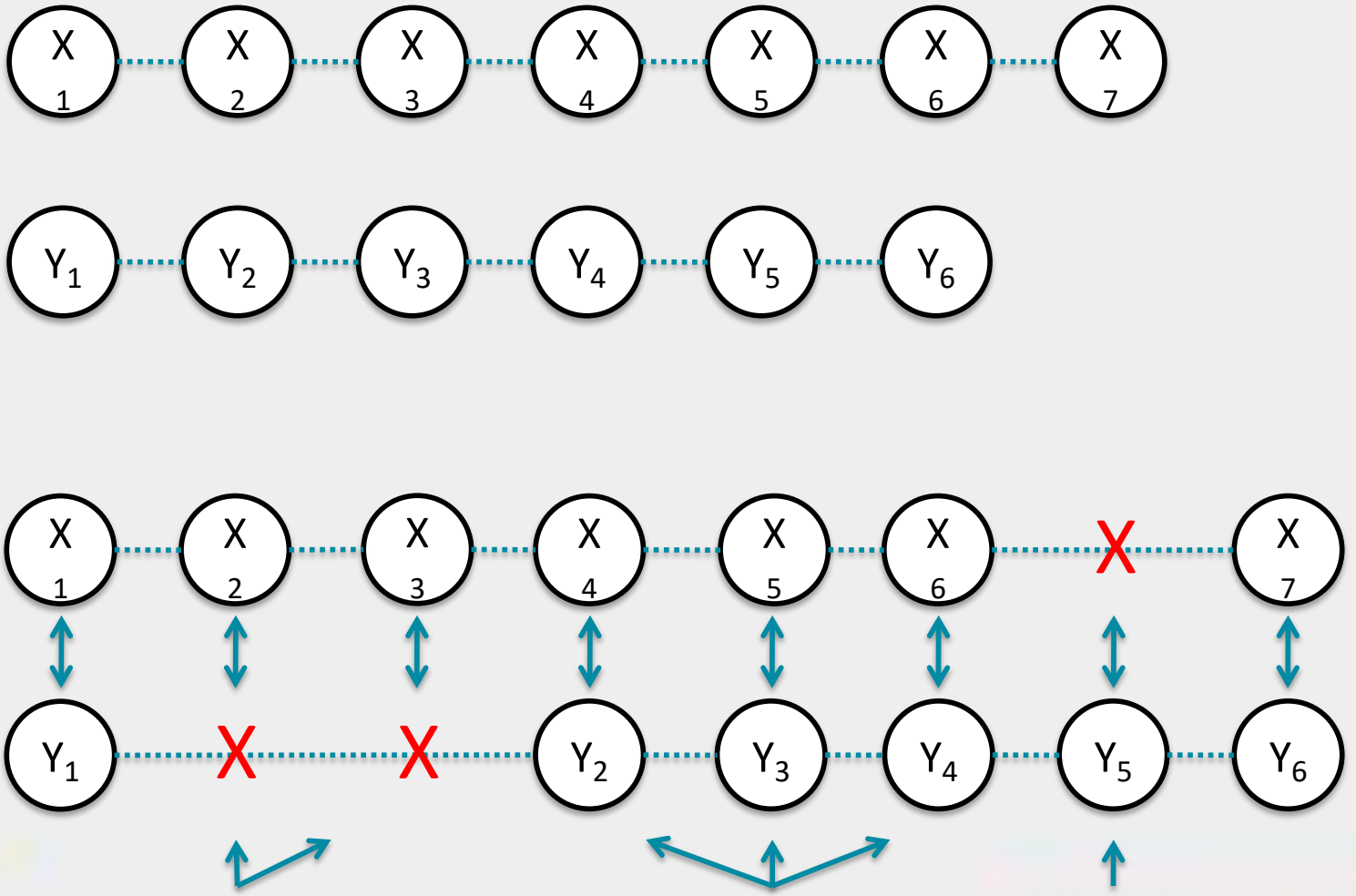
Example

Alignment

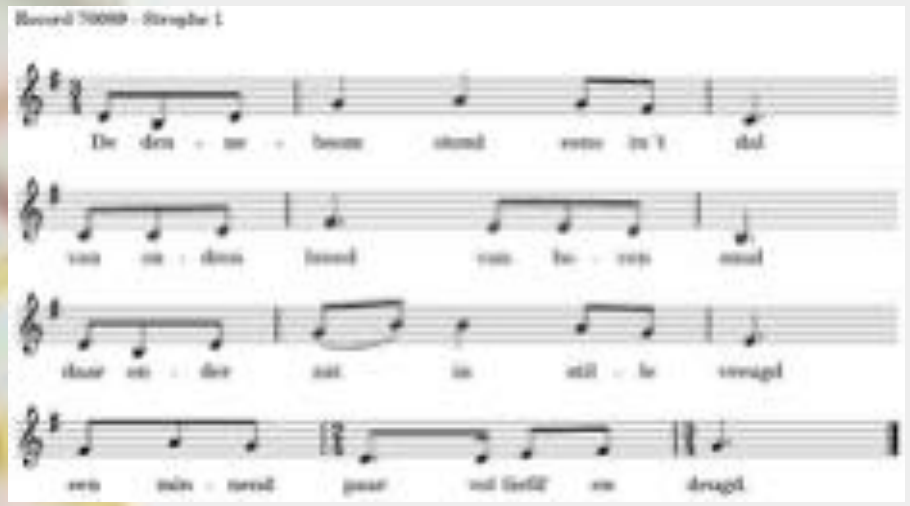

X1 X2 X3 X4 X5 X6 X7
Y1 Y2 Y3 Y4 Y5 Y6

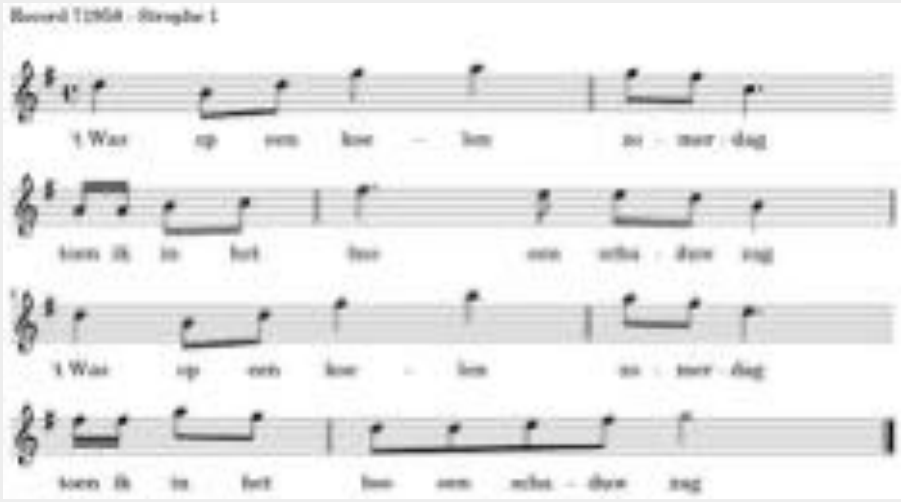

X1 X2 X3 X4 X5 X6 X7
Y1 Y2 Y3 Y4 Y5 Y6

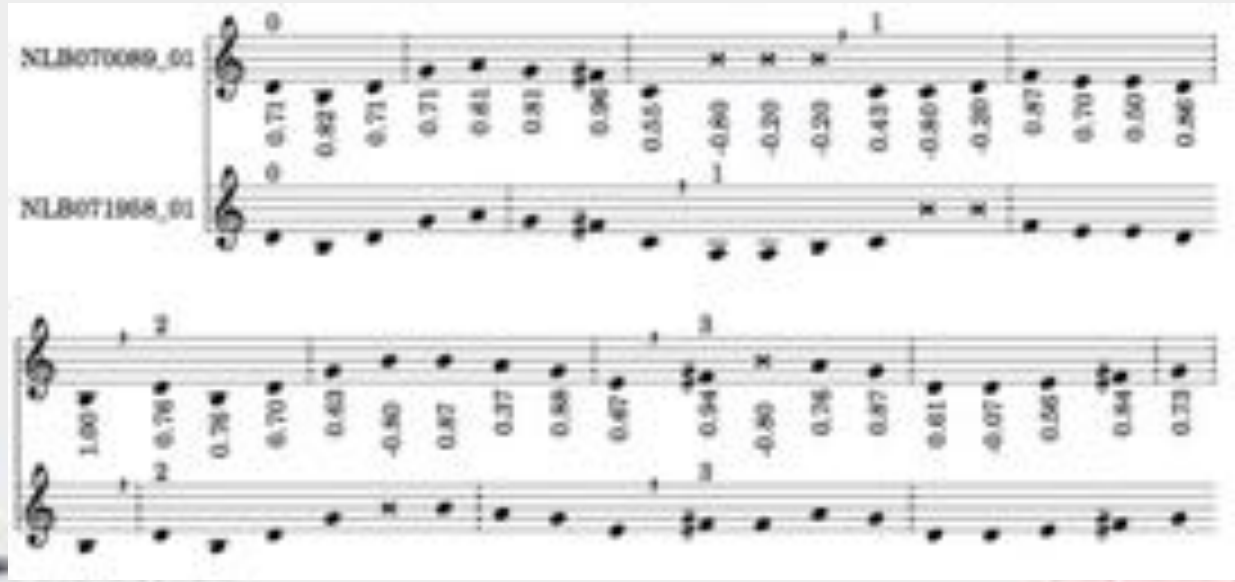
Alignment


X1 X2 X3 X4 X5 X6 X7
Y1 Y2 Y3 Y4 Y5 Y6
X1 X2 X3 X4 X5 X6 X X7
Y1 X X Y2 Y3 Y4 Y5 Y6
Gap in Y
Association
Gap in X

Alignment of Melodies



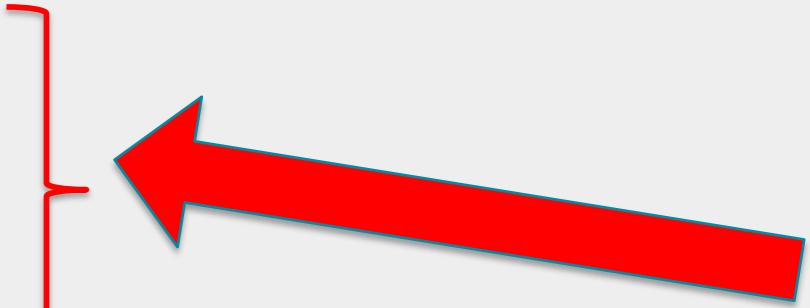




Alignment Algorithm

There is an algorithm that given

- two sequences of symbols
- an association scoring function
- a gap scoring function



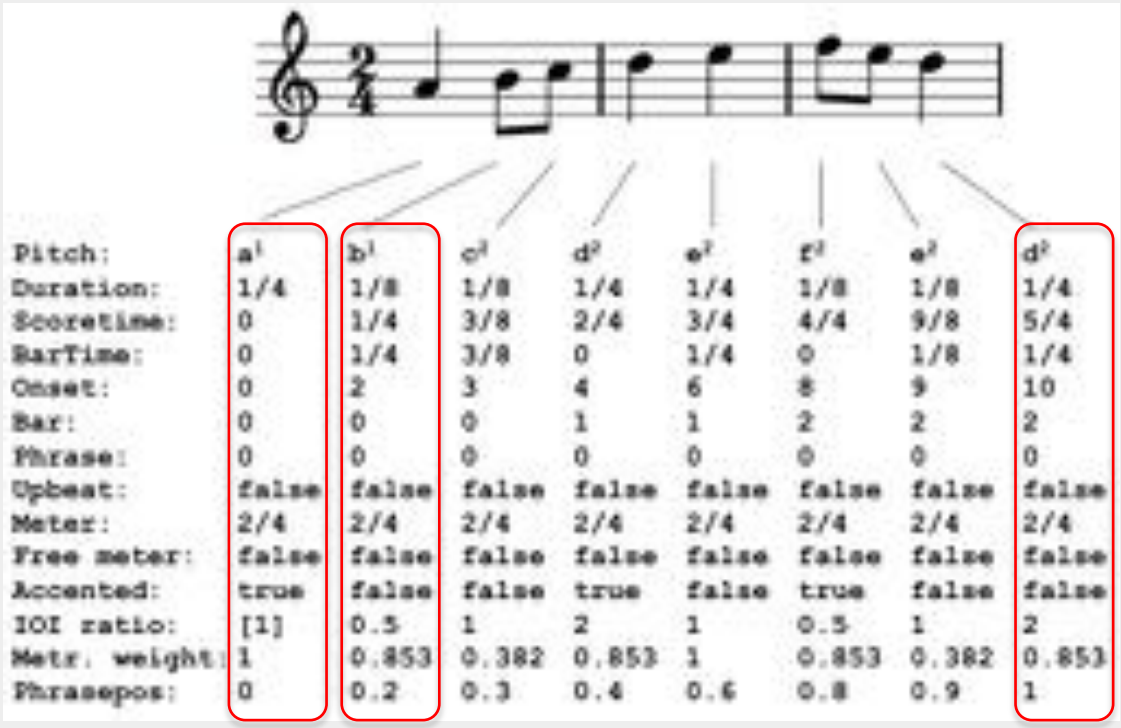
finds the optimal alignment efficiently.

Smith, T. F. & Waterman, M. S. (1981). “Identification of Common Molecular Subsequences”. *Journal of Molecular Biology*, 147(1), 195–197.

Alignment of Melodies

One way of doing it

Symbols:



Pitch:	a^1	b^1	c^2	d^2	e^2	f^2	e^2	d^2
Duration:	1/4	1/8	1/8	1/4	1/4	1/8	1/8	1/4
Scoretime:	0	1/4	3/8	2/4	3/4	4/4	9/8	5/4
BarTime:	0	1/4	3/8	0	1/4	0	1/8	1/4
Onset:	0	2	3	4	6	8	9	10
Bar:	0	0	0	1	1	2	2	2
Phrase:	0	0	0	0	0	0	0	0
Upbeat:	false	false	false	false	false	false	false	false
Meter:	2/4	2/4	2/4	2/4	2/4	2/4	2/4	2/4
Free meter:	false	false	false	false	false	false	false	false
Accented:	true	false	false	true	false	true	false	false
IOI ratio:	[1]	0.5	1	2	1	0.5	1	2
Metr. weight:	1	0.853	0.382	0.853	1	0.853	0.382	0.853
Phrasepos:	0	0.2	0.3	0.4	0.6	0.8	0.9	1

X_1 X_2 ... X_8

Scoring: The better the pitch, the metric weight and the position within the phrase correspond, the higher the association score. Gap penalty is affine.

Models of similarity

Geometric models (Nonmetric multidimensional scaling)

Featural models (Tversky)

Alignment models

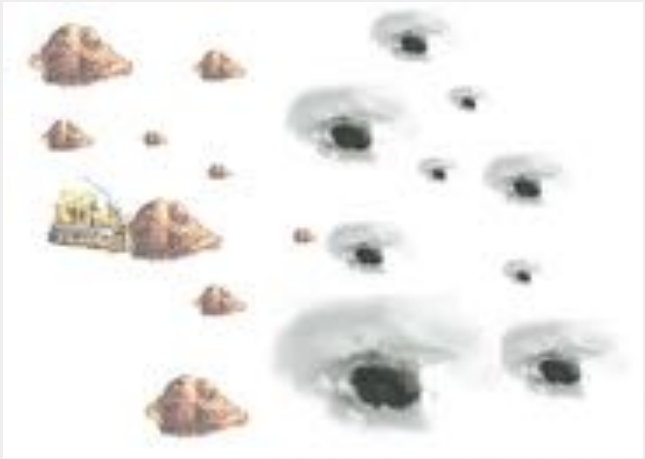
Transformational models

Transformational models

- Similarity as transformation
- as a function of effort or complexity necessary to transform one object into the other

- Example:
  - Transportation distances: similarity between melodic incipits

$$\mathrm{EMD}(A,B) = \frac{\min_{F \in \mathcal{F}} \sum_{i=1}^{m} \sum_{j=1}^{n} f_{ij} d_{ij}}{min(W,U)}$$



Overview

- The challenge of music similarity in MIR
- Similarity
  - Why important?
  - What is tricky about similarity?
  - How to predict similarity?

This course

- Examples similarity:
  - Dance music classification (rhythmic similarity)
  - Similarity between folk tunes (melodic similarity)
  - Similarity between short melodic incipits (melodic similarity)
  - Games: similar music in similar contexts in games (e.g. leitmotif)

For further study

- Lorentz workshop “Music similarity”, Jan 19-23, 2015

https://www.lorentzcenter.nl/lc/web/2015/669/info.php3?wsid=669&venue=Oort

Scientific organizers:

Christina Anagnostopoulou (Athens, Greece)
Elaine Chew (London, United Kingdom)
Elizabeth Margulis (Fayetteville, USA)
Anja Volk (Utrecht, The Netherlands)

For further study

- Lorentz workshop “Music similarity”, Jan 19-23, 2015
  - Concepts, cognition and computation
  - Slides of talks on website
- Special Issue “Music similarity”, Journal of New Music Research
  - Volume 45 (3), 2016

Important facts/Summary

- Similarity
  - Why is modelling similarity challenging?
  - What sort of information is used to model similarity in MIR?
  - Why is the concept similarity fundamental for humans?
  - What concrete similarity/classification models have you encountered during the course (especially think of: research papers)

Literature

- Goldstone, Medin, Gentner, 1991: Relational Similarity and the Nonindependence of Features in Similarity Judgments; *Cognitive Psychology*.
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