Multilingual Lexical Acquisition by Bootstrapping Cognate Seed Lexicons

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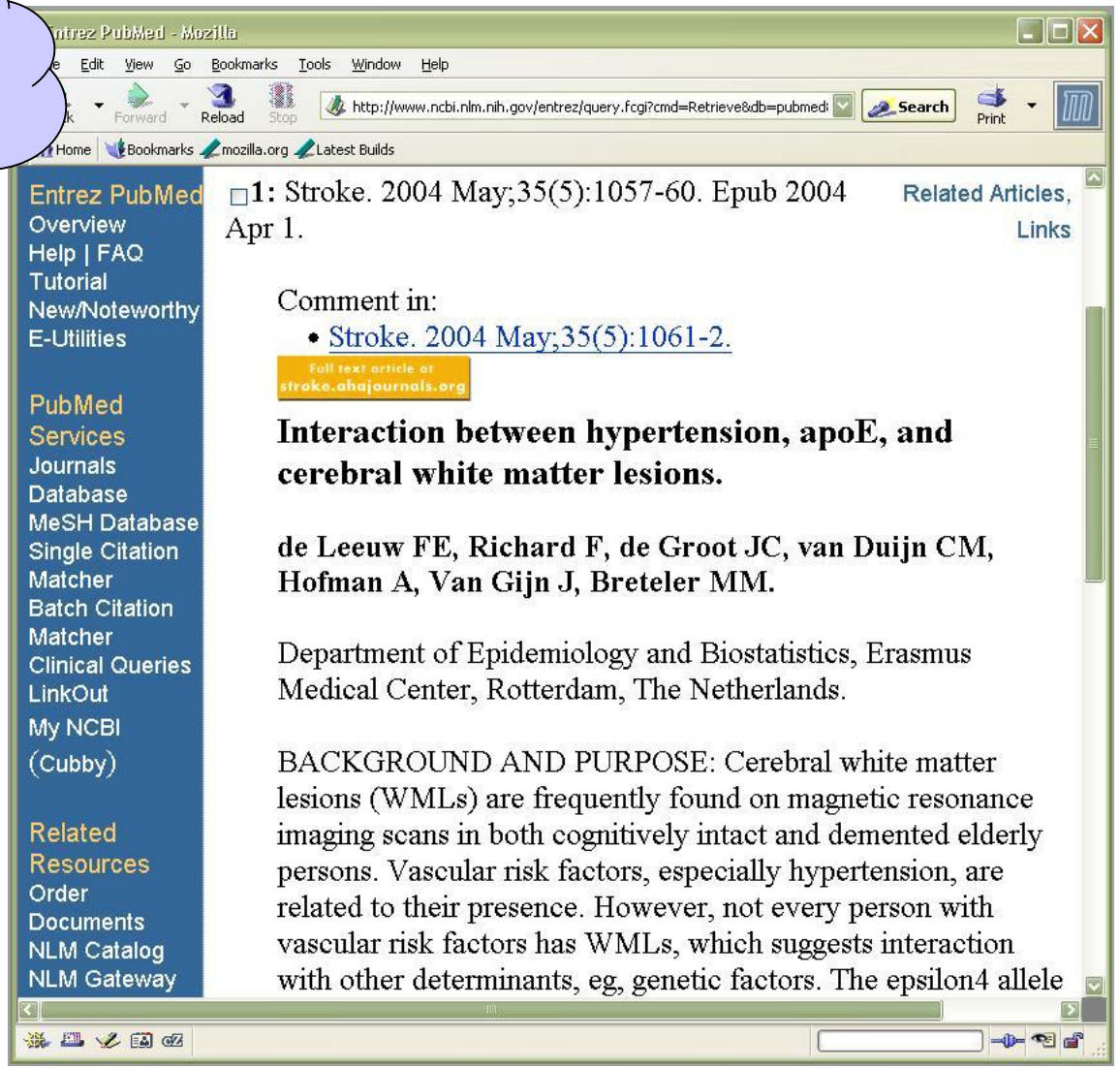
Cross-Language Text Retrieval

„Korrelation von Hypertonie und Läsion der Weißen Substanz“

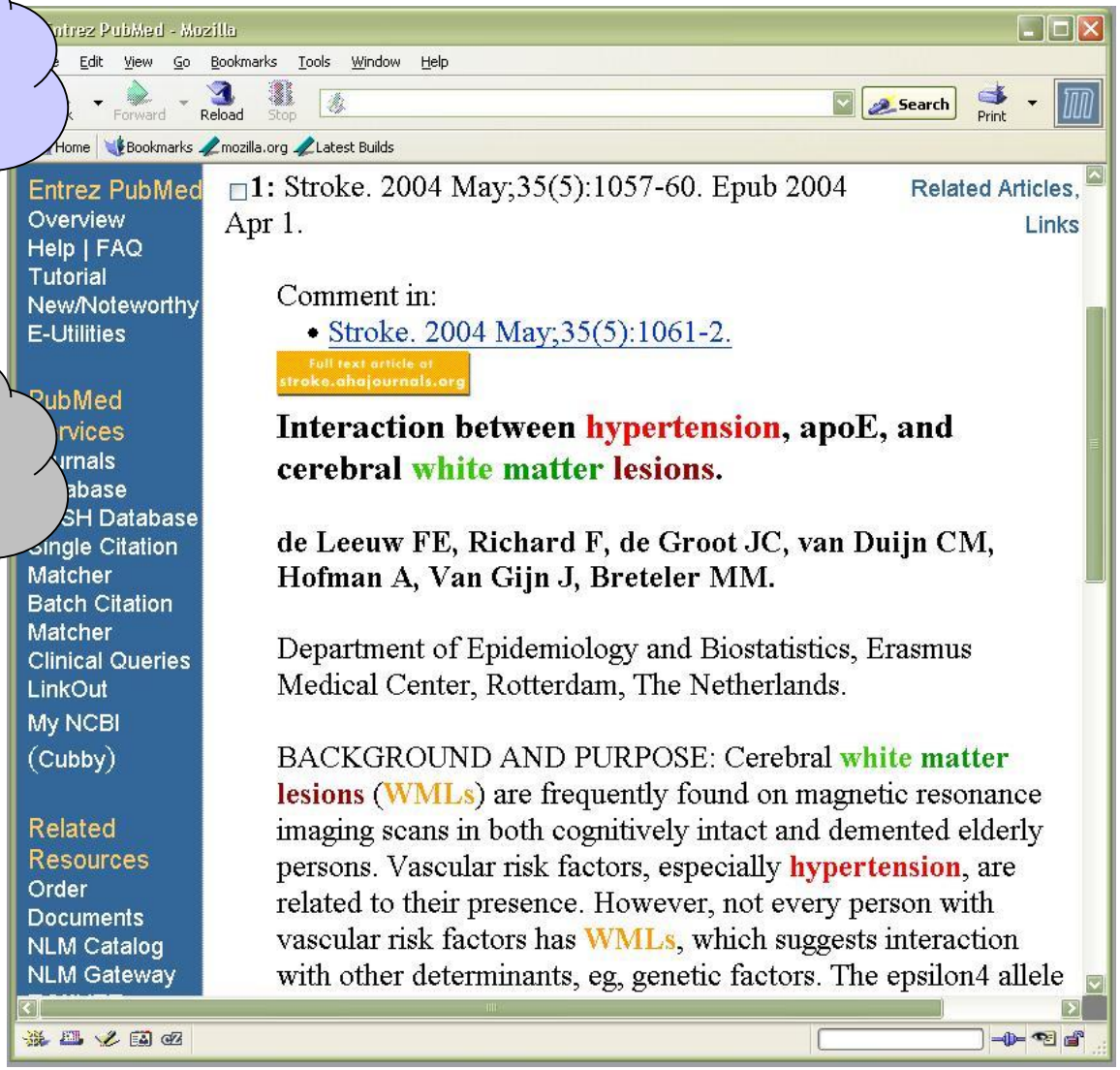


Cross-Language Text Retrieval

„Korrelation von Hypertonie und Läsion der Weißen Substanz“

„Correlation of high blood pressure and lesion of the white substance“

Search Engine



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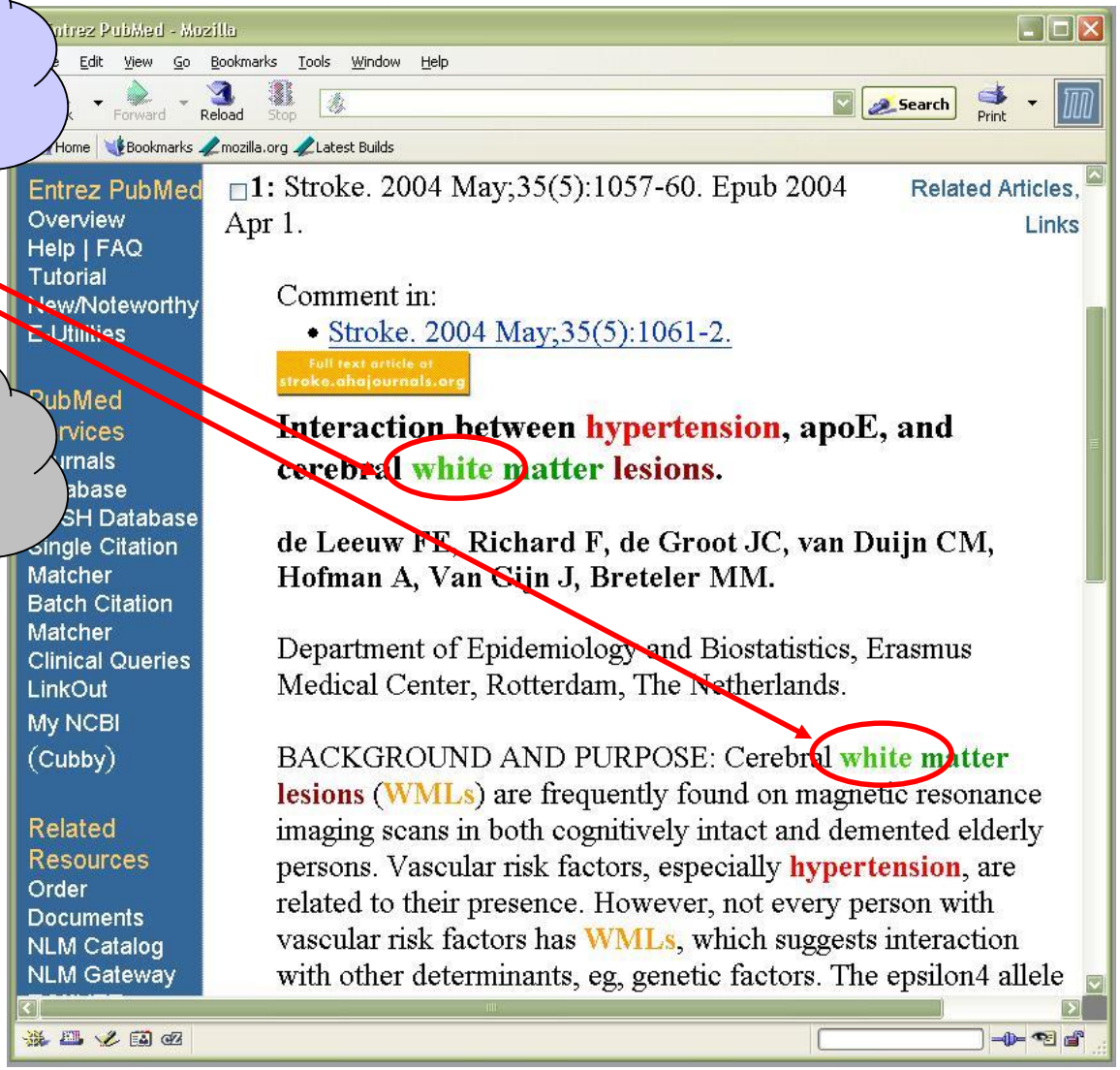
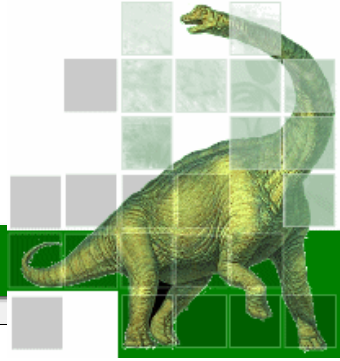


MorphoSaurus* semantic indexing system



- Subword oriented:
  - Subwords are atomic conceptual or linguistic units

stomach, gastr-, diaphys-,
anti-, bi-, hyper- , -itis
-ary, -ion, -it, -is, -o-, -s-

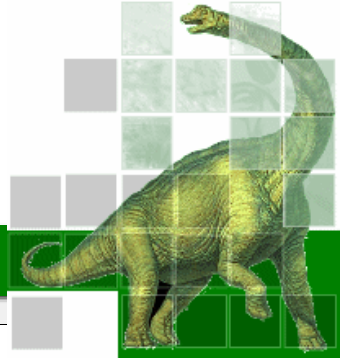
- Multilingual subword lexicon:
  - Good coverage for German, English, Portuguese (manually), French, Spanish, Swedish under construction
- Subword thesaurus
  - Groups synonyms and translations are in equivalence classes.

#female = { ***woman***, ***women***, ***female***, ***frau-***, ***weib-***, ***mulher-***}

MID (MorphoSaurus Identifier)

**http://www.morphosaurus.net*

Example of MorphoSaurus Indexing



High TSH values suggest the diagnosis of primary hypo-thyroidism ...

Erhöhte TSH-Werte erlauben die Diagnose einer primären Hypothyreose ...

Original

Orthographic Normalization

Orthografic Rules

high tsh values suggest the diagnosis of primary hypo-thyroidism ...

erhoehte tsh-werte erlauben die diagnose einer primaeren hypothyreose ...

Segmenter

Subword Lexicon

high tsh value s **suggest** the **diagnos** is of **primar** y **hypo thyroid** ism

er **hoeh** te **tsh wert** e **erlaub** en die **diagnos** e einer **primaer** en **hypo thyre** ose

Semantic Normalization

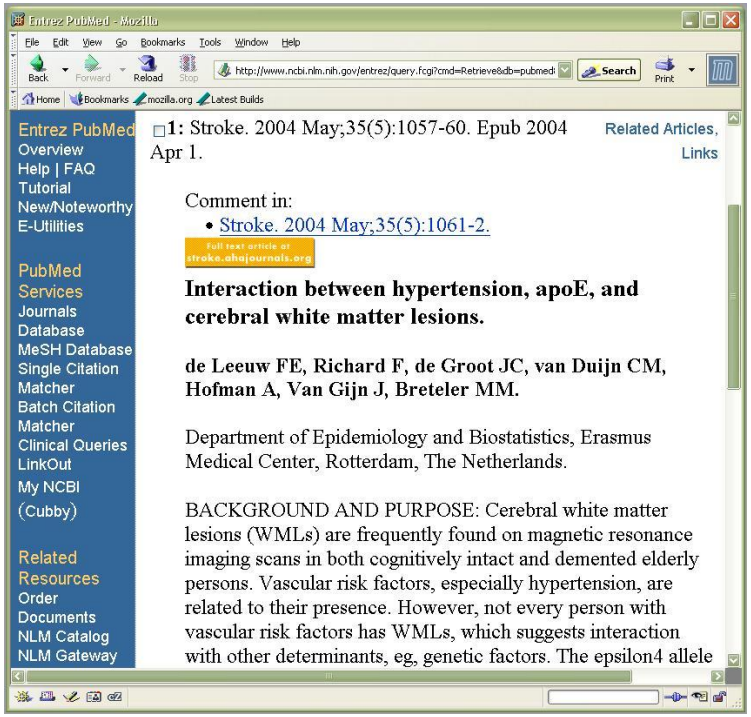
Subword Thesaurus

Interlingua of MIDs

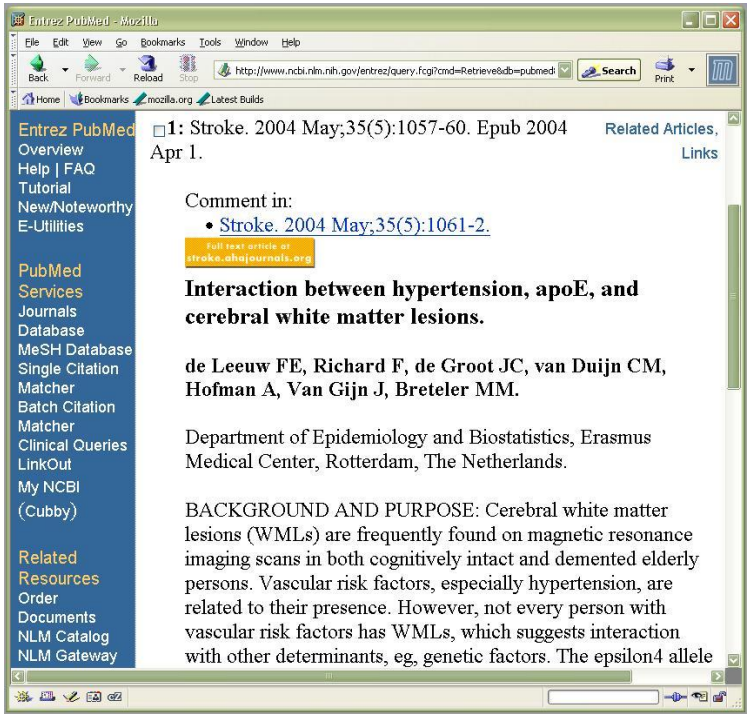
#up tsh #value #suggest #diagnost #primar #small #thyre

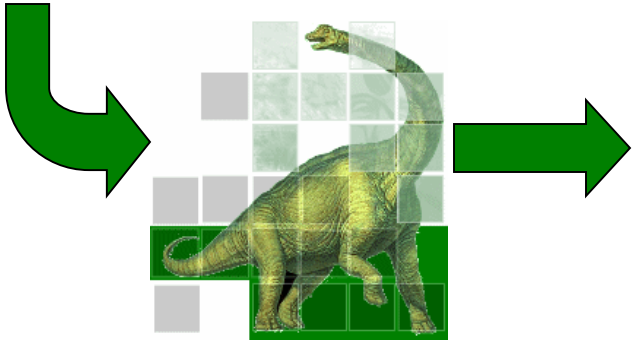
#up tsh #value #permit #diagnost #primar #small #thyre

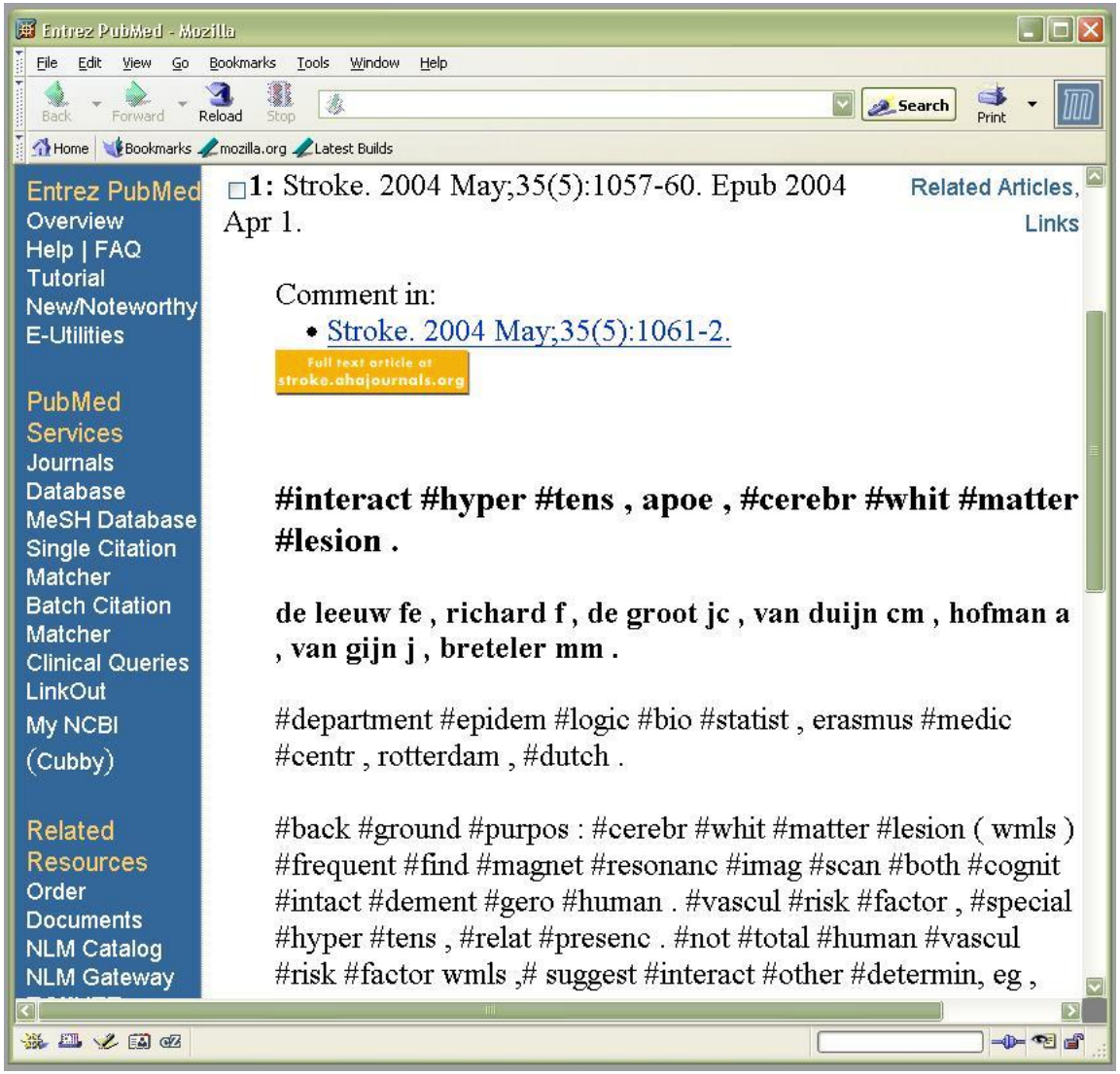
MorphoSaurus Indexing



MorphoSaurus Indexing

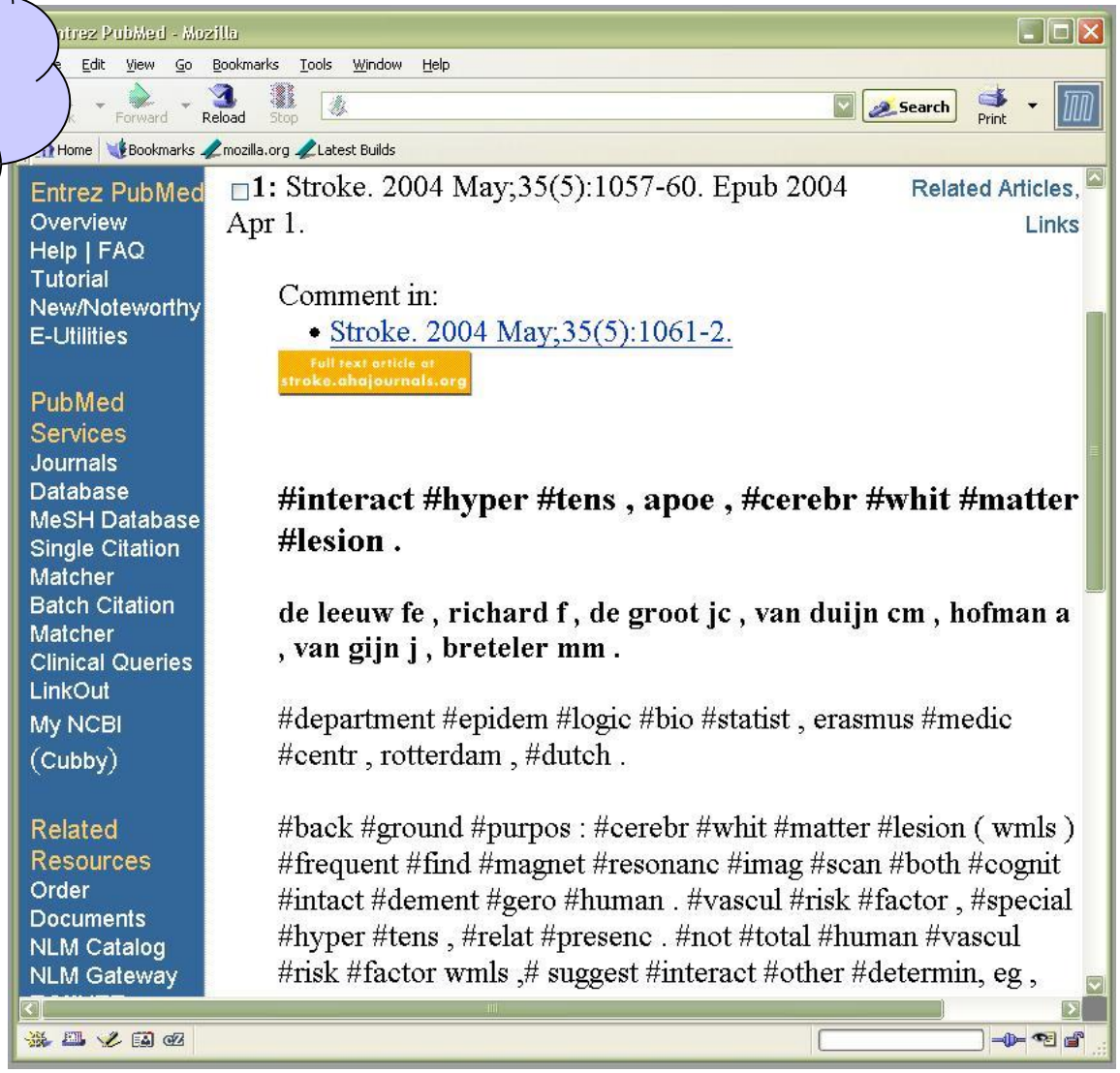






MorphoSaurus Search

„Korrelation von Hypertonie und Läsion der Weißen Substanz“



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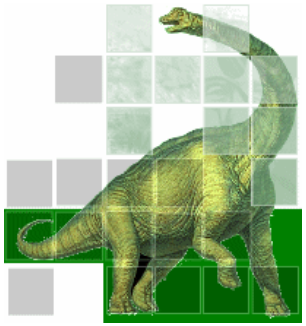
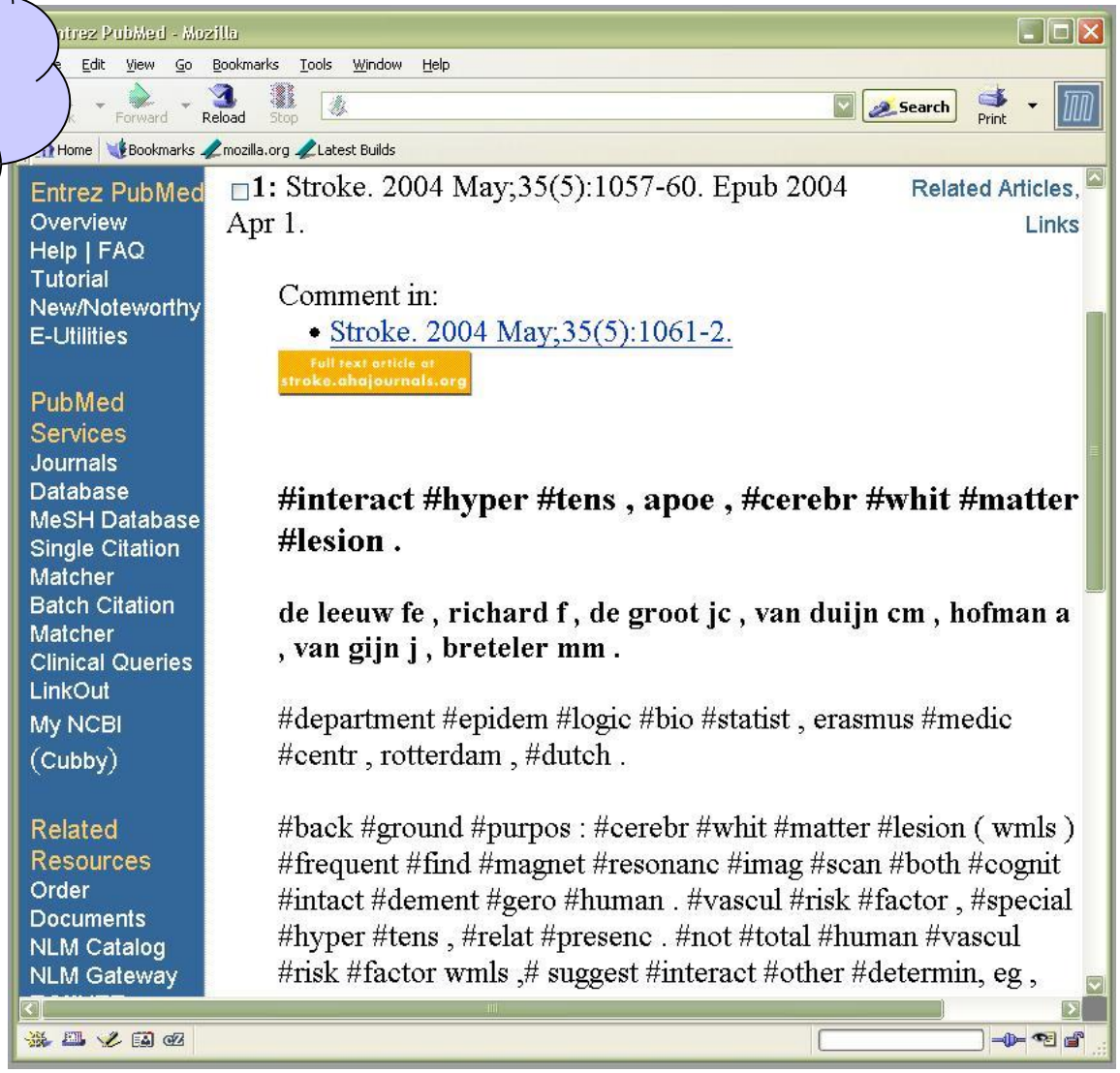


„#correl #hyper #tens #lesion #whit #matter“



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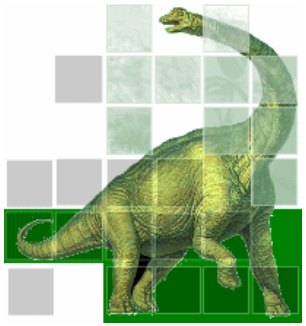

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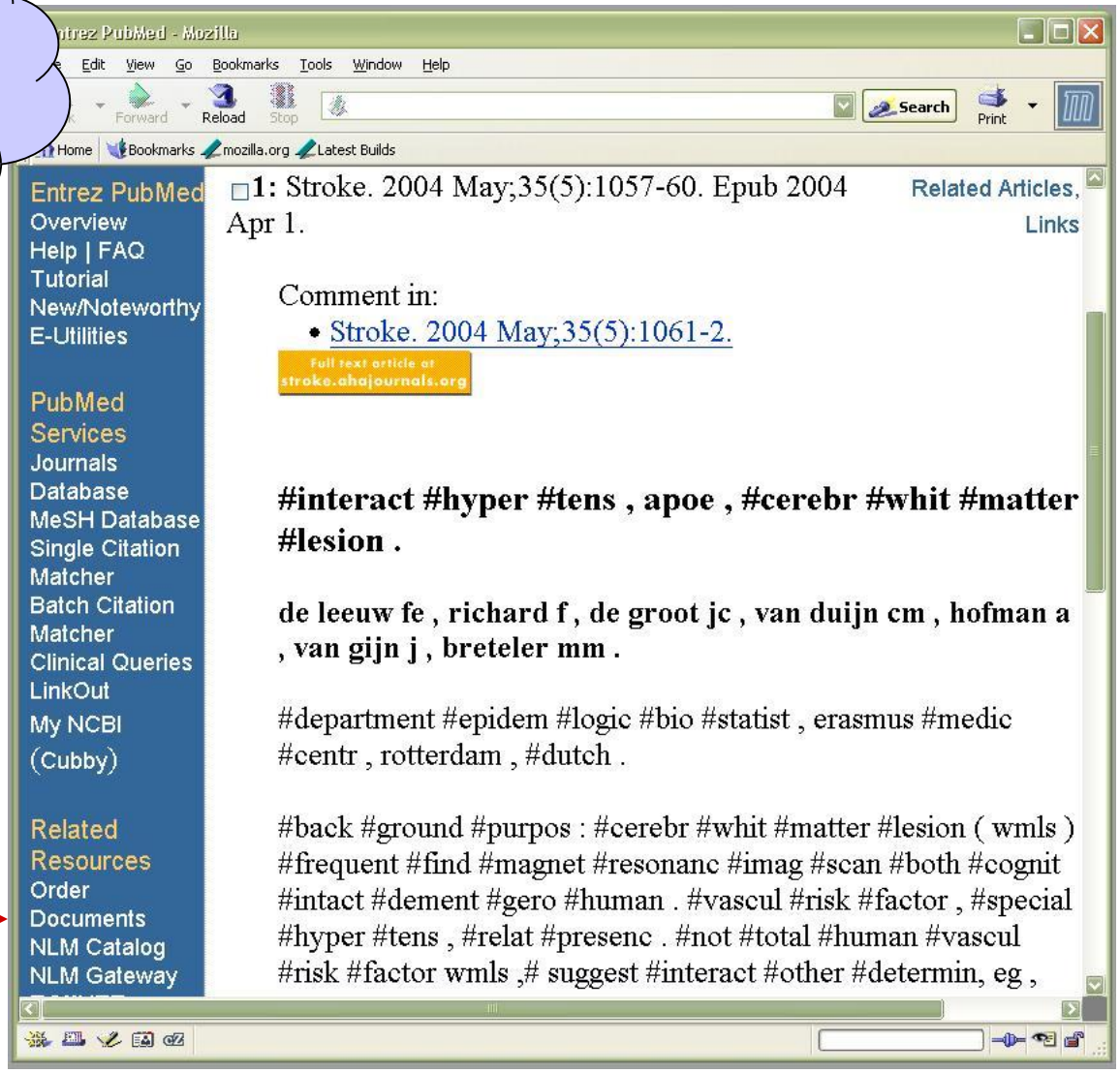
Search Engine



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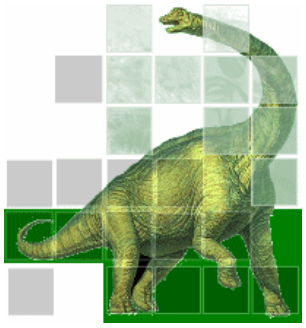

„#correl #hyper #tens #lesion #whit #matter“

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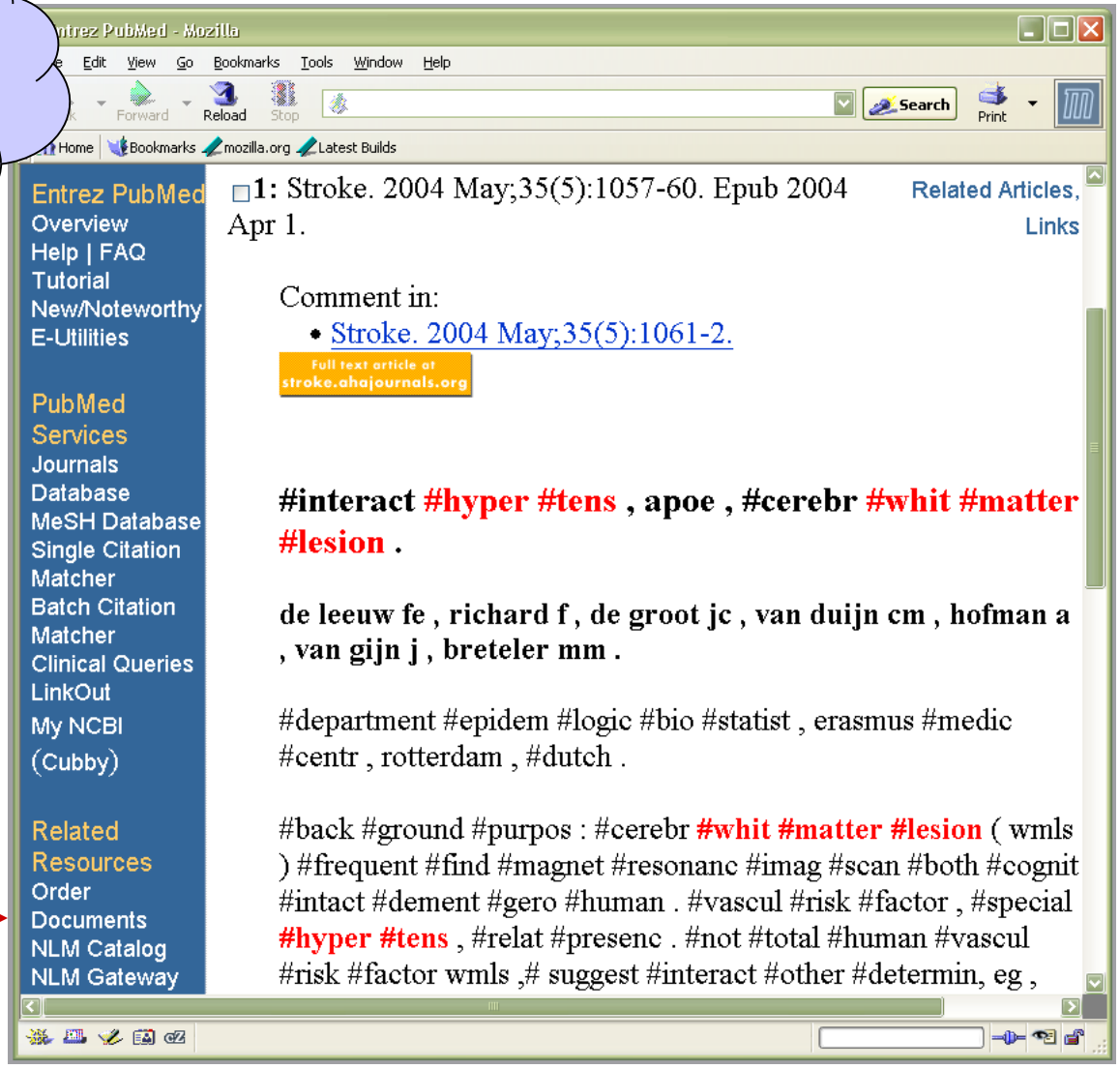
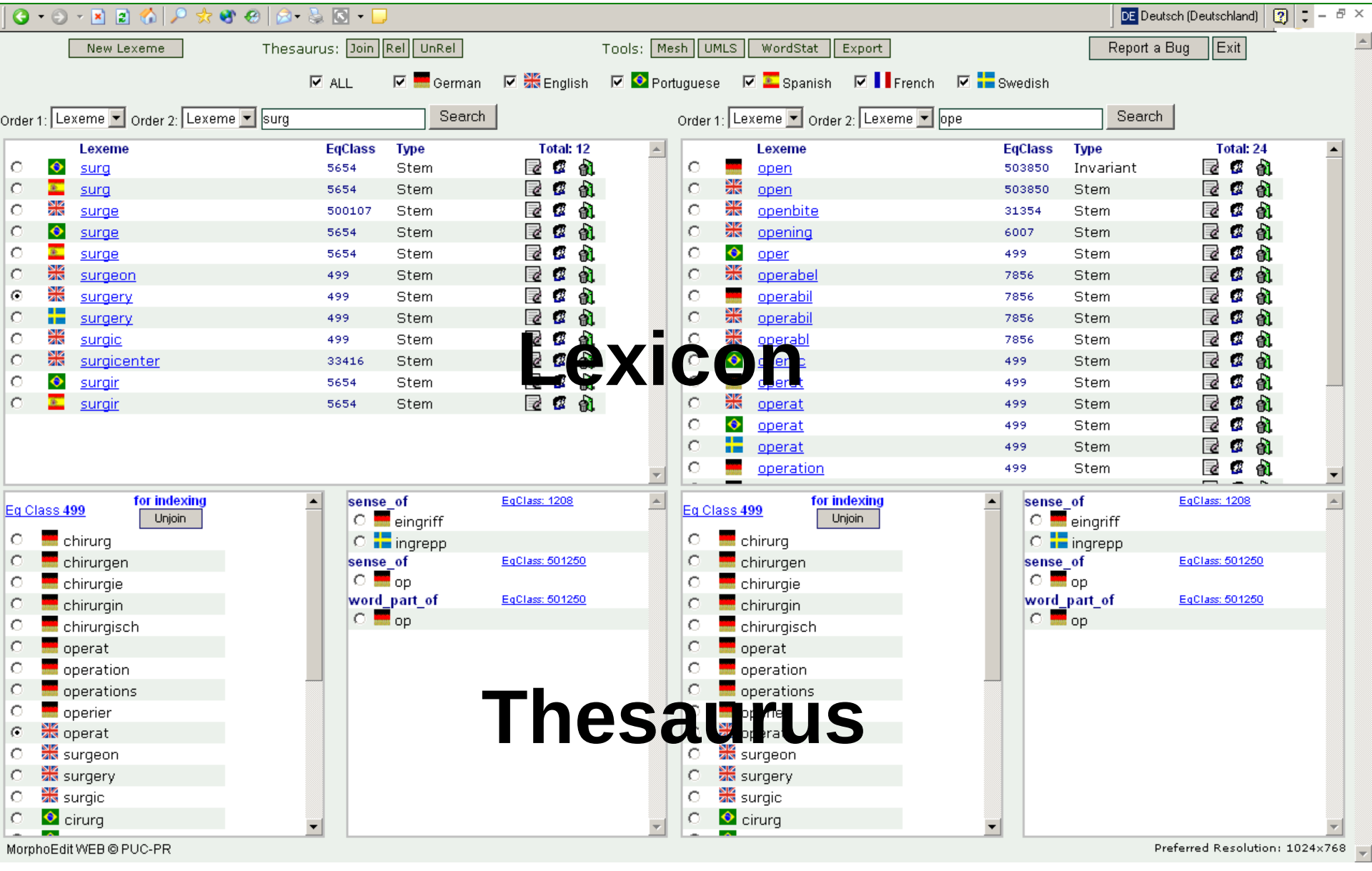


MorphoSaurus Database



Lexicon Construction

- Manual construction of lexicon labor-intensive
- Many medical terms exhibit high degree of similarity across languages (“cognates”):
  surgical, *chirurgisch*, *chirurgique*, *cirúrgico*, *quirurgico*, *kirurgisk*
- Others don’t (“non-cognate translations”):
  spleen, *Milz*, *rate*, *baço*, *bazo*, *mjälten*
- Project: development of automated technique for lexicon acquisition for new languages
- Case study:
  Acquisition of medical subword lexemes for target languages Spanish, French and Swedish

Automatic Lexicon Acquisition

Two steps of lexicon acquisition:

1. *Generation and Validation* of trusted subword cognates for the target languages
2. *Bootstrapping*: iterative learning of non cognate subword translations

Resources for Cognate Acquisition

- Manually constructed subword lexicons in the source languages:
  - German (~22,000 stems)
  - English (~22,000 stems)
  - Portuguese (~14,000 stems)
- Manually created list of prefixes and suffixes for the target languages
- Medical corpora for all languages
- Word frequency lists generated from these corpora
- Language pair specific string substitution rules

Generating Cognate Candidates

List of Portuguese Subwords (14,004 stems):

...
estomag-
mulher-
...

Generating Cognate Candidates

List of Portuguese Subwords (14,004 stems):

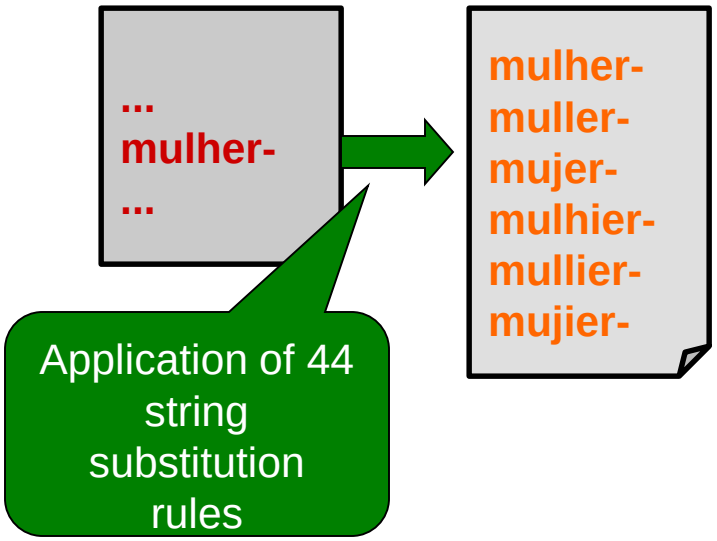
...
estomag-
mulher-
...

Application of 44 string substitution rules

Rule (Port. » Span.)
qua » cua
eia » ena
ss » s
lh » j
lh » ll
l » ll
f » h
...

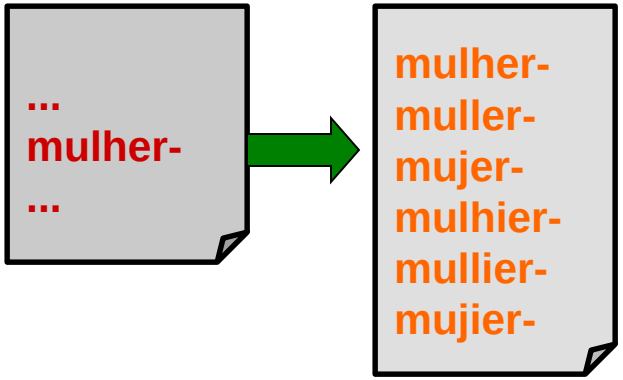
Generating Cognate Candidates

List of Portuguese Subwords (14,004 stems):



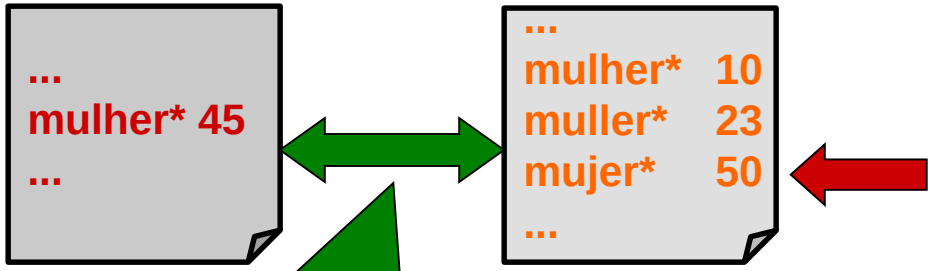
Generating Cognate Candidates

List of Portuguese Subwords (14,004 stems):



Word frequency lists derived from unrelated corpora:

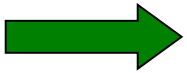
Size (Portuguese) ~ Size(Spanish)

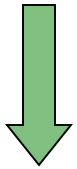


Comparison between word frequency lists:

Choose that cognate alternative with the *most similar* corpus frequency

Semantic Mapping

mulher-  mujer-



MID: #female = { woman, women, female-, frau-, weib-, mulher-, mujer- }

Semantic Mapping

MID: #female = { woman, women, female-, frau-, weib-, mulher-, **mujer-**}

Language Pair	Source Lexicon	Cognates acquired
Portuguese-Spanish	14,004	**8,644**
German-French English-French	21,705 21,501	**9,536**
German-Swedish English-Swedish	21,705 21,501	**6,086**

Use of parallel corpora to identify false cognates:

- Example:
  - Portuguese *crianc-* (*child*) ↔ Spanish *crianz- (breed)*
  - Portuguese *crianc-* (*child*) ↔ Spanish *nin-* (*child*)

- UMLS Metathesaurus as parallel corpus
  - English-Spanish: 60,526 translations
  - English-French: 17,130 translations
  - English-Swedish: 10,953 translations

- English-Spanish Example
  - „*Cell Growth*“ ↔ „*Crecimiento Celular*“

Cognate Validation

- Use generated cognate seed lexicons to process the UMLS translations with the MorphoSaurus

Cognate Validation

- Use generated cognate seed lexicons to process the UMLS translations with the MorphoSaurus
- Whenever a MID co-occurs on both sides of a translation pair, the corresponding lexicon entry is taken to be valid
- Discard candidates that never matched

„Abdominal wall procedure“:

|abdomin|al|	**#abdom**
|wall|	**#wall**
|proced|ure|	**#operat**

„Cirugia de la pared abdominal“:

|cirug|ia|	
|pared|	**#wall**
|abdomin|al|	**#abdom**

Cognate Validation

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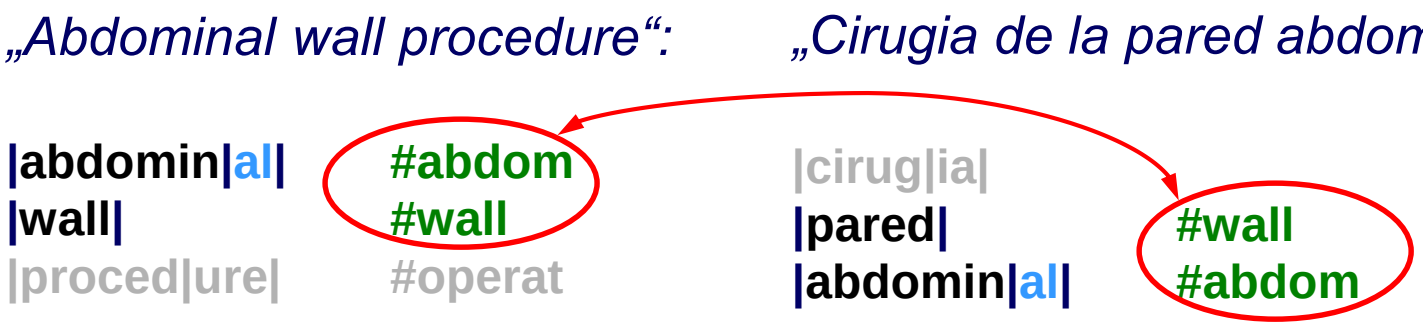

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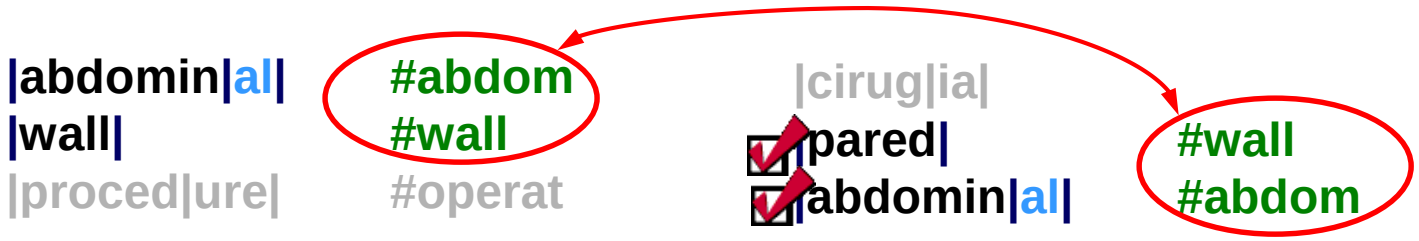


Cognate Validation

Language Pair	Source Lexicon	Cognates acquired	Cognates validates
Portuguese-Spanish	14,004	**8,644**	**3,230**
German-French **English-French**	21,705 21,501	**9,536**	**3,540**
German-Swedish **English-Swedish**	21,705 21,501	**6,086**	**1,565**

„Abdominal wall procedure“:

|abdomin|al|
|wall|
|proced|ure|

#abdom
#wall
#operat

„Cirugia de la pared abdominal“:

|cirug|ia|
|pared|
|abdomin|al|

#wall
#abdom

Step 2: Bootstrapping

- Acquisition of non-cognates
  uses:
  - validated cognate seed lexicons
  - parallel corpora

„Abdominal wall procedure“:

|abdomin|al| #abdom
|wall| #wall
|proced|ure| #operat

„Cirugia de la pared abdominal“:

|cirug|ia|
|pared| #wall
|abdomin|al| #abdom

Bootstrapping Algorithm

For every UMLS term pair do

„Abdominal wall procedure“:

|abdomin|al| #abdom
|wall| #wall
|proced|ure| #operat

„Cirugia de la pared abdominal“:

|cirug|ia|
|pared| #wall
|abdomin|al| #abdom

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

„Abdominal wall procedure“:

|abdomin|al|
|wall|
|proced|ure|

#abdom
#wall
#operat

„Cirugia de la pared abdominal“:

|cirug|ia|
|pared|
|abdomin|al|

#wall
#abdom

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

„Abdominal wall procedure“:

|abdomin|al|
|wall|
|proced|ure|

#abdom
#wall
#operat

„Cirugia de la pared abdominal“:

|cirug|ia|
|pared|
|abdomin|al|

#wall
#abdom

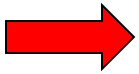
Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

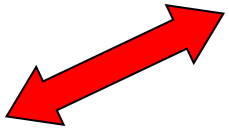
Take supernumerary MID and invalid segmentation from target



„Abdominal wall procedure“:

|abdomin|al|
|wall|
|proced|ure|

#abdom
#wall
#operat



„Cirugia de la pared abdominal“:

|cirug|ia|
|pared|
|abdomin|al|

#wall
#abdom

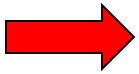
Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

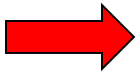


Restore invalid segmentation and strip off potential affixes

„Abdominal wall procedure“:

|abdomin|al| #abdom
|wall| #wall
|proced|ure| **#operat**

„Cirugia de la pared abdominal“:

|cirug|ia|  **|cirug|ia|**
|pared| #wall
|abdomin|al| #abdom

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

„Abdominal wall procedure“:

|abdomin|al| #abdom
|wall| #wall
|proced|ure| #operat

„Cirugia de la pared abdominal“:

|cirug|ia| → |cirug|ia|
|pared| #wall
|abdomin|al| #abdom

#operat = { proced, surgery, operat, prozess, operier, proced, process, metod, cirug }

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

Repeat all until quiescence

„Abdominal wall procedure“: *„Cirugia de la pared abdominal“:*

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

Repeat all until quiescence

„Abdominal wall procedure“:

„Skin operations“:

|skin| **#derma**

|operat|ions| **#operat**

„Cirugia de la pared abdominal“:

„Cirugia de piel“:

|cirug|ia| **#operat**

|piel|

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

Repeat all until quiescence

„Abdominal wall procedure“:
„Skin operations“:

|skin| **#derma**
|operat|ions| **#operat**

„Cirugia de la pared abdominal“:
„Cirugia de piel“:

|cirug|ia| **#operat**
|piel| → **|piel|**

#derma = { derm, cutis, skin, haut, kutis, pele, cutis, piel } ←

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

Repeat all until quiescence

„Abdominal wall procedure“:
„Skin operations“:
„Skin abnormalities“:

|skin| **#derma**
|abnorm|alities| **#anomal**

„Cirugia de la pared abdominal“:
„Cirugia de piel“:
„Malformacion de la piel“:

|malformation|
|piel| **#derma**

Bootstrapping Algorithm

For every UMLS term pair do

If there is exactly one invalid segmentation in target language

If there is exactly one more MID in source language

Take supernumerary MID and invalid segmentation from target

Restore invalid segmentation and strip off potential affixes

Add new stem into target lexicon. Link it to source MID.

Repeat all until quiescence

„Abdominal wall procedure“:
„Skin operations“:
„Skin abnormalities“:

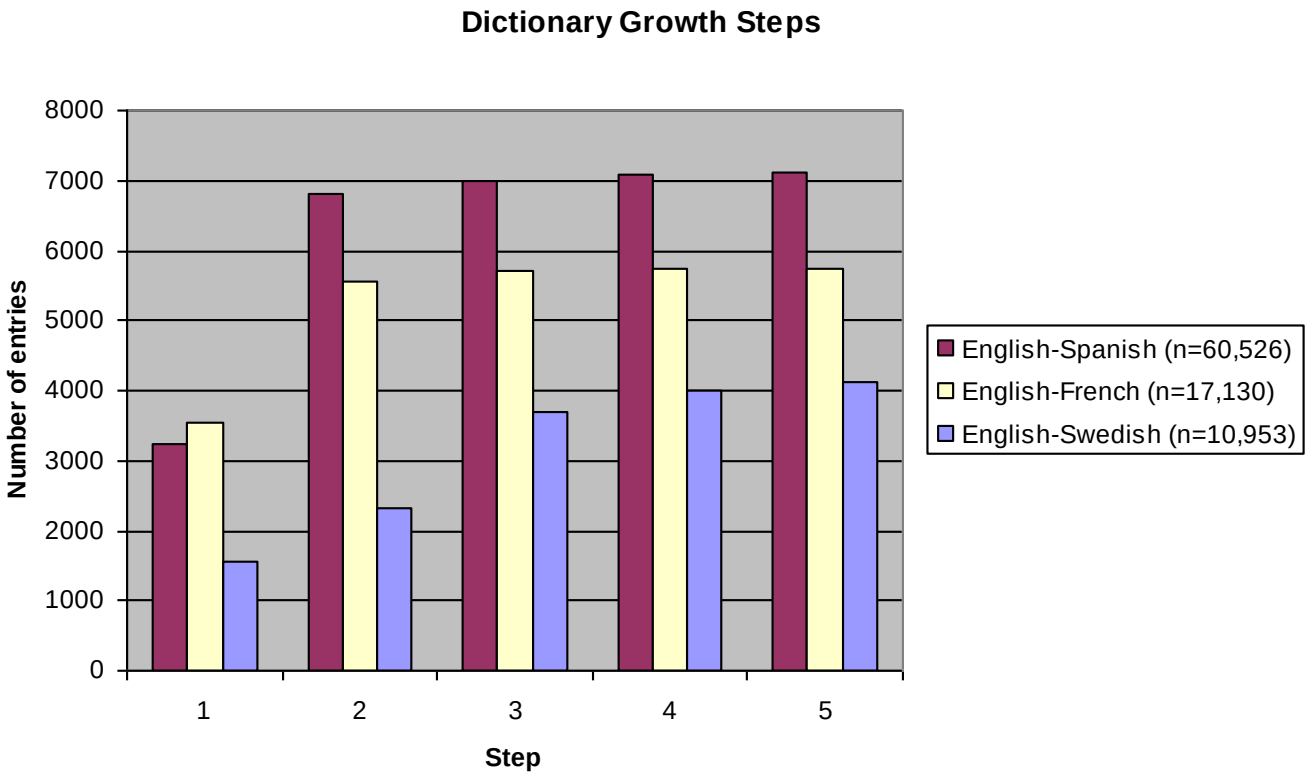
|skin| **#derma**
|abnorm|alities| **#anomal**

„Cirugia de la pared abdominal“:
„Cirugia de piel“:
„Malformacion de la piel“:

|malformation| → **|malform|ation|**
|piel| **#derma**

#anormal = { abnorm, anomal, abnorm, anomal, abnorm, anomal, malform }

Bootstrapping Results



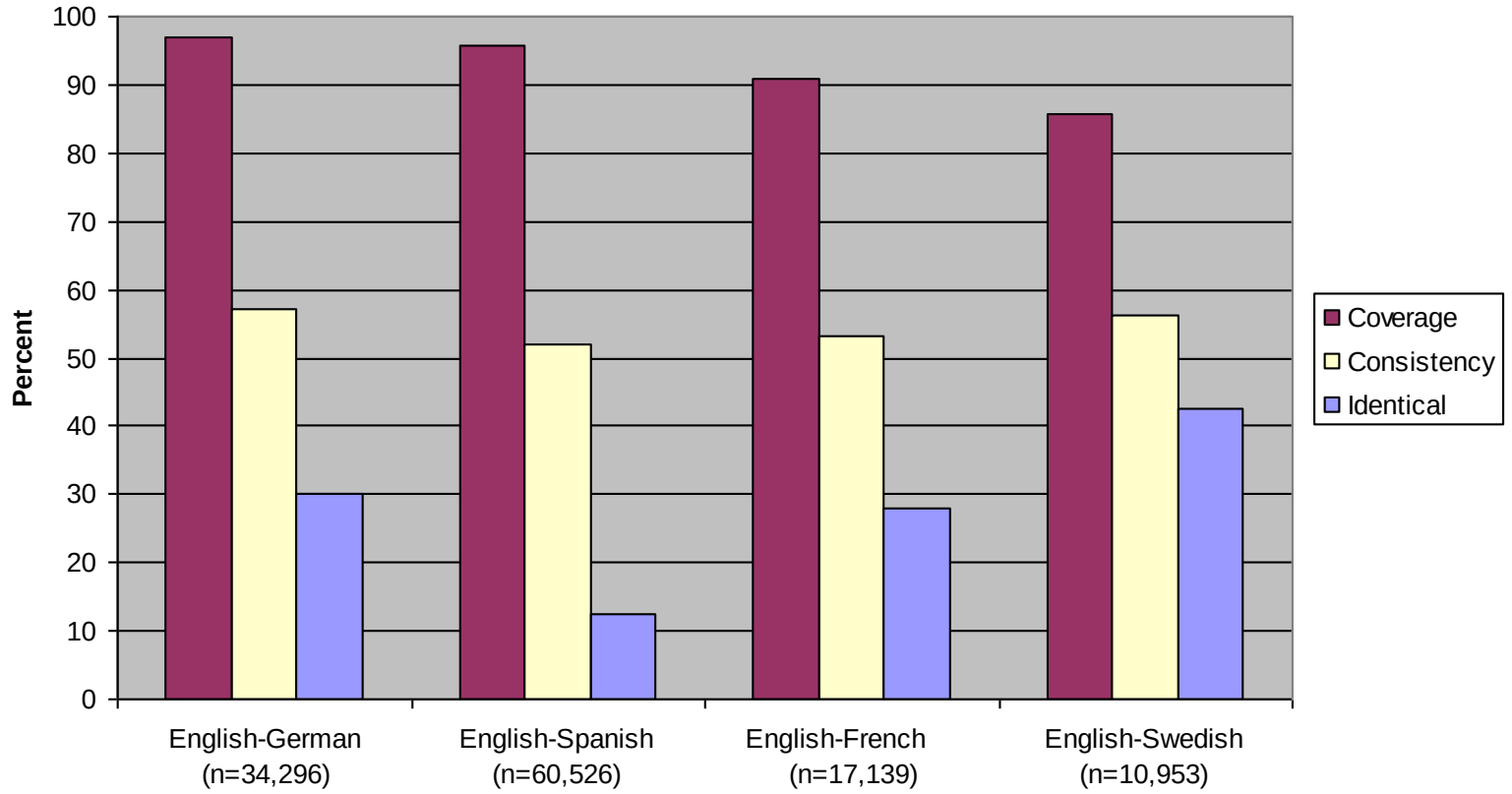
Total: 7,154 Spanish,
5,734 French and
4,148 Swedish entries acquired

Evaluation

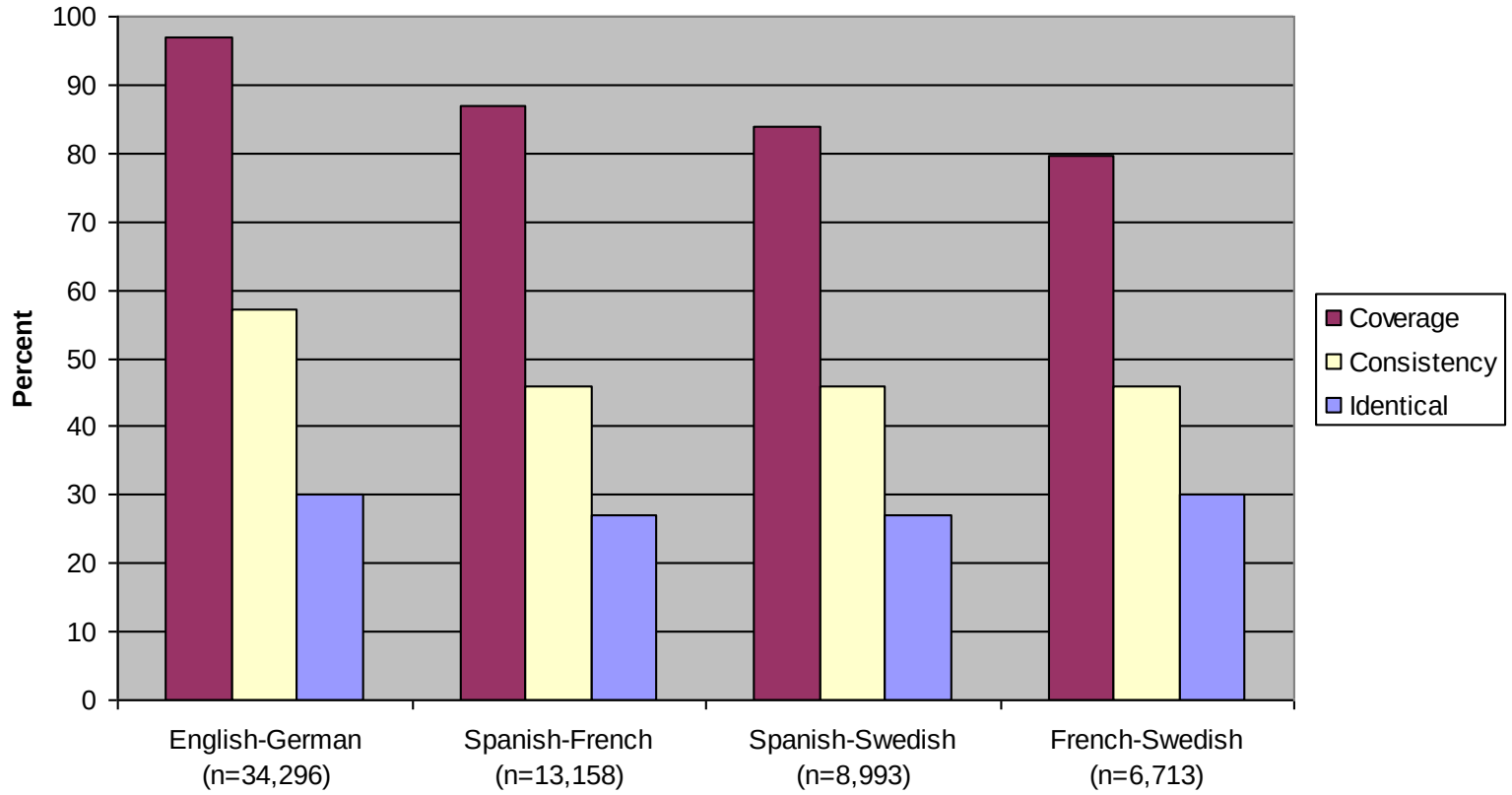
- Process the English-Spanish, English-French and English-Swedish UMLS translation pairs with the MorphoSaurus system
- Additionally process Spanish-French, Spanish-Swedish, and French-Swedish UMLS translation pairs

- Measures:
  - Coverage: At least one MID co-occurs on both sides
  - Consistency $$C_{AU(i)} = \frac{(100 * A)}{(A + N + M)}$$
    - *A*: Number of MIDs co-occurring on both sides
    - *N,M*: Number of MIDs occurring on only one side
  - Identical Indexes

Results


Percent
100
90
80
70
60
50
40
30
20
10
0
English-German (n=34,296)
English-Spanish (n=60,526)
English-French (n=17,139)
English-Swedish (n=10,953)
Coverage
Consistency
Identical

Results


100
90
80
70
60
50
40
30
20
10
0
Percent
English-German
(n=34,296)
Spanish-French
(n=13,158)
Spanish-Swedish
(n=8,993)
French-Swedish
(n=6,713)
Coverage
Consistency
Identical

Conclusion

- Cross-Language Document Retrieval based on a language-independent, interlingual layer.
- Automated approach for acquiring lexicon entries for new languages
- Significant amount cognate subwords can be acquired using simple string substitution rules.
- These seed lexicons are further enlarged by subword translations which are *not* cognates by bootstrapping and using parallel corpora.
- Current limitation: size of parallel corpora for bootstrapping step

Automatic Lexicon Acquisition for a Medical Cross-Language Information Retrieval System

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Freiburg University Hospital
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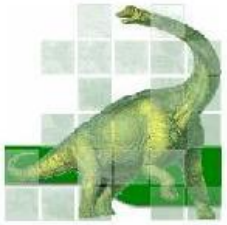
Jena University, Language &
Information Engineering
(Germany)

www.MorphoSaurus.net

MorphoSaurus Search

Search Engine



Search: darmkrebsrisiko (English/German/Portuguese)

Language: All Information Level: Any MorphoSaurus: Use

Search

Search results for 'darmkrebsrisiko' : **Best 20 Documents of 2095 matches (298 msecs)**

Entrez PubMed (94%) Expert information
Keywords: MEDLINE, NCBI, National Center for Biotechnology Information, National Library of Medicine, NLM, PubMed
Description: PubMed is the National Library of Medicine's search service that provides access to over 11 million citations in MEDLINE, PreMEDLINE, and other related databases, with links to participating online journals.
... almost unaltered **risk** of all other **cancers** (SIR, 1.2; 95% CI, 1.0 1.4), including nonelevated **risks** for several **gastrointestinal** tract **cancers.** At 10 years of follow up, the absolute **risk** of liver **cancer** was 6% among men and 1.5% among women. With 21 liver **cancers** and 508 nonhepatobiliary **cancers,** first degree ... (Cached)
http://supreme.coling.uni-jena.de/~coling/search_engine_docs/original/medline/14724826.html

Deutsches Ärzteblatt (91%) Expert information
... DEUTSCHES ÄRZTEBLATT PRINT wErhöhtes **Risiko** für **gastrointestinale Karzinome** nach Cholezystektomie Deutsches Ärzteblatt 99, Ausgabe 26 vom 28.06.2002, Seite A 1824 B 1541 C 1437 MEDIZIN: Referiert Eine Cholezystektomie führt möglicherweise über toxische Effekte des alkalischen Refluats auf die Speiseröhrenschleimhaut zu einem mäßiggradigen Anstieg des **Adenokarzinomrisikos** der Speiseröhre (Barrett **Karzinom).** Aber ... (Cached)
http://supreme.coling.uni-jena.de/~coling/search_engine_docs/original/aerzteblatt/artikeldruck.asp%3fid=32191.html

Dickdarm und Mastdarmkrebs Kolorektales Karzinom (91%) Patient information
Keywords: Dickdarm, Mastdarmkrebs
Description: Dickdarm und Mastdarmkrebs ist eine bösartige Schleimhautwucherung im Dickdarm oder Mastdarm. Ärzte bezeichnen diese Krebsart auch als kolorektales Karzinom (von griechisch kolon, Darm und lateinisch intestinum rectum, Enddarm). Häufig wird der Dickdarm und Mastdarmkrebs auch nur als Kolonkarzinom bezeichnet, obwohl ein Kolonkarzinom im eigentlichen Sinne nur Dickdarmkrebs ist.
... Werbung Sponsoring NetDoctor.com Dickdarm und **Mastdarmkrebs** (Kolorektales **Karzinom)** Prof. Dr. med. Stefan Endres, Facharzt für Innere Medizin und **Gastroenterologie** Was ist Dickdarm und **Mastdarmkrebs?** Dickdarm und **Mastdarmkrebs** ist eine **bösartige** Schleimhautwucherung im Dickdarm oder Mastdarm. Ärzte bezeichnen diese **Krebsart** auch als kolorektales **Karzinom** (von griechisch kolon, **Darm** und lateinisch **intestinum** ... (Cached)
http://www.netdoktor.de/krankheiten/Fakta/dickdarm_mastdarmkrebs.htm

Evaluation

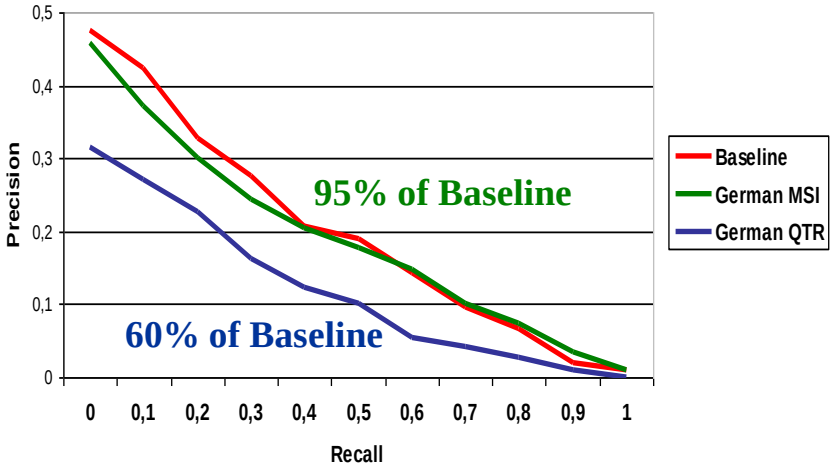
- OHSUMED-Corpus (Hersh et al., 1994)
  - Subset of MEDLINE
  - ~233,000 English documents
  - 106 English user queries, additionally translated to German, Portuguese, Spanish and Swedish by medical experts
  - query-document pairs have been manually judged for relevance
- Search Engine: Lucene
  - http://lucene.apache.org/

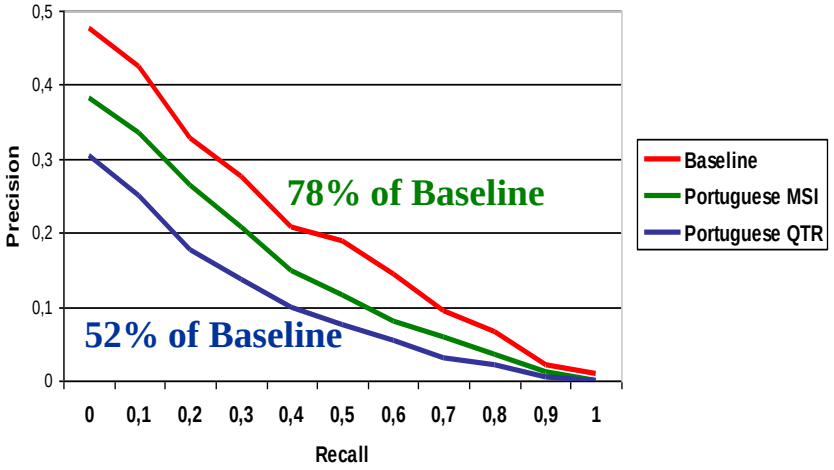
Evaluation

- Baseline: monolingual text retrieval
  - (stemmed) English user queries
  - (stemmed) English texts
- Query translation (QTR)
  - Google translator
  - Multilingual dictionary compiled from UMLS
- MorphoSaurus Indexing (MSI)
  - Interlingual representation of both user queries and documents

Evaluation Results

German (n = 22,385) Top 200 **Portuguese (n = 14,862)**

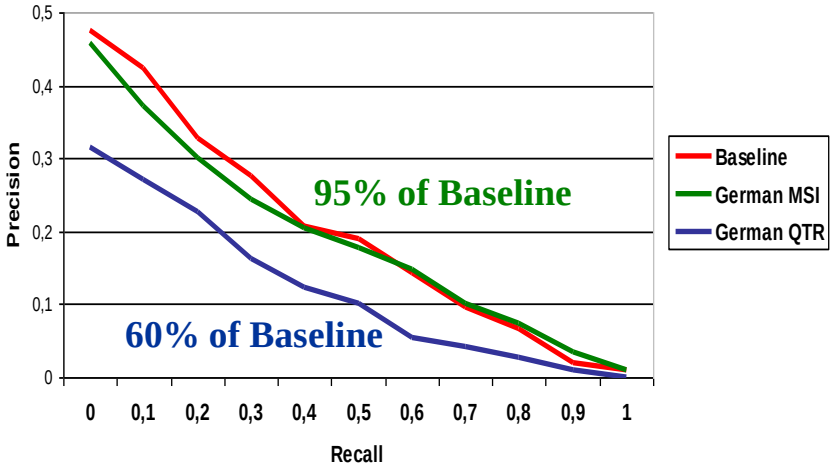




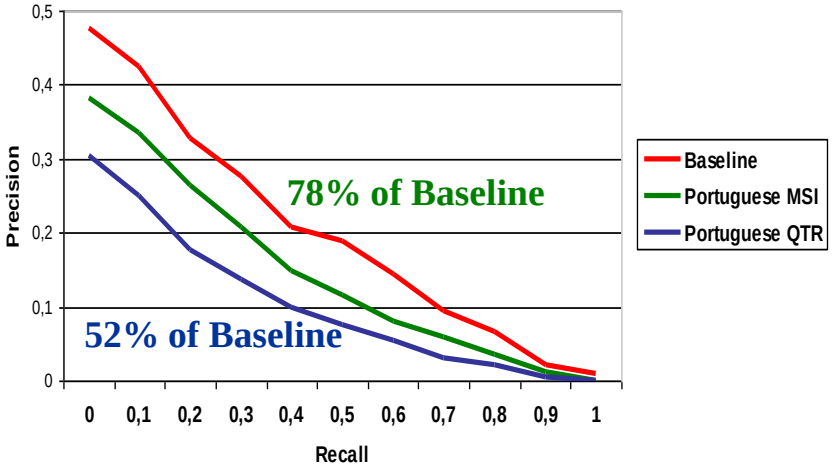
Evaluation Results

German (n = 22,385)

Top 200

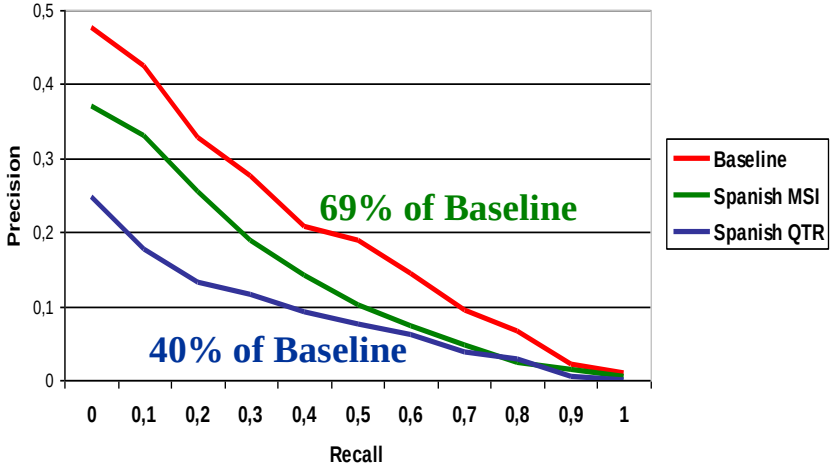


Portuguese (n = 14,862)

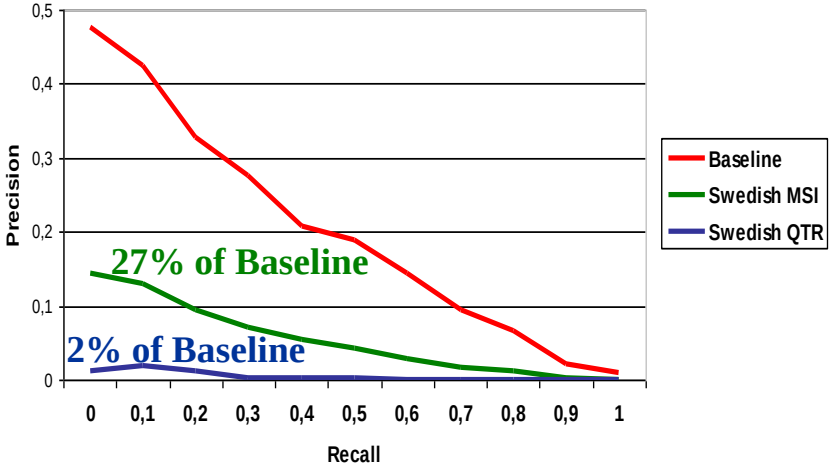


Spanish (n = 7,154)

Top 200



Swedish (n = 4,148)



Semantic Mapping

#female = { woman, women, female, frau, weib, mulher, mujer }

Language Pair	Source Lexicon	Selected Cognates	Linked MIDs
Portuguese-Spanish	14,004	**8,644**	**6,036**
German-Swedish **English-Swedish**	21,705 21,501	4,249 4,140	3,308 3,208
Combined Swedish Evidence (set union)		**6,086**	**4,157**