Knowledge-based Method for Determining the Meaning of Ambiguous Biomedical Terms Using Information Content Measures of Similarity

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Objective of this work

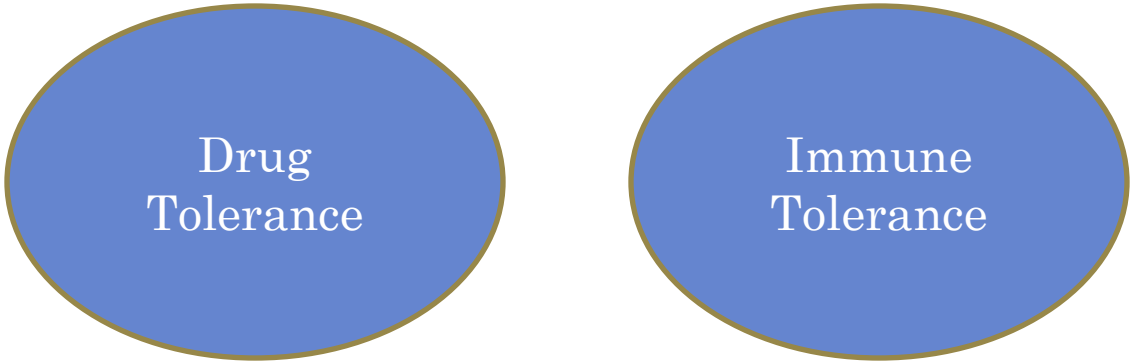
- Develop and evaluate a method than can
  disambiguate terms in biomedical text by
  exploiting similarity information
  extrapolated from the Unified Medical Language System

- Evaluate the efficacy of Information Content-based similarity measures over path-based similarity measures for Word Sense Disambiguation, WSD

Word Sense Disambiguation

Word sense disambiguation is the task of determining the appropriate sense of a term given context in which it is used.

TERM: tolerance



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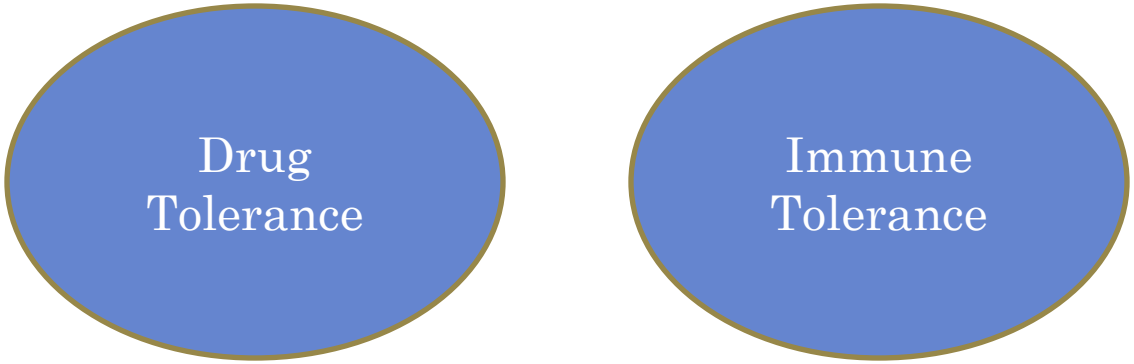
Busprione attenuates tolerance to morphine in mice with skin cancer



Sense inventory: Unified Medical Language System

- Unified Medical Language Sources (UMLS)
  - Semantic Network
  - Metathesaurus
    - ~1.7 million biomedical and clinical concepts; integrated semi-automatically
    - CUIs (Concept Unique Identifiers), linked:
      - Hierarchical: PAR/CHD and RB/RN
      - Non-hierarchical: SIB, RO
    - Sources viewed together or independently
      - Medical Subject Heading (MSH)
  - SPECIALIST Lexicon
    - Biomedical and clinical terms, including variants

Word Sense Disambiguation

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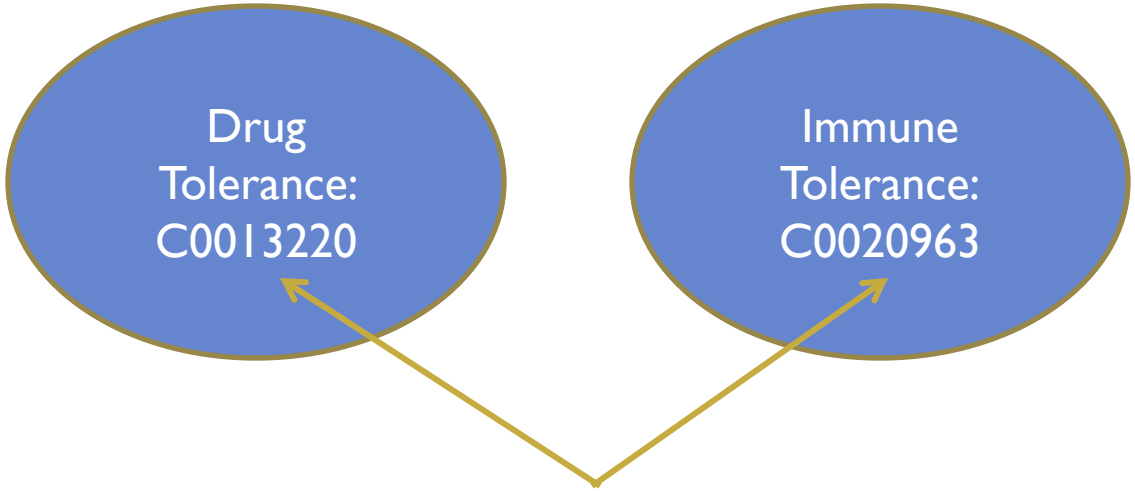

Concept Unique Identifiers: CUIs

SENSERELATE ALGORITHM

- Each possible sense of a **target word** is assigned a score [sum similarity between it and its surrounding terms]
- Assign target word the sense with highest score

- Proposed by Patwardhan and Pedersen 2003 using WordNet

- UMLS::SenseRelate is a modification of this algorithm using information from the UMLS

NEXT UP: an example

SENSERELATE EXAMPLE

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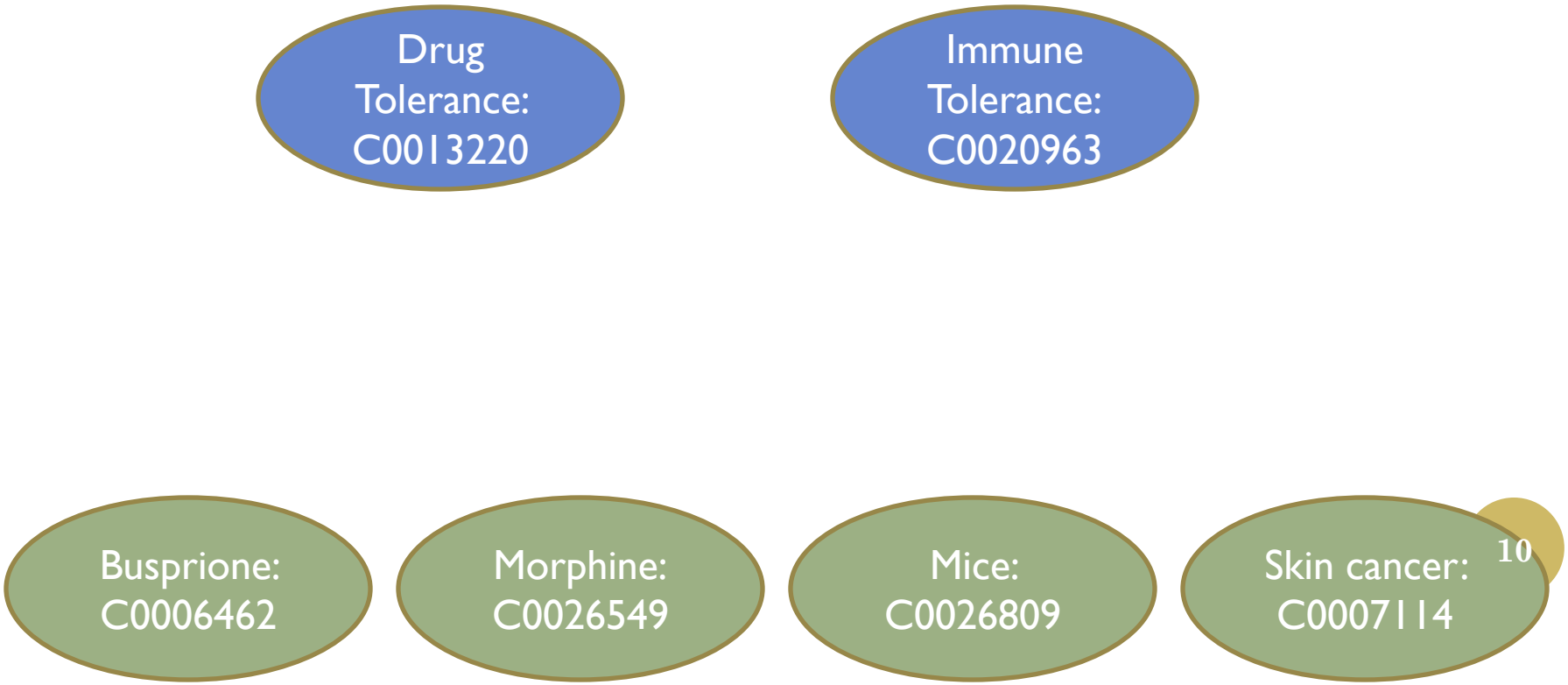

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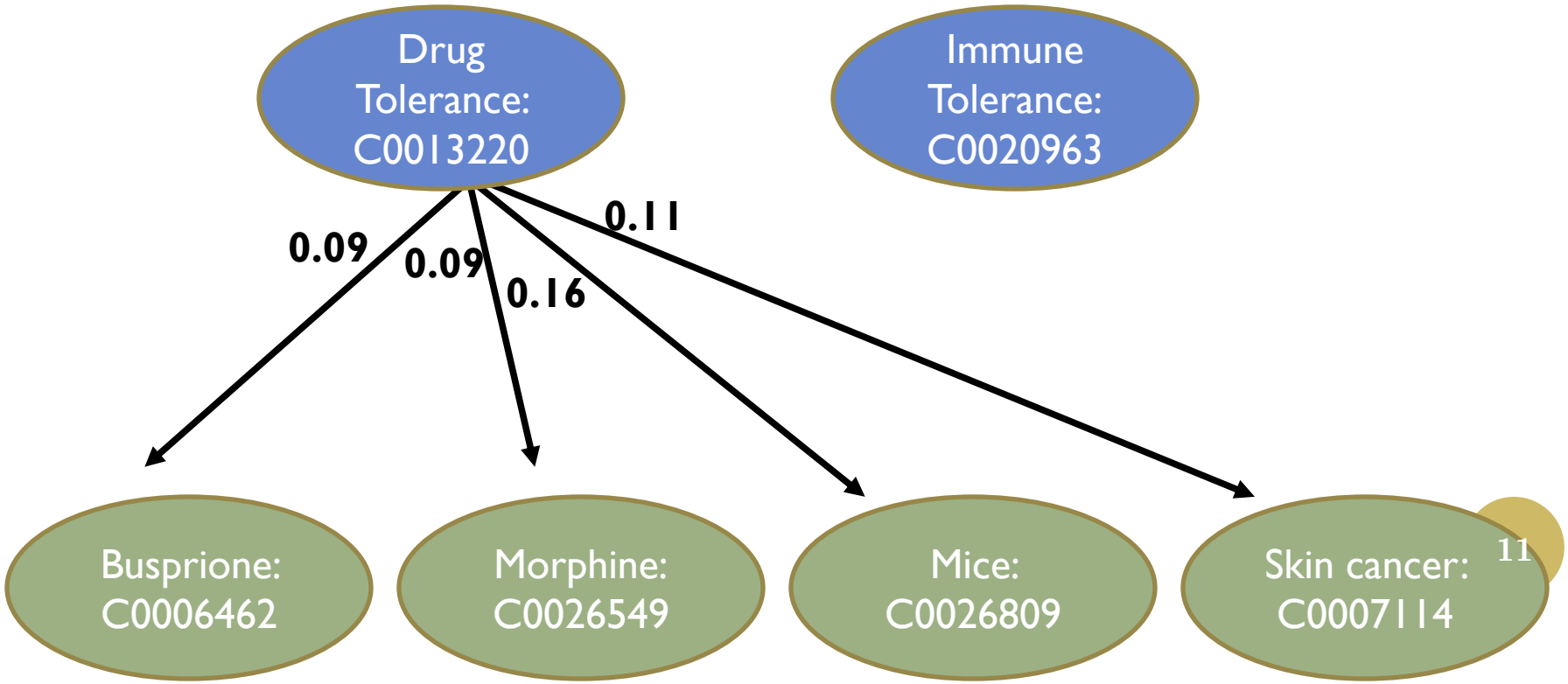
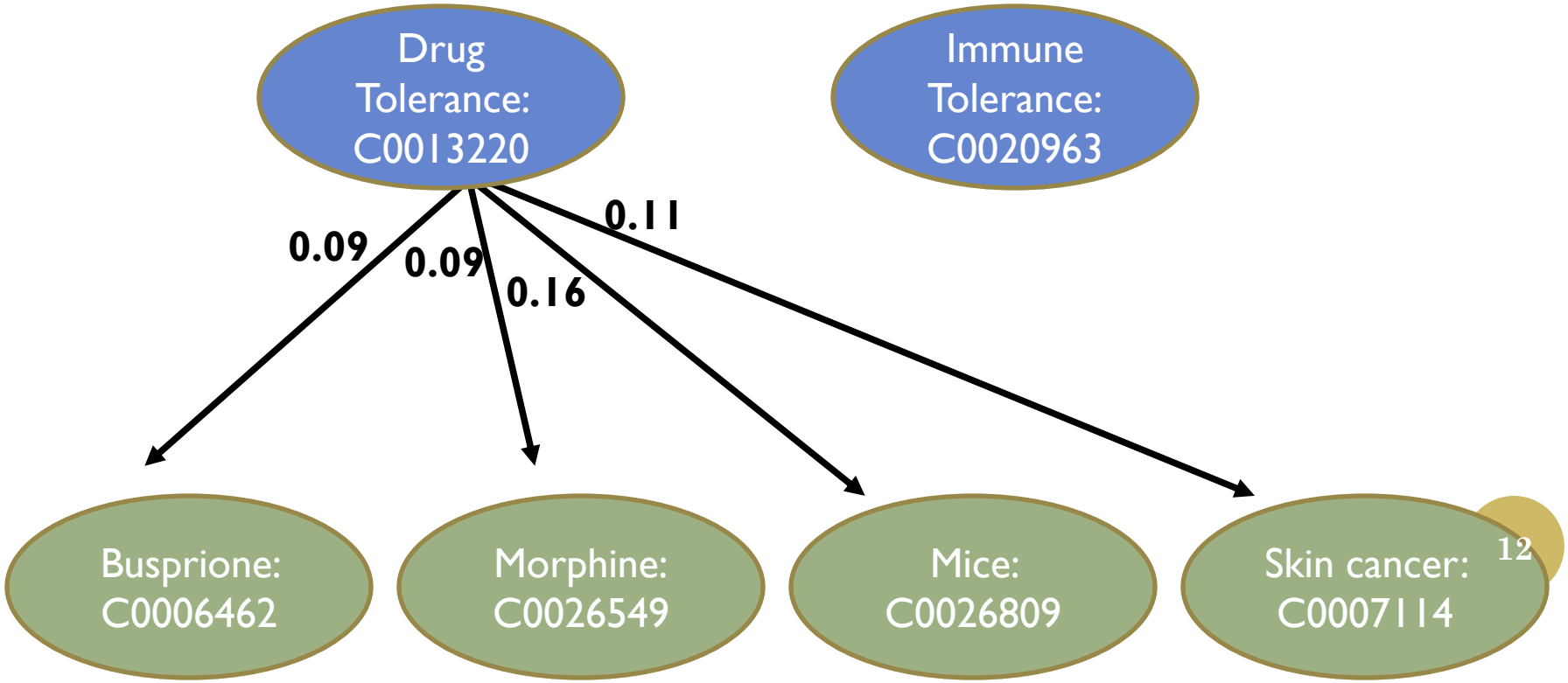


SENSERELATE EXAMPLE

Busprione attenuates tolerance to morphine in mice with skin cancer

Drug Tolerance
Score = 0.09 + 0.09 + 0.16 + 0.11 = 0.45



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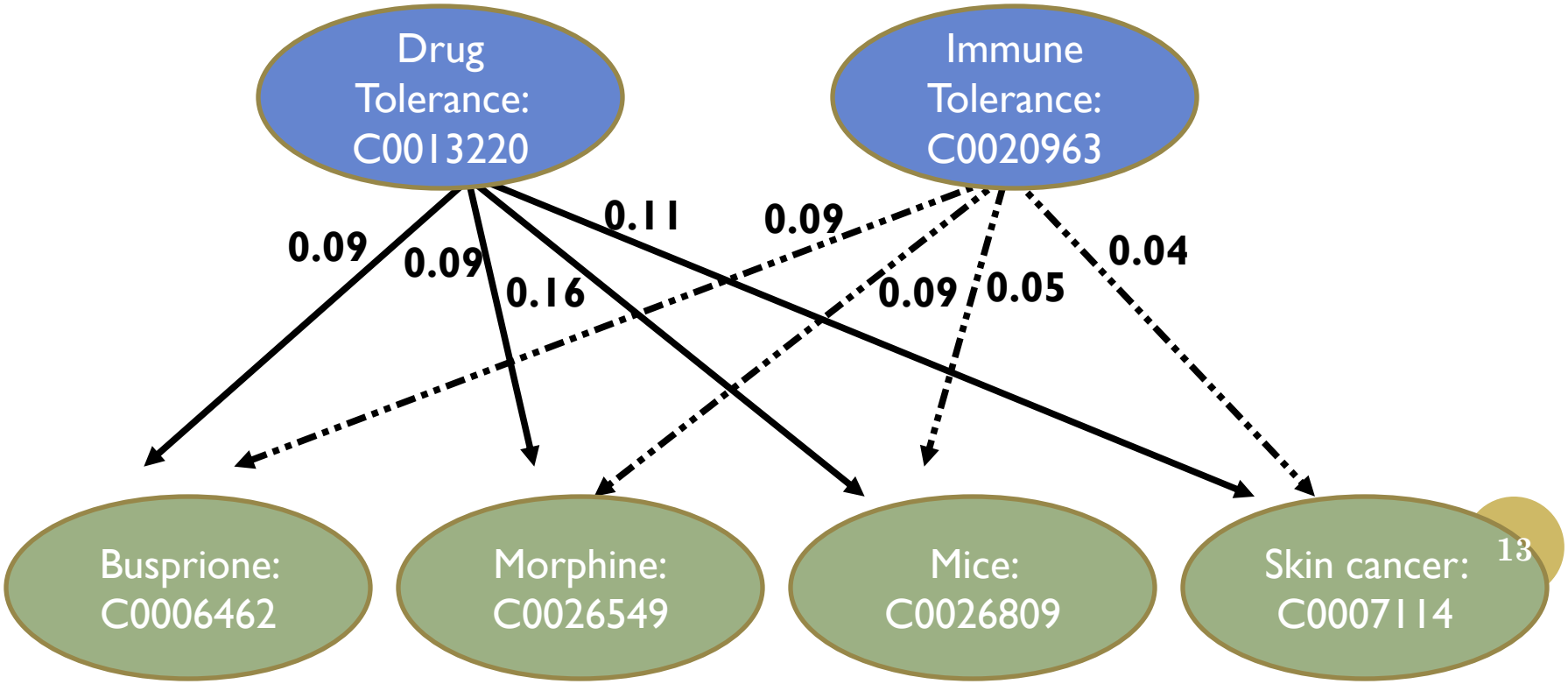

SENSERELATE EXAMPLE

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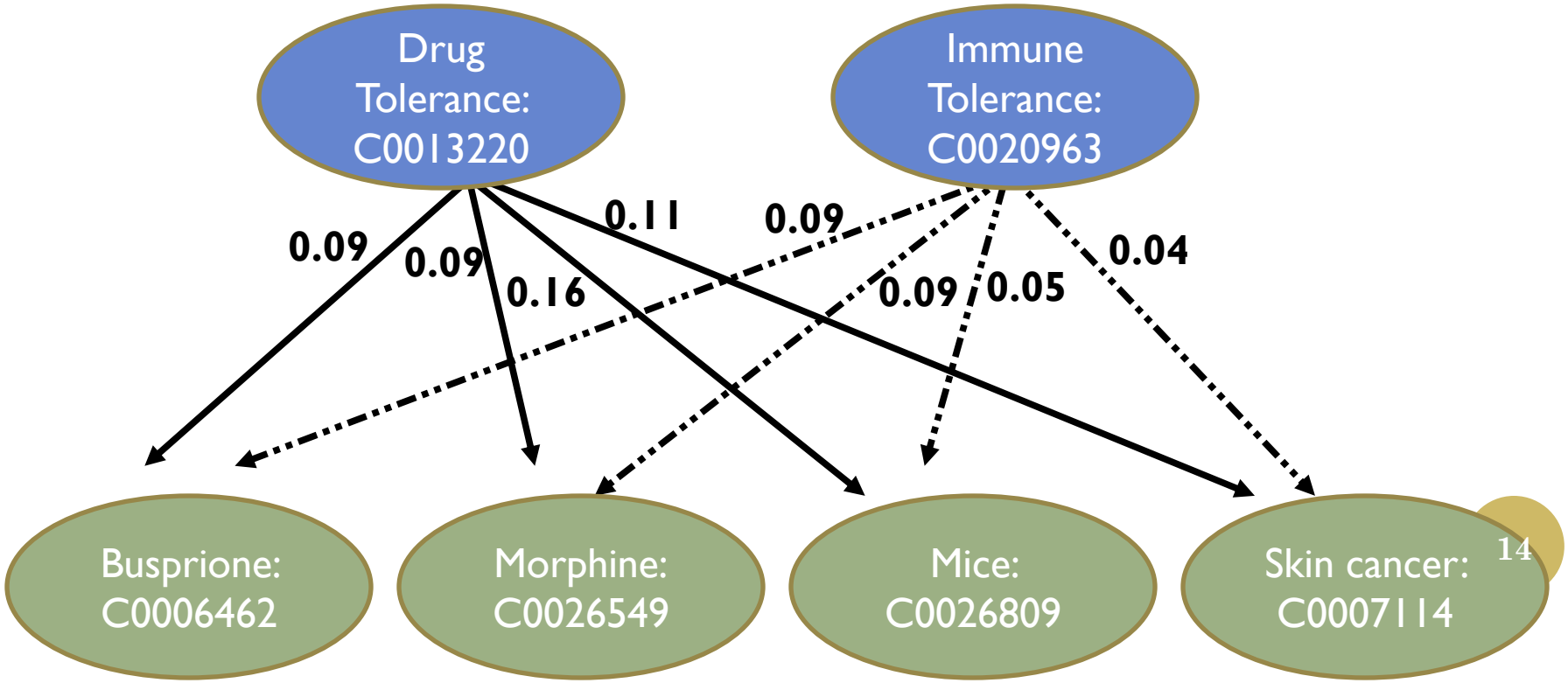
Drug Tolerance	Immune Tolerance
Score = 0.09 + 0.09 + 0.16 + 0.11 = 0.45	Score = 0.09 + 0.09 + 0.05 + 0.05 = 0.27



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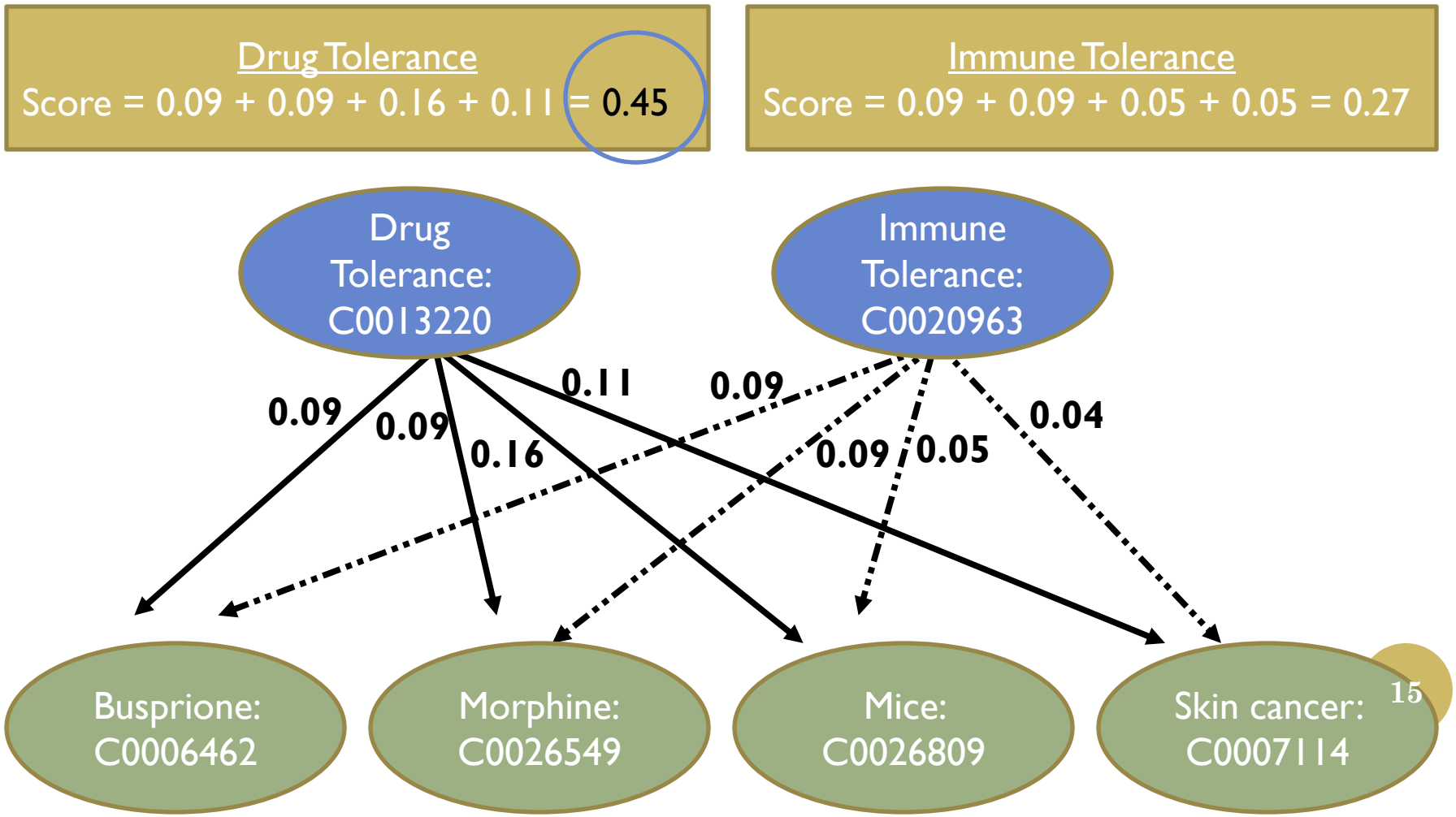

Sense Relate **Assumption**

An ambiguous word is often used in the sense that is most similar to the sense of the terms that surround it

SenseRelate Components

- Identifying the concepts of surrounding terms
- Calculating semantic similarity

Identifying the concepts of the surrounding terms

Use the SPECIALIST LEXICON to identify the terms and map the terms doing a string match to the MRCONSO table in the UMLS

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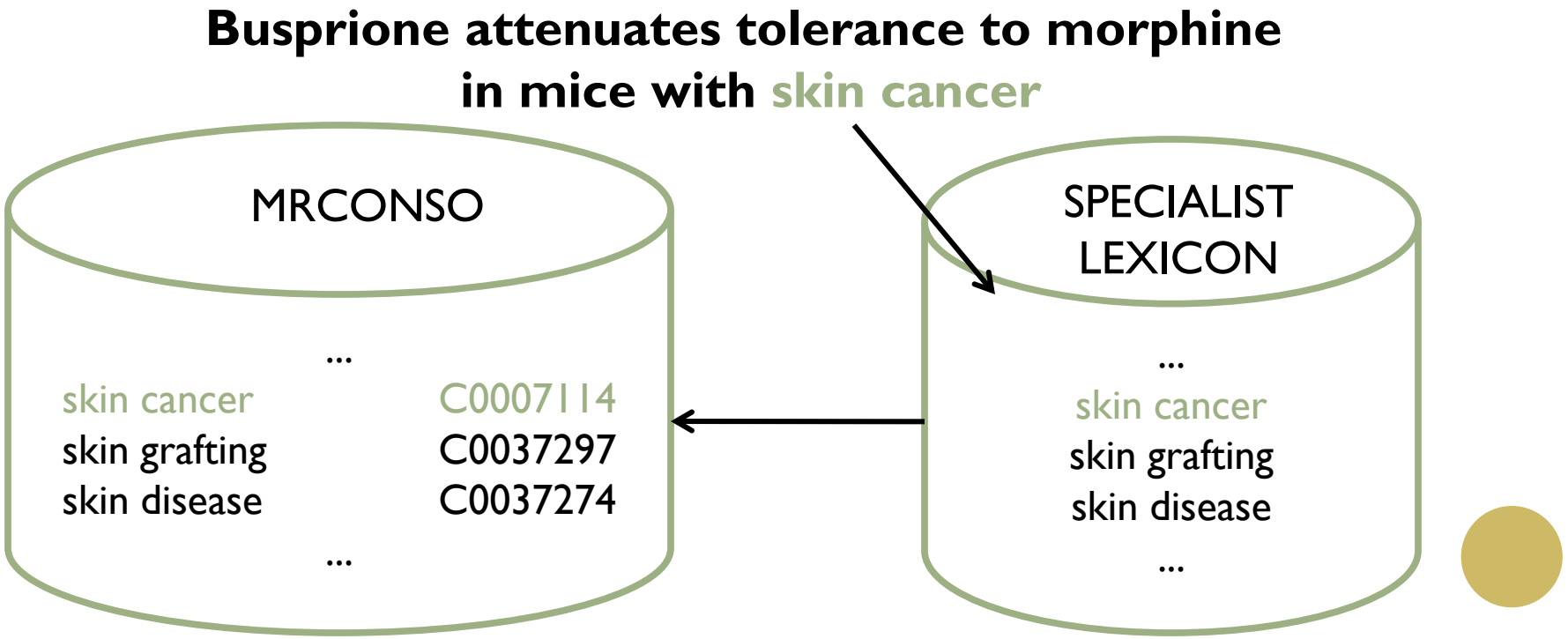
IDENTIFYING THE CONCEPTS OF THE SURROUNDING TERMS

Use the SPECIALIST LEXICON to identify the terms and map the terms doing a string match to the MRCONSO table in the UMLS



Semantic Similarity Measures

- Path-based measures
  - Path
  - Wu and Palmer
  - Leacock and Chodorow
  - Ngyuen and Al-Mubaid
- Information content (IC)-based measures
  - Resnik
  - Lin
  - Jiang and Conrath

Path-based similarity measures

- Use only the path information obtained from a taxonomy

PATH-BASED SIMILARITY MEASURES

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- Path measure
  - sim(c1,c2) = 1 / minpath(c2,c2)
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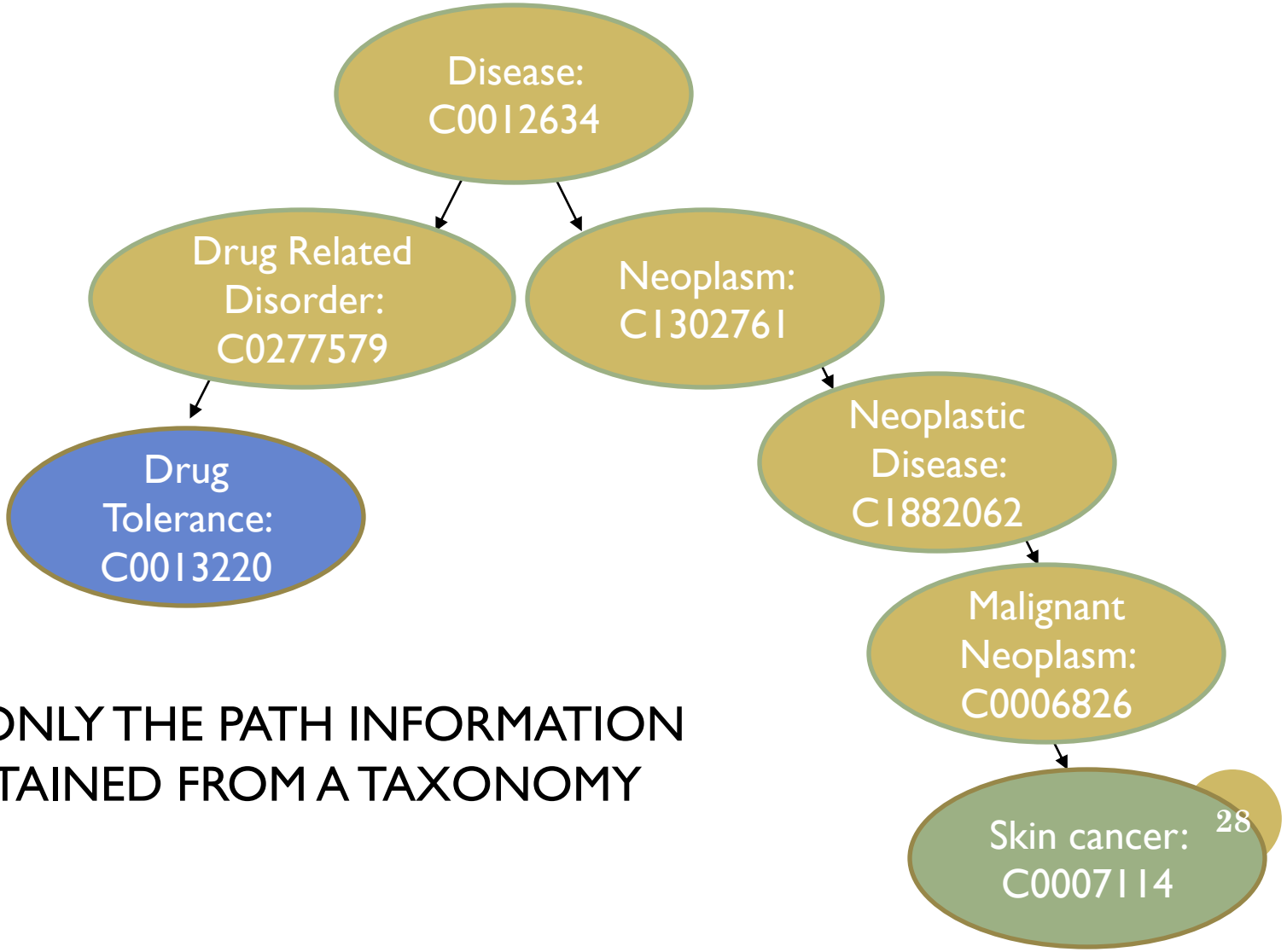
    - where LCS is the least common subsumer of the two concepts
- Nyguen and Al-Mubaid, 2006
  - sim(c1,c2) = log ((2 + minpath(c1,c2) - 1) * (D - depth(LCS(c1,c2))))

Path-based Similarity Measures



USE ONLY THE PATH INFORMATION OBTAINED FROM A TAXONOMY

Information content-based Measures

- Incorporate the probability of the concepts
  - IC = -log(P(concept))

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- Incorporate the probability of the concepts
  - IC = -log(P(concept))
- P(concept)
  - Calculated by summing the probability of the concept and the probability of its descendants
  - Probabilities are obtained from an external corpus

Information content-based Measures

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- Resnik, 1995
  - sim(c1,c2) = IC(LCS(c1,c2))

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- Incorporate the probability of the concepts
  - IC = -log(P(concept)
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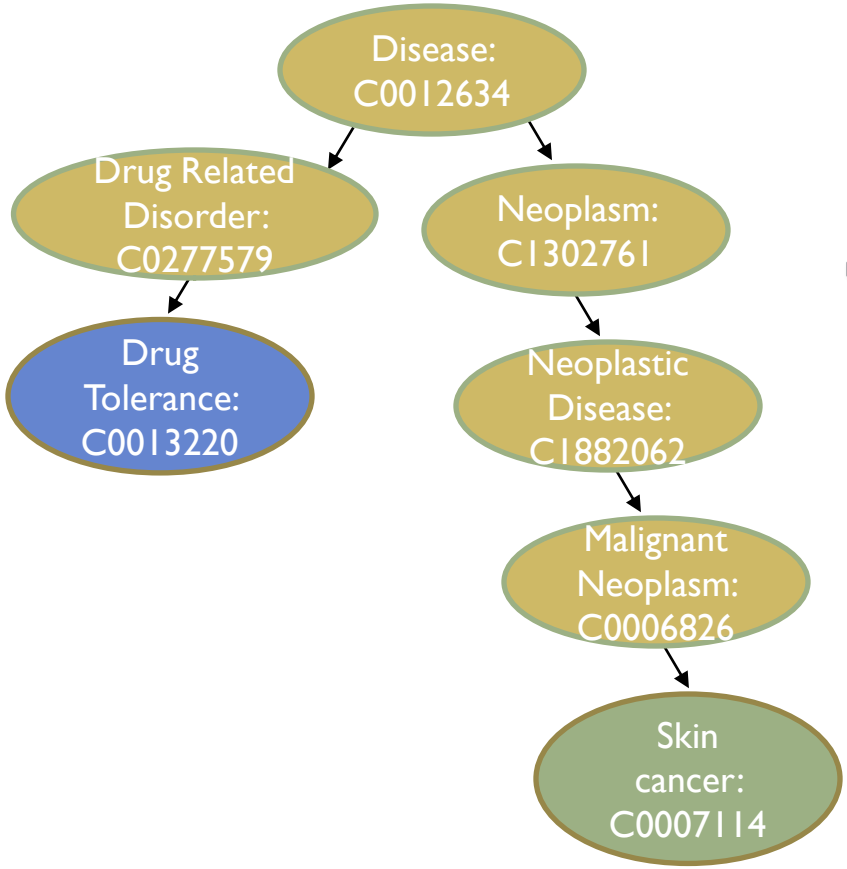
  - sim(c1,c2) = 1 ÷ (IC(c1)+IC(c2) – 2* IC(LCS(c1,c2))
- Lin, 1998
  - sim(c1,c2) = (2*IC(LCS(c2,c2))) / (IC(c1)+IC(c2))

IC-BASED SIMILARITY MEASURES

PATH INFORMATION



PROBABILITY OF CONCEPTS

EXTERNAL CORPUS

Experimental Framework

- Use open-source UMLS::Similarity package to obtain the similarity between the terms and possible senses in the SenseRelate algorithm

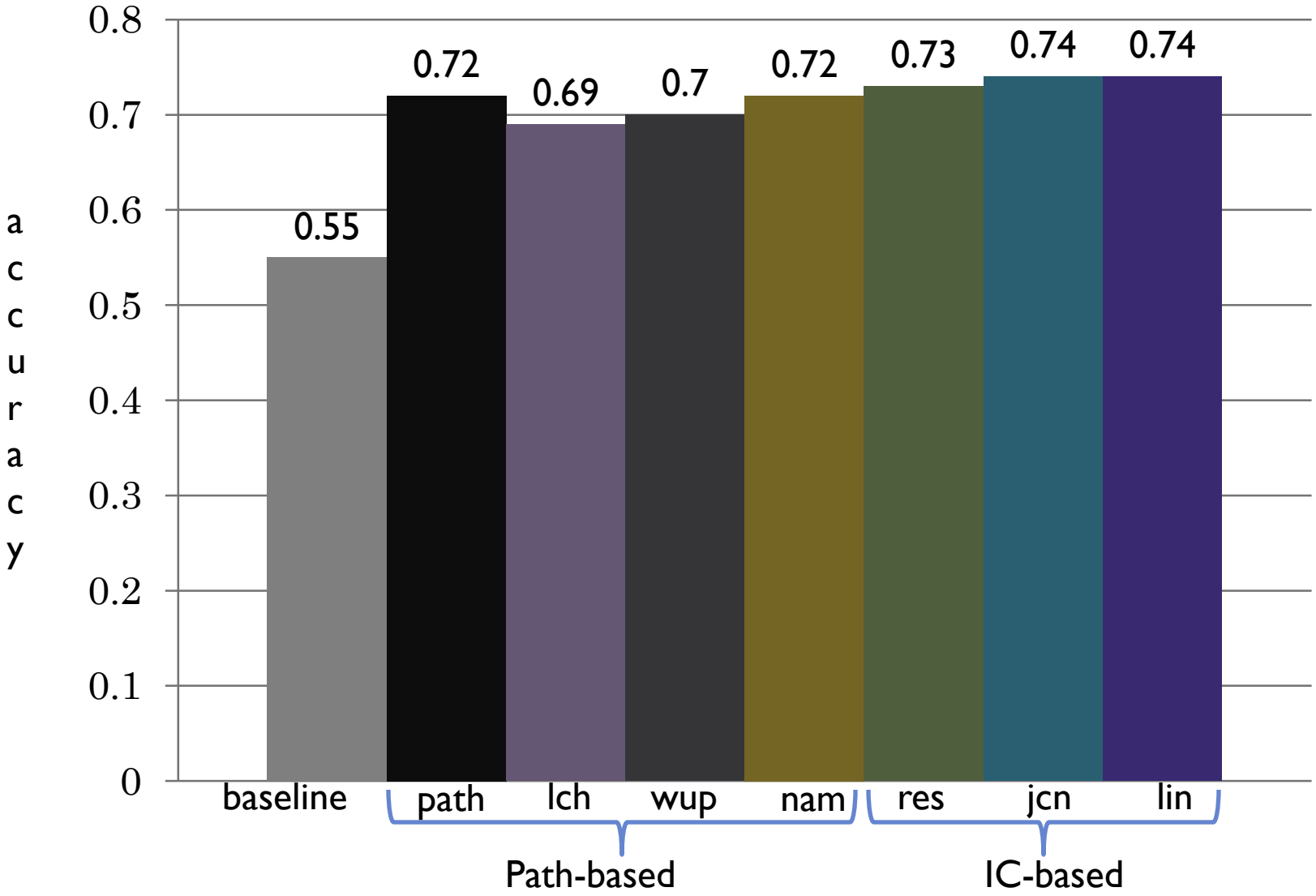
- Path information: parent/child relations in MSH source

- Information content: calculated using the UMLSonMedline dataset created by NLM
  - Consists of concepts from 2009AB UMLS and the frequency they occurred in Medline using the Essie Search Engine (Ide et al 2007)
  - Medline: database of citations of biomedical/clinical articles

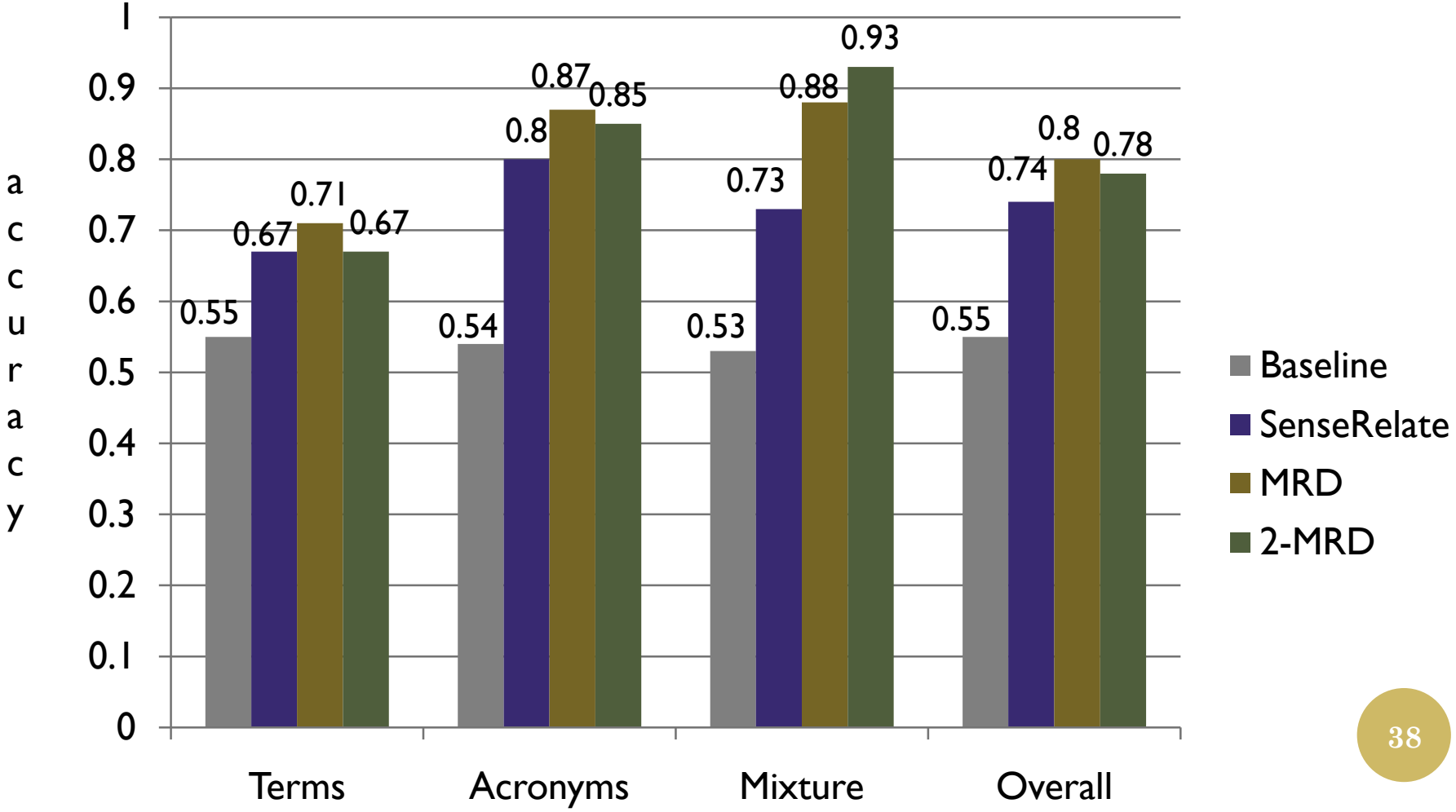
Evaluation Data: MSH WSD

- MSH-WSD dataset (Jimeno-Yepes, et al 2011)
  - 203 target words (ambiguous word) from Medline
    - 106 terms e.g. tolerance
    - 88 acronyms e.g. CA (calcium, california)
    - 9 mixtures e.g. bat (brown adipose tissue)
  - Each target word contains ~187 instances (Medline abstracts)
    - abstract = ~ 500 words
  - Each target word in the instances assigned a concept from MSH by exploiting the manually assigned MSH concepts assigned to the abstract
  - Average of 2.08 possible senses per target word
  - Majority sense over all the target words is 54.5%

RESULTS


accuracy
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.55
0.72
0.69
0.7
0.72
0.73
0.74
0.74
baseline
path
lch
wup
nam
res
jcn
lin
Path-based
IC-based

Comparison across subsets of MSH-WSD



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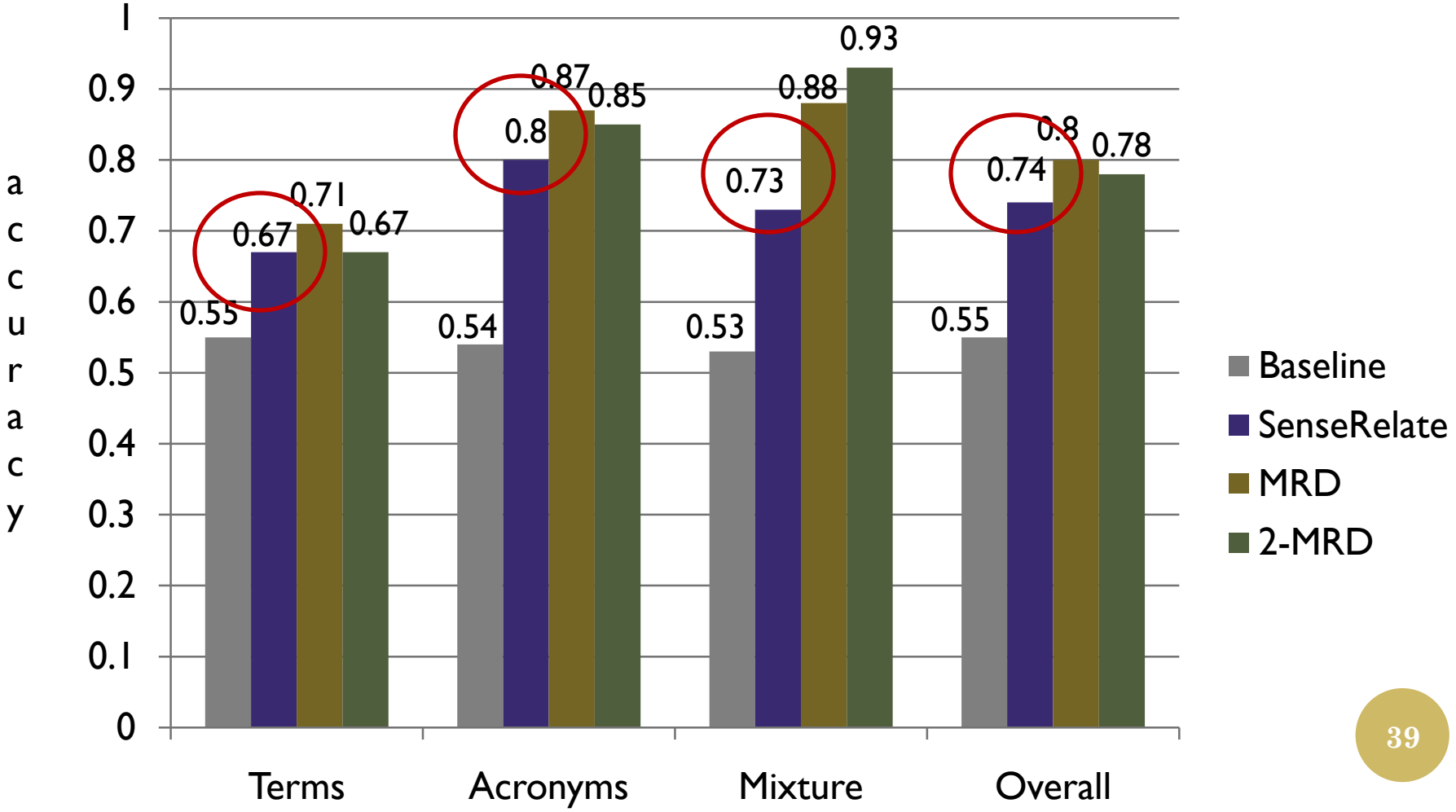

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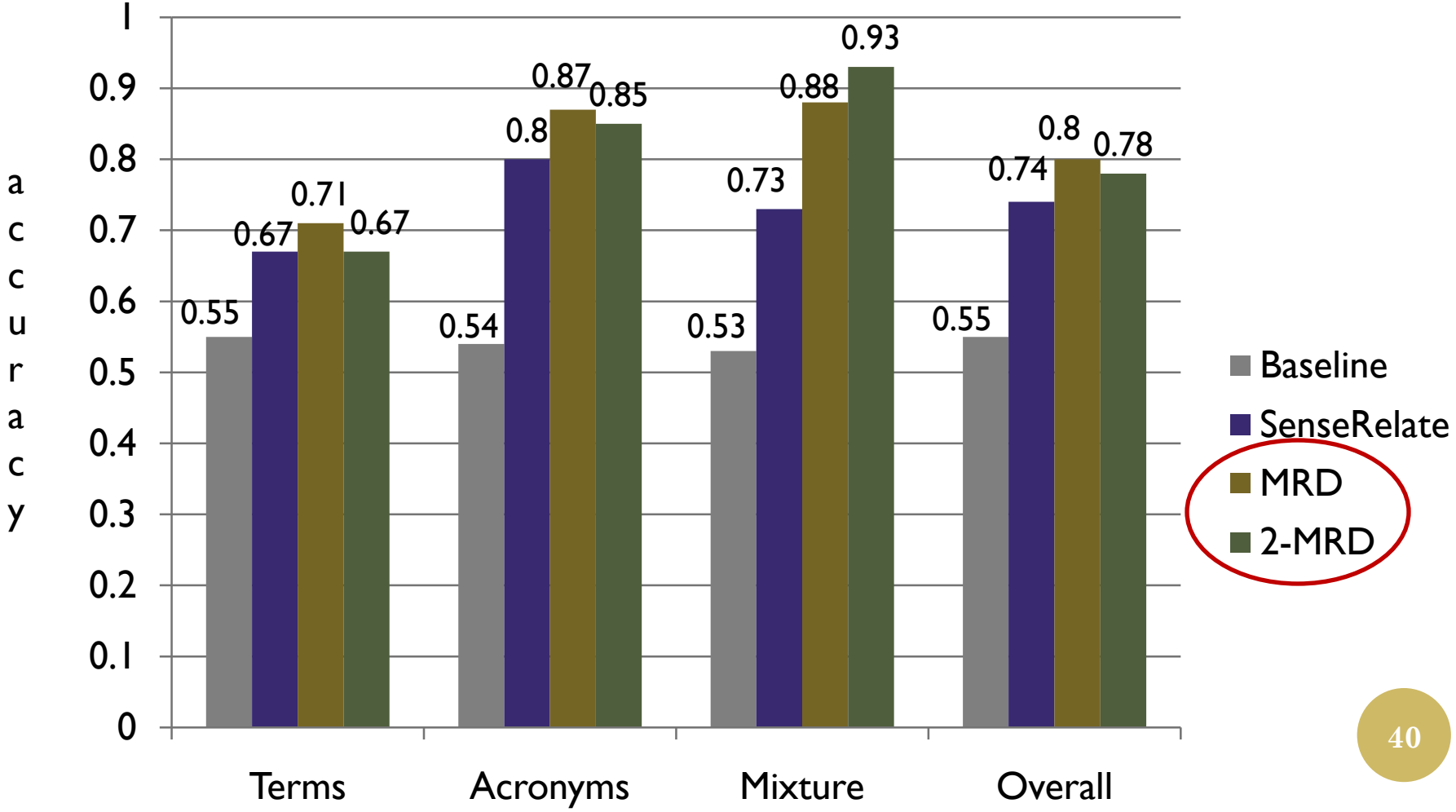

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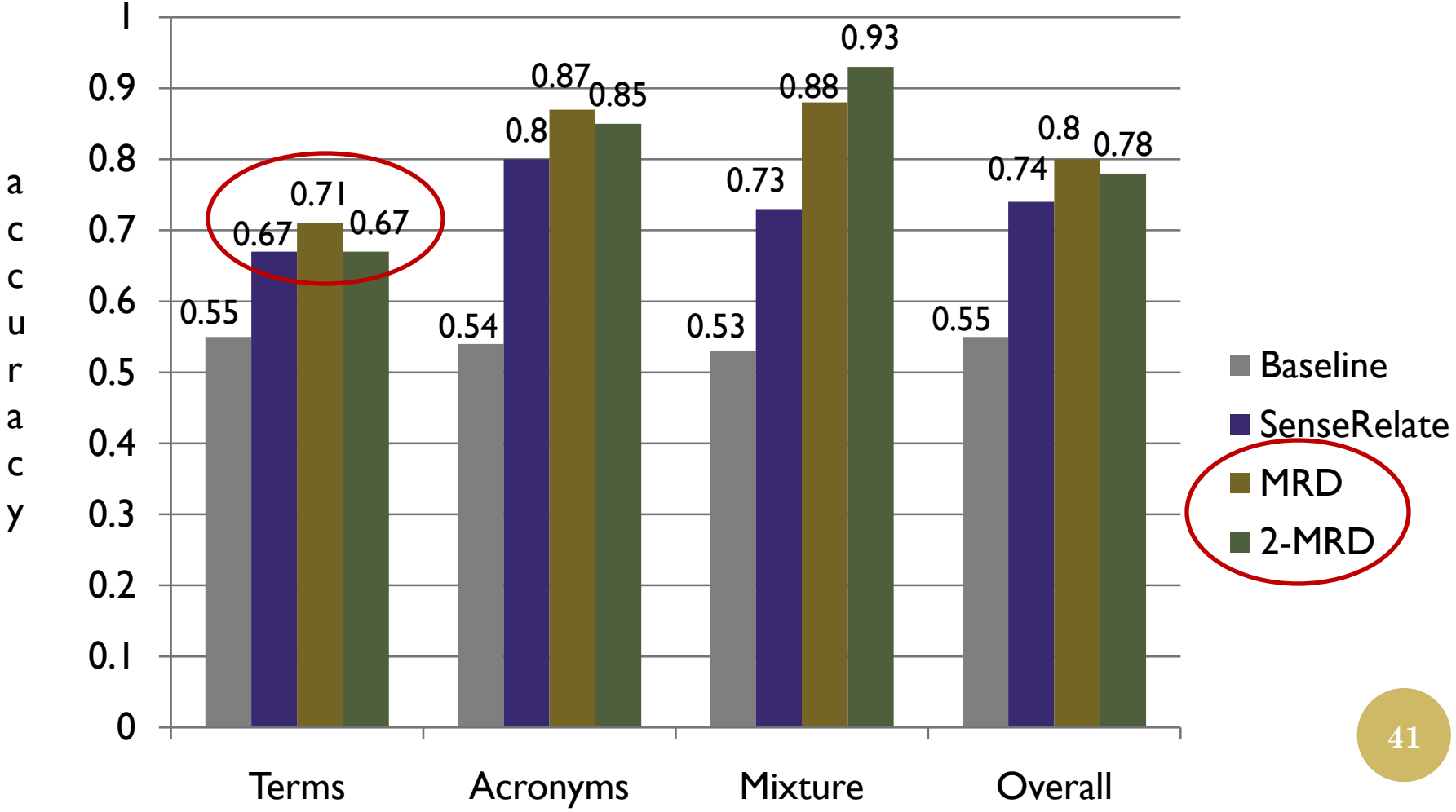

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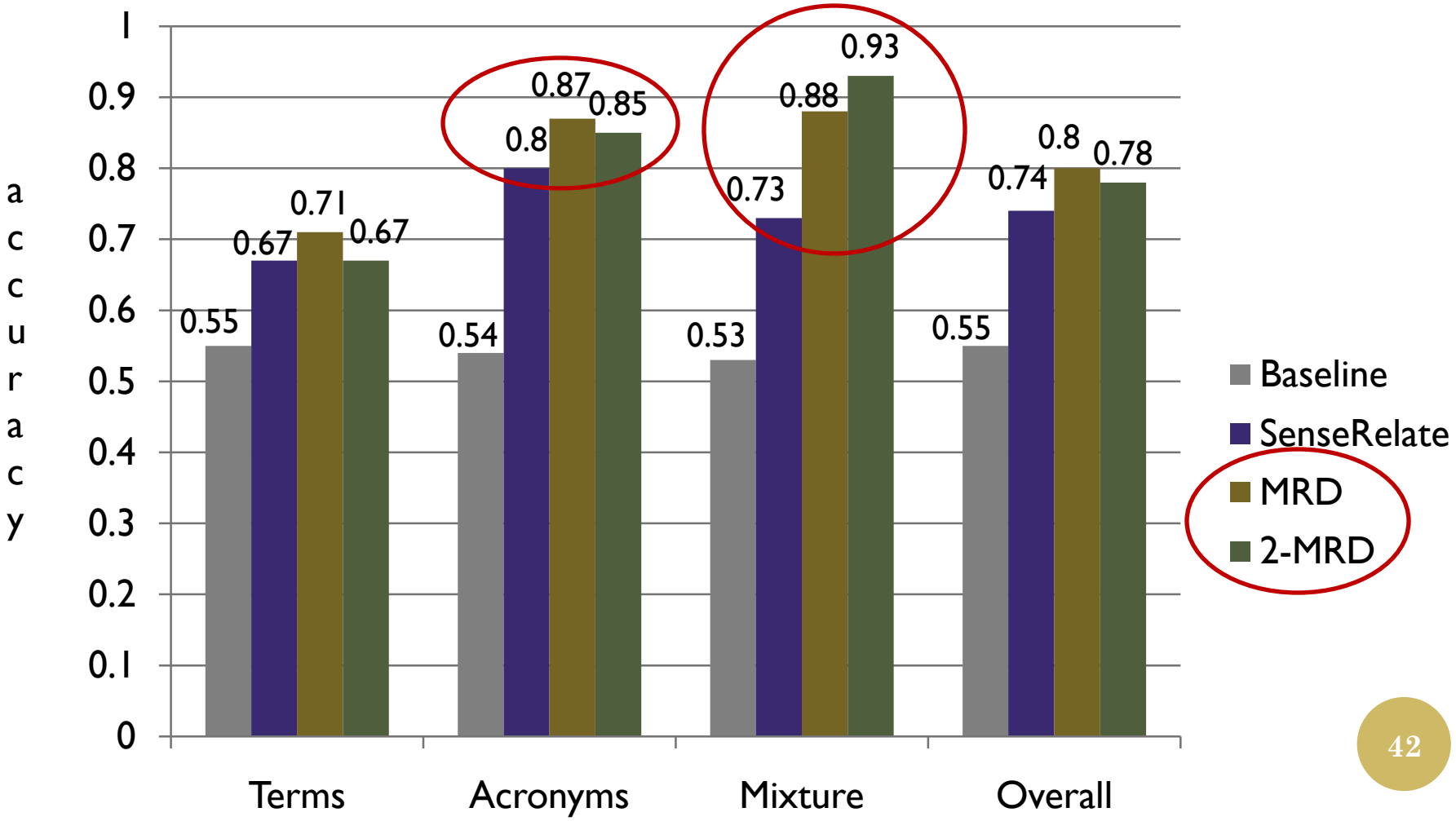


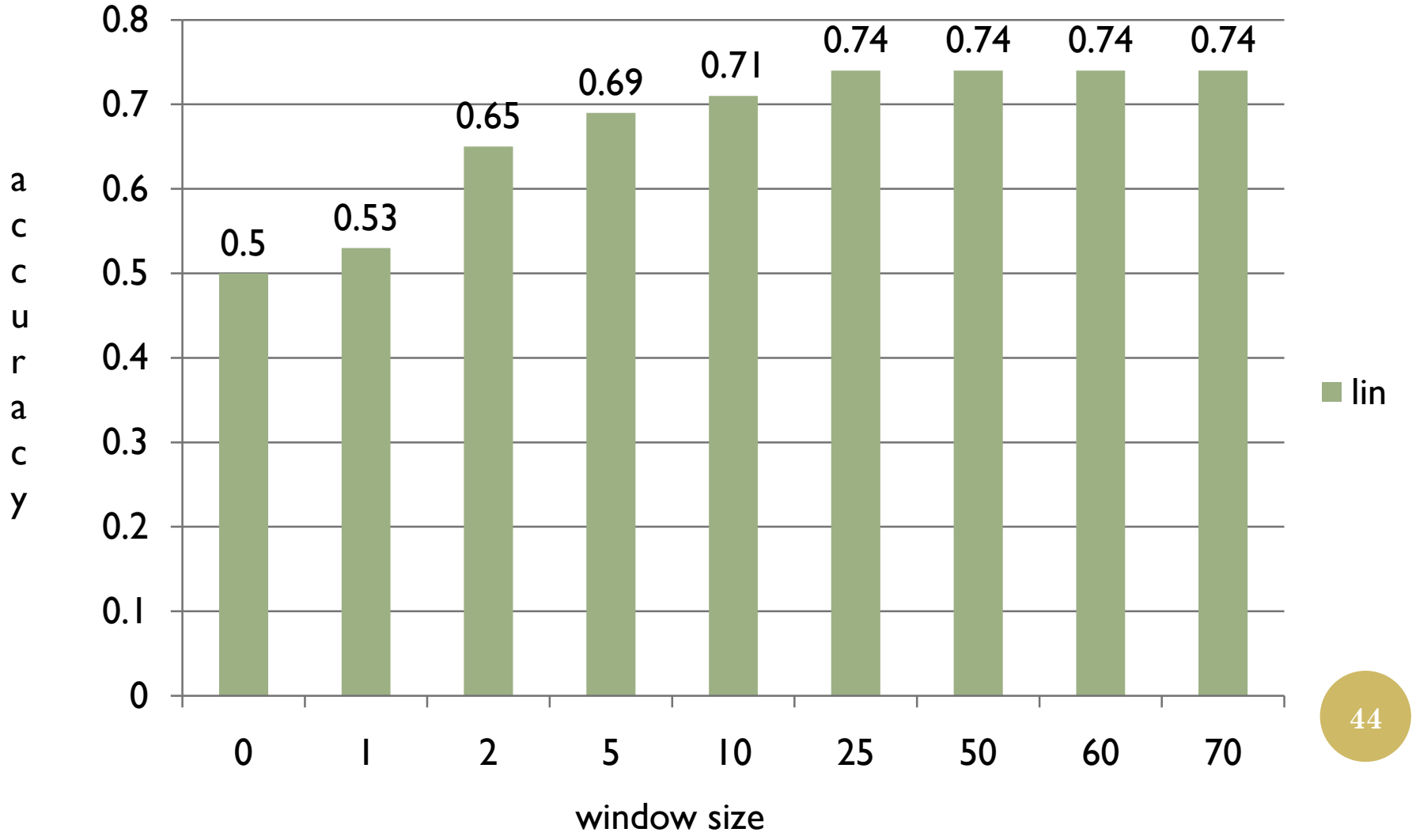
WINDOW SIZES

- Use the terms surrounding the target word within a specified window: 1, 2, 5, 10, 25, 50, 60, 70

WINDOW SIZE = 2

Busprione attenuates tolerance to morphine in mice with skin_cancer

Comparison of window sizes for lin



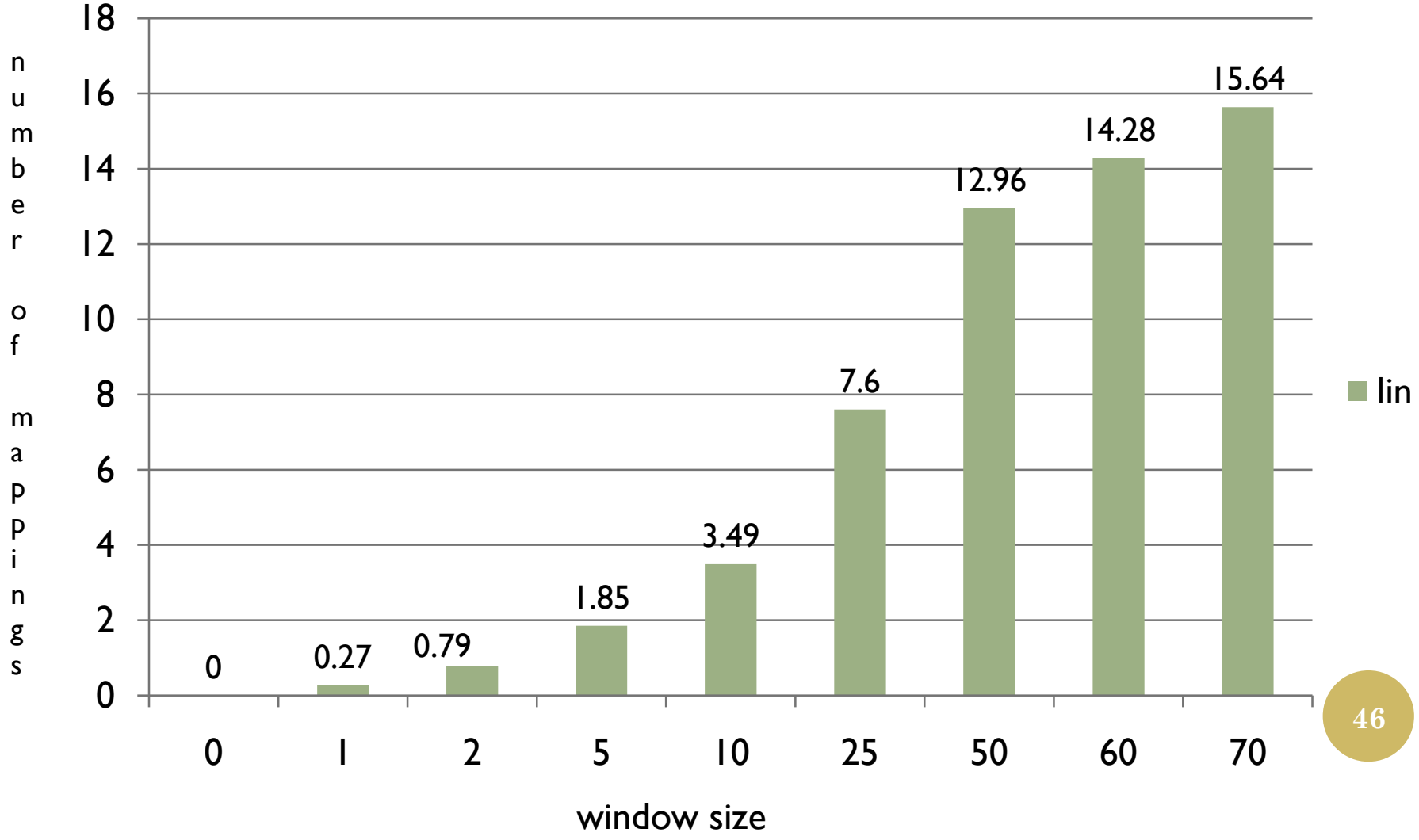
SURROUNDING TERMS

Not all terms have a concept in the UMLS

therefore

Not all surrounding terms in the window mapped to CUIs

WINDOW SIZES VERSUS MAPPED TERMS



Future Work: Mapping Terms

- Currently looking at mapping the terms to CUIs using information from the concept mapping system MetaMap
  - Obtain the terms from MetaMap and do a dictionary look up in MRCONSO
    - Hypothesis – the terms obtained by MetaMap are more accurate than using the SPECIALIST Lexicon
  - Obtain the CUIs from MetaMap
    - Hypothesis – the CUIs obtained by MetaMap will be more accurate than the dictionary look-up

Objective #1

Develop and evaluate a method than can disambiguate terms in biomedical text by exploiting similarity information extrapolated from the UMLS

- UMLS::SenseRelate statistically significantly higher disambiguation accuracy than the baseline
- On par with previous unsupervised methods for terms

Objective #2

Evaluate the efficacy of IC-based similarity measures over path-based measures on a secondary task

- There is no statistically significant difference between the accuracies obtained by the IC-based measures
- There is a statistically significant difference between the IC-based measures and the path-based measures

Take home message:

An ambiguous word is often used in the sense that is most similar to the sense of the concepts of the terms that surround it

Resources

- Software:
  - UMLS::SenseRelate
    - http://search.cpan.org/dist/UMLS-SenseRelate/
  - UMLS::Similarity
    - http://search.cpan.org/dist/UMLS-Similarity/
- Data
  - MSH-WSD
    - http://wsd.nlm.nih.gov/collaboration.shtml

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THANK YOU

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QUESTIONS?