Meaning Representations for Natural Languages Tutorial Part 2

Common Meaning Representations

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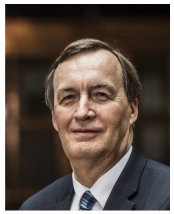


Representation Roadmap

Meaning Representations for Natural Languages Tutorial Part 2A

Common Meaning Representations

AMR

- **AMR Format & Basics**
- Some Details & Design Decisions
- Practice - Walking through a few AMRs
- Multi-sentence AMRs
- Relation to Other Formalisms

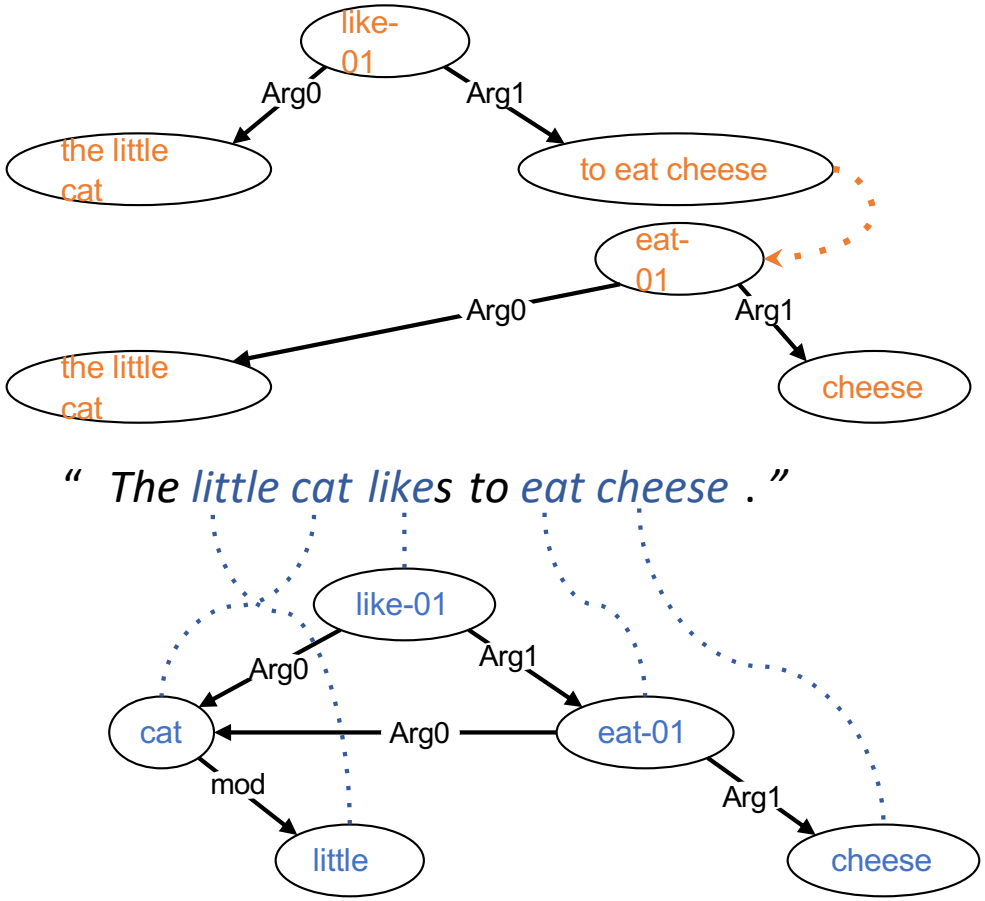
Abstract Meaning Representation: AMR

- **AMR** as a format is older (Kasper 1989, Langkilde & Knight 1998), but with no PropBank, no training data.
- **Propbank showed that large-scale training sets could be annotated for SRL**
- **Modern AMR** (Banarescu et al. (2013) main innovation: making large-scale sembanking possible:
  - AMR 3.0 more than 60k sentences in English
  - CAMR more than 20k sentences in Chinese

and me… AMR/PropBank Lexicon Unification

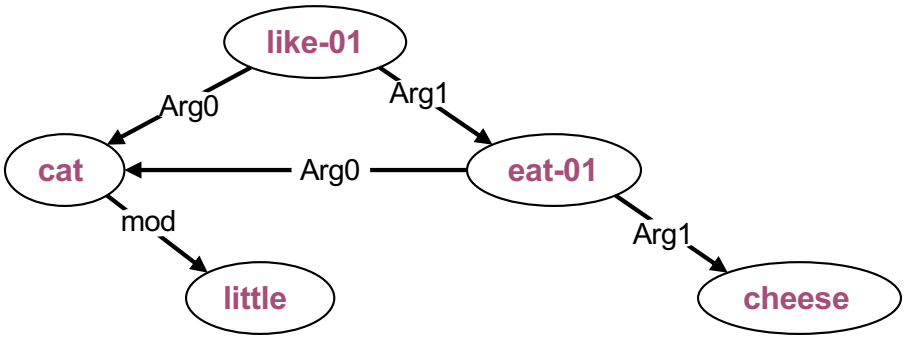
AMR Basics – SRL to AMR

- Shift from SRL to AMR – from spans to graphs
- **In SRL** we separately represent each predicate's arguments with spans
- AMR instead uses graphs with one node per concept



AMR Basics – PENMAN

```
(l / like-01
      :ARG0 (c / cat
            :mod (l2 / little))
      :ARG1 (e / eat-01
            :ARG0 c
            :ARG1 (c2 / cheese)))
```

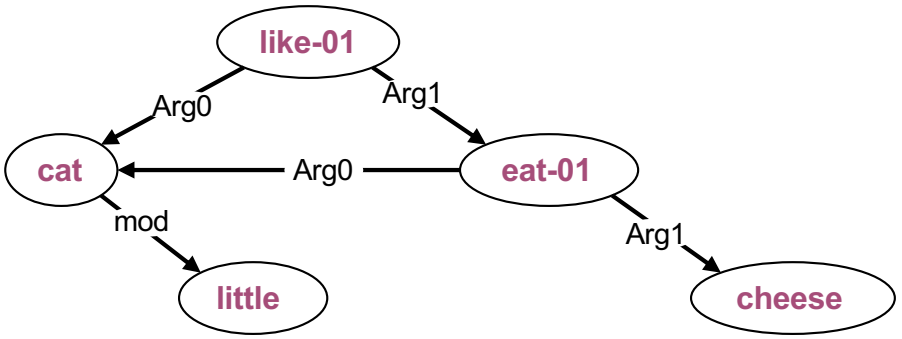


"The little cat likes to eat cheese"

AMR Basics – PENMAN

- **concepts** from the sentence appear as nodes

```
(l / like-01
      :ARG0 (c / cat
            :mod (l2 / little))
      :ARG1 (e / eat-01
            :ARG0 c
            :ARG1 (c2 / cheese)))
```

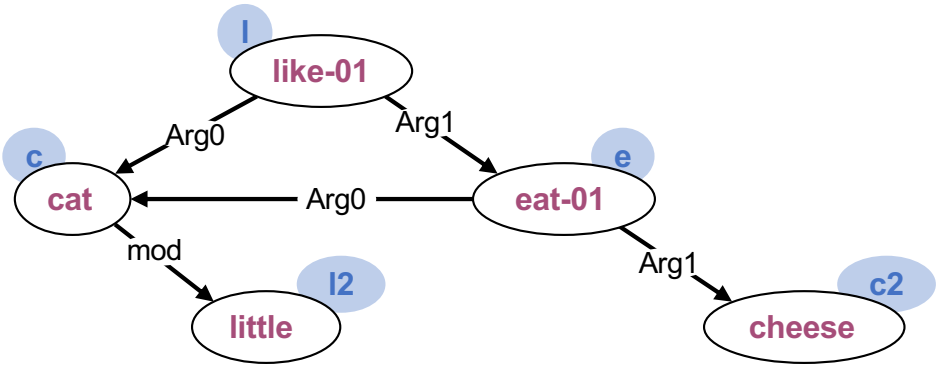


*"The **little cat likes** to **eat cheese**"*

AMR Basics – PENMAN

- **concepts** from the sentence appear as nodes
- unique **variables** identify each concept

```
(l / like-01
      :ARG0 (c / cat
            :mod (l2 / little))
      :ARG1 (e / eat-01
            :ARG0 c
            :ARG1 (c2 / cheese)))
```

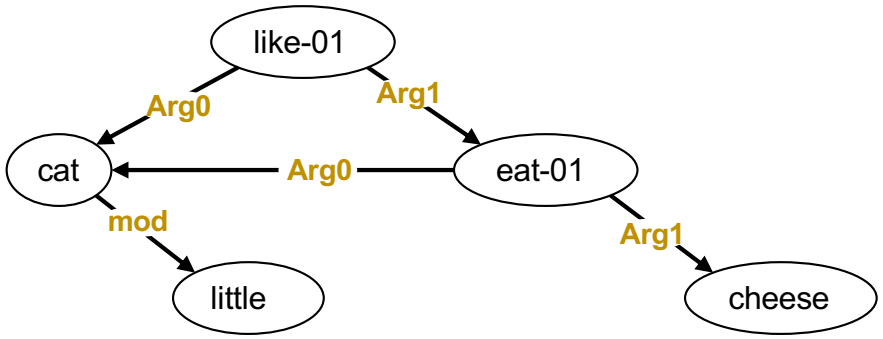


"The little cat likes to eat cheese"

AMR Basics – PENMAN

- **Edges** are represented by:
  - → indentation
  - colons (:EDGE)

```
(l / like-01
      :ARG0 (c / cat
            :mod (l2 / little))
      :ARG1 (e / eat-01
            :ARG0 c
            :ARG1 (c2 / cheese)))
```



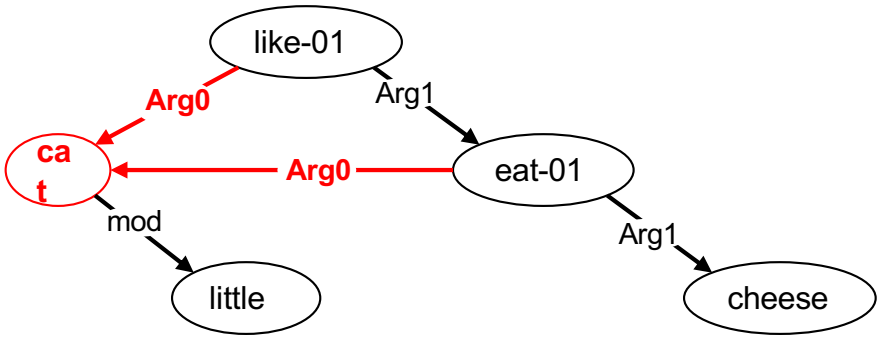
"The little cat likes to eat cheese"

AMR Basics – PENMAN

Re-entrancy of variables:

- For concepts that are the target of multiple edges in a graph
- Once a concept has a variable:
  - use that variable to refer to it anywhere else in the graph
  - applies to *any* kind of reference to the same entity-- paraphrases, pronouns, etc.

```
(l / like-01
      :ARG0 (c / cat
            :mod (l2 / little))
      :ARG1 (e / eat-01
            :ARG0 c
            :ARG1 (c2 / cheese)))
```



"The little cat likes to eat cheese"

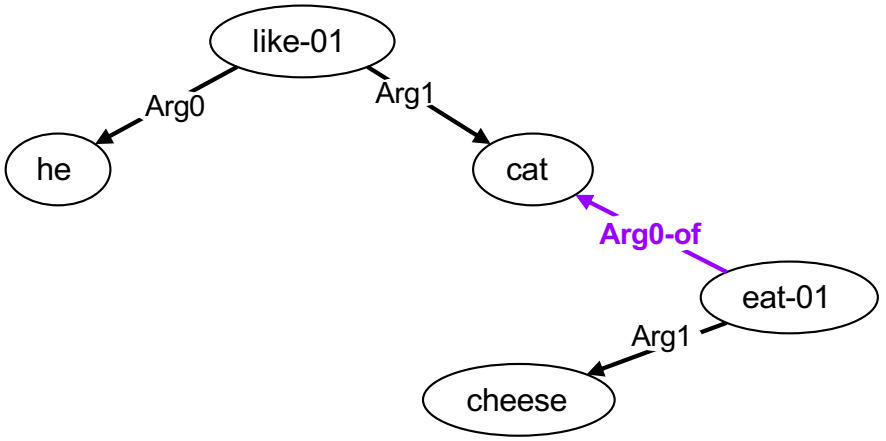
AMR Basics – PENMAN

Inverse roles:

- Allow us to encode things like relative clauses
- Any relation of the form ":X-of" is an inverse
- Meaning is interchangeable!

*(predicate, ARG0, entity) = (entity, ARG0-**of**, predicate)*

```
(l / like-01
      :ARG0 (h / he)
      :ARG1 (c / cat
            :ARG0-of (e / eat-01
                  :ARG1 (c2 / cheese))))
```

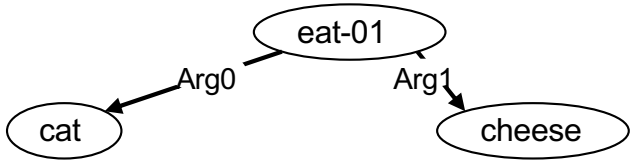


"He likes cats that eat cheese"

AMR Basics – PENMAN

Semantically-rooted graphs:

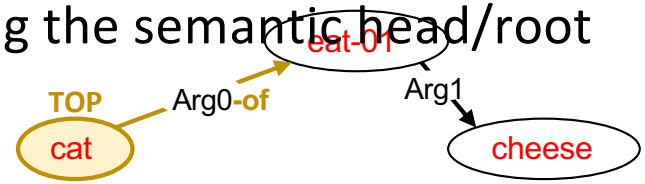
- Same graph for "cats eat cheese" and "cats *that* eat cheese"?



- No! Every graph gets a "Top" edge defining the semantic head/root

"Cats eat cheese."

```
(e / eat-01
    :ARG0 (c / cat)
    :ARG1 (c2 / cheese))
```



"cats that eat cheese"

```
(c / cat
    :ARG0-of (e / eat-01
        :ARG1 (c2 / cheese)))
```

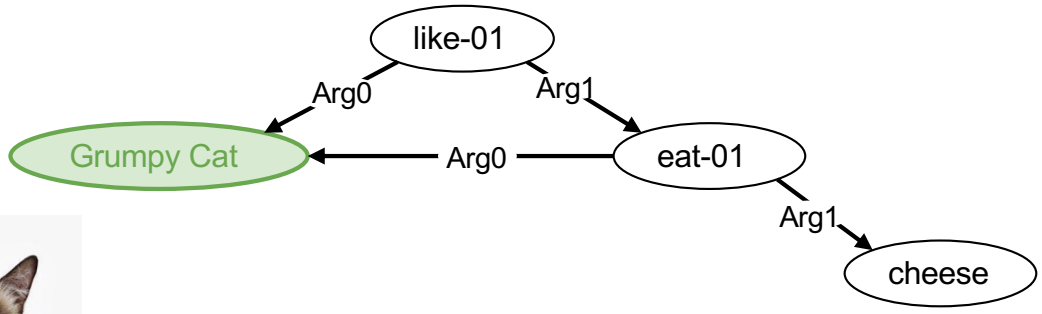
AMR Basics – PENMAN

Named Entities:

- Head node is a **category**
  - AMR provides 70+ categories

- NE annotations:
  - **:name**, for name tokens
  - **:wiki**, for name of Wikipedia page (if available)
    - given as strings
    - these are **constants**-- not assigned variables

```
(l / like-01
      :ARG0 (a / animal
            :name (n / name :op1 "Grumpy" :op2 "Cat")
            :wiki "Grumpy_Cat")
      :ARG1 (e / eat-01
            :ARG0 a
            :ARG1 (c2 / cheese)))
```

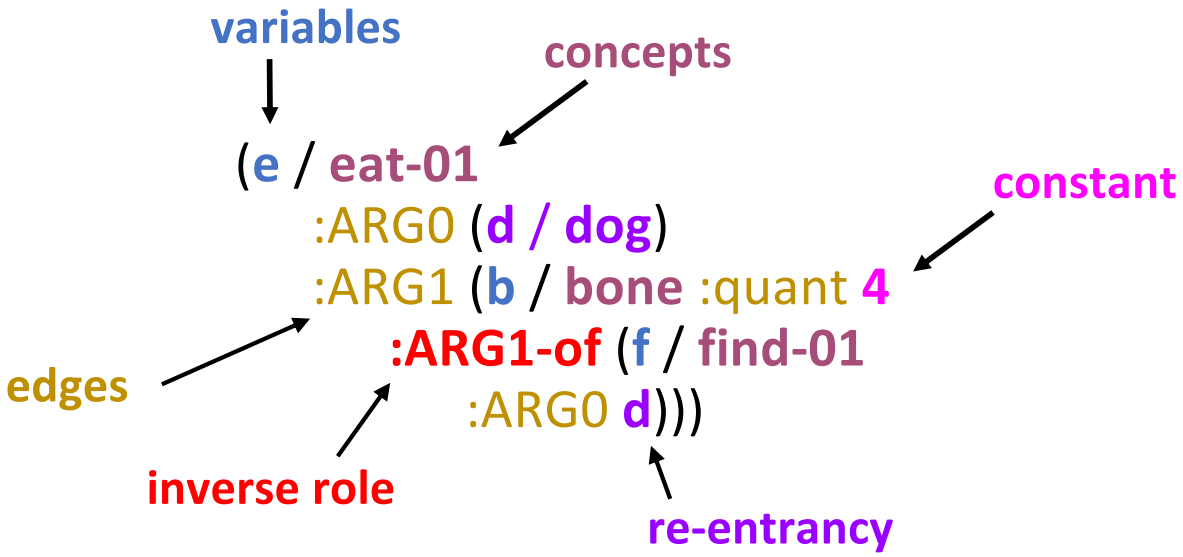


*"**Grumpy Cat** likes to eat cheese"*

AMR Basics – PENMAN

- That's AMR notation! Let's review:

"The dog ate the four bones it found."



AMR Basics 2 – Annotation Philosophy

- AMR does **limited normalization**
  - reduces ***arbitrary syntactic variation*** ("syntactic sugar")
  - maximizes cross-linguistic robustness
- All **predicative things → PropBank rolesets**
  - verbs, adjectives, many nouns
  - ***Some*** morphological decomposition
- **Limited speculation**:
  - represent direct contents of sentence
  - add pragmatic content only when it can be done ***consistently***
- **Canonicalize** the rest:
  - removal of semantically light predicates and some features like definiteness ***(controversial)***

AMR Basics 2 – Annotation Philosophy

Normalization of predicates:

- We generalize across **parts of speech** and **etymologically related words**:

*My **fear** of snakes* NOUN
fear-01

*I am **fearful** of snakes* ADJECTIVE
fear-01

*I **fear** snakes* VERB
fear-01

*I'm **afraid** of snakes* ADJECTIVE
fear-01

- But we *don't* generalize over **synonyms** (hard to do consistently):

*My **fear** of snakes* NOUN
fear-01

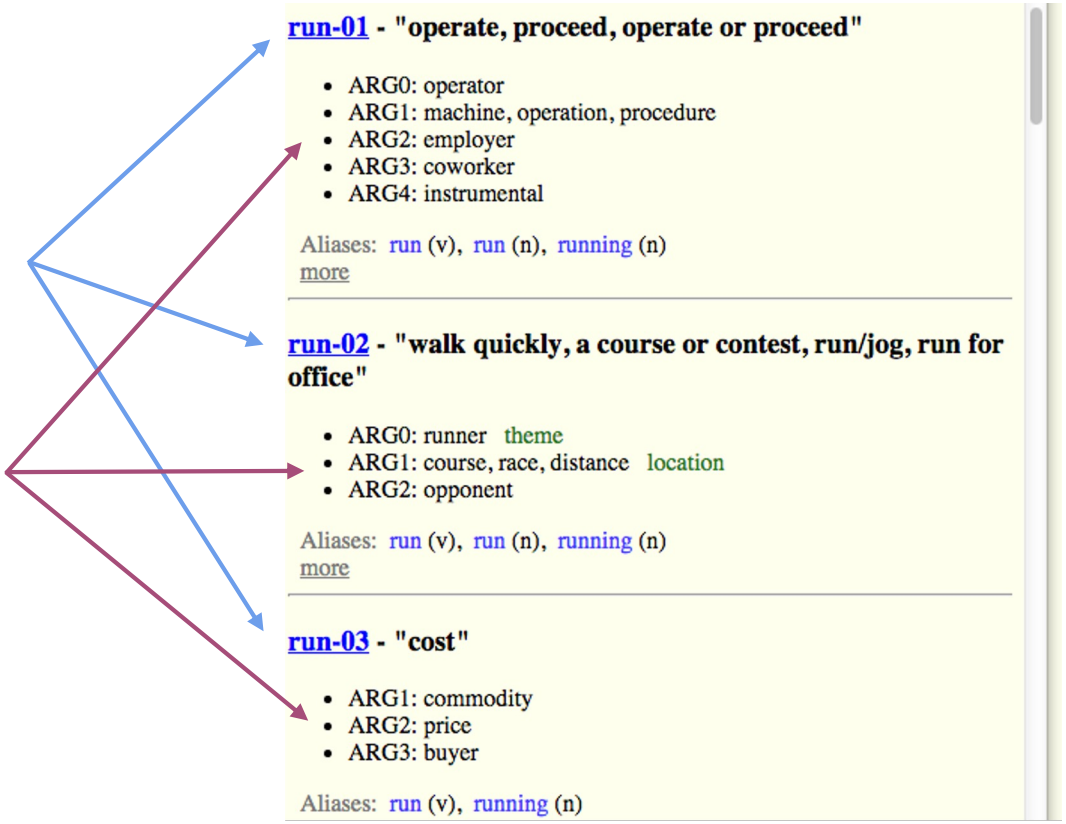
*I'm **terrified** of snakes* ADJECTIVE
terrify-01

*Snakes **creep** me **out*** VERB+PARTICLE
creep_out-03

AMR Basics 2 – Annotation Philosophy

Normalization of predicates:

- Predicates use the ***PropBank*** *inventory.*
- Each lemma leads annotators to a list of senses.
- Each sense has its own definitions for its numbered (core) arguments



AMR Basics 2 – Annotation Philosophy

Roles beyond predicates:

- If a semantic role is not in the **core roles** for a roleset, AMR provides an inventory of **non-core roles**

run-01 - "operate, proceed, operate or proceed"

- ARG0: operator
- ARG1: machine, operation, procedure
- ARG2: employer
- ARG3: coworker
- ARG4: instrumental

- These express things like **:time, :manner, :part, :location, :frequency**
- Inventory on handout, or in editor (the **[roles]** button)

- **General semantic roles (incl. shortcuts):** :accompanier ex :age ex :beneficiary ex :cause ex :compared-to ex :concession ex :condition ex :consist-of ex :cost ex :degree ex :destination ex :direction ex :domain ex :duration ex :employed-by ex :example ex :extent ex :frequency ex :instrument ex :li ex :location ex :manner ex :meaning ex :medium ex :mod ex :mode ex :name ex :ord ex :part ex :path ex :polarity ex :polite ex :poss ex :purpose ex :role ex :source ex :subevent ex :subset ex :superset ex :time ex :topic ex :value ex
- **In quantities:** :quant ex :unit ex :scale ex examples quantity types
- **In date-entity:** :day :month :year :weekday :time :timezone ex :quarter :dayperiod :season :year2 :decade :century :calendar ex :era ex :mod date-entity examples
- **Ops:** :op1 :op2 :op3 :op4 :op5 :op6 :op7 :op8 :op9 :op10 examples
- **In multi-sentence:** :snt1 :snt2 :snt3 :snt4 :snt5 :snt6 :snt7 :snt8 :snt9 :snt10 examples

AMR Basics 2 – Annotation Philosophy

Semantic-concept-to-node ratio:

- Ideally 1:1
- But, **multi-word expressions**?
  - modeled as a single node
- **Morphologically complex words**?
  - Some → decomposed
    - but, limited
    - e.g. kill does not become "cause to die"

"The thief was lining his pockets with their investments"

```
(l / line-pocket-02
    :ARG0 (p / person
        :ARG0-of (t / thieve-01))
    :ARG1 (t2 / thing
        :ARG2-of (i2 / invest-01
            :ARG0 (t3 / they)))))
```

AMR Basics 2 – Annotation Philosophy

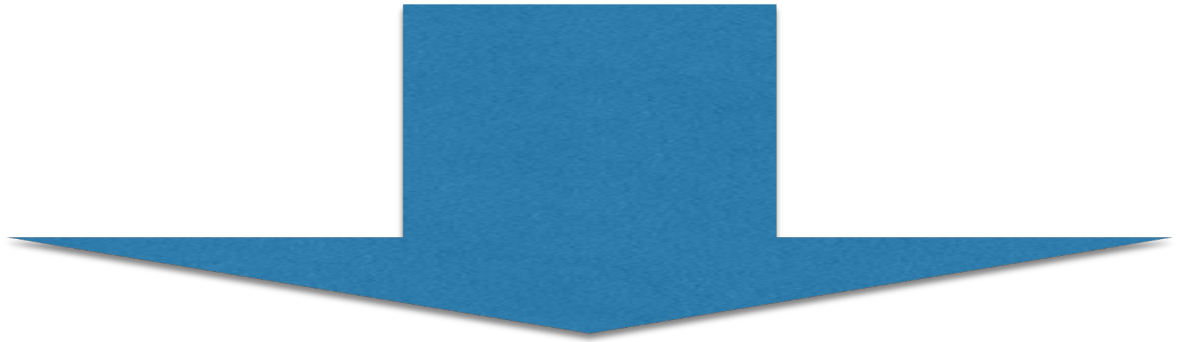
Canonical forms:

- All concepts drop **plurality**, **aspect**, **definiteness**, and **tense**
- Non-predicative terms simply represented in **singular**, **nominative** form

a cat *the cat* *cats* *the cats*	*eating* *eats* *ate* *will eat*	*they* *their* *them*
(c / cat)	(e / eat-01)	(t / they)

AMR Basics 2 – Annotation Philosophy

The man described the mission as a disaster.
The man's description of the mission: disaster.
As the man described it, the mission was a disaster.
The man described the mission as disastrous.



(d / describe-01
:ARG0 (m / man)
:ARG1 (m2 / mission)
:ARG2 (d / disaster))

Representation Roadmap

Meaning Representations for Natural Languages Tutorial Part 2A

Common Meaning Representations

AMR

- AMR Format & Basics
- **AMR: Some Details & Design Decisions**
- Practice - Walking through a few AMRs
- Multi-sentence AMRs
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Details - Specialized Normalizations

- AMR uses special ***abstract concepts*** we use for **normalizable entities** and **quantities**.

date-entity

:day	
:quarter	
:month	:dayperiod
:year	:season
:weekday	:decade
:time	:century
:timezone	:calendar
:era	

"Tuesday the 19th of May"

```
(d / date-entity
    :weekday (t / tuesday)
    :day 19
    :month 5)
```

Details - Specialized Normalizations

- AMR uses special ***abstract concepts*** we use for **normalizable entities** and **quantities**.

monetary-quantity
 :quant
 :unit dollar, euro, pound, yen …
temperature-quantity
 :quant
 :unit degrees, kelvins …
 :scale celsius, fahrenheit
frequency-quantity
 :quant hertz …
etc.

"five bucks"

```
(m / monetary-quantity
    :quant 5
    :unit (d / dollar))
```

"100° Celsius"

```
(t / temperature-quantity
    :quant 100
    :unit (d / degree)
    :scale (c / celsius))
```

Details - Specialized Normalizations

- And special ***abstract rolesets*** we can use for more complex **normalizable entities**.

"$2/taco Tuesdays"

```
(r / rate-entity-91
        :ARG1 (m / monetary-
quantity
                :unit dollar
                :quant 2)
        :ARG2 (t / taco
                :quant 1)
        :ARG4 (d / date-entity
                :weekday (t /
tuesday))
```

rate-entity-91
:ARG1 *quantity (implied default 1)*
:ARG2 *per quantity*
:ARG3 *regular interval between events*
:ARG4 *entity on which recurring event happens*

Details - Specialized Rolesets

- Other **complex relations** are also given special **abstract rolesets:**
  - ex: organizational/employment roles

"The US president"

```
(p / person
      :ARG0-of (h / have-org-role-91
         :ARG1 (c / country
               :name (n / name :op1 "US")
                  :wiki "United_States")
         :ARG2 (p2 / president)))
```

have-org-role-91
:ARG0 *office-holder*
:ARG1 *organization*
:ARG2 *title of office held*
:ARG3 *description of responsibility*

Details - Specialized Predicates

- **Reification -91 rolesets:**

"I am in Macau."

```
(b / be-located-at-91
      :ARG1 (i / i)
      :ARG2 (c / city
            :name (n / name :op1 "Macau")))
```

be-located-at-91 *reification of :location*
:ARG1 *entity*
:ARG2 *location*

Details - Reduction of Semantically-Light Matrix Verbs

Specific predicates are *NOT* used in AMR:

- **English Copula *be*:**
  - semantically-light
  - many languages don't use a copula

- Replace with relative **semantic** relation
  - e.g. **:domain** = "is an attribute of"
    = "is a category of"

*"The pizza **is** free."*

(f / free-01
  :ARG1 (p / pizza))

*"The house **is** a pit."*

(p / pit
  :domain (h / house))

Details - Reduction of Semantically-Light Matrix Verbs

Specific predicates are *NOT* used in AMR:

- **Light Verb Constructions**:
  - semantically-light verb dropped
  - roleset for heavy noun used instead

*"I **took** a **walk** in the park."*

(**w / walk-01**
:ARG0 (i2 / i)
:location (p / park))

Details - Discourse Connectives and Coordination

- For **two-place** discourse connectives, we define **abstract rolesets**

"We walked home even though it was raining."

```
(h / have-concession-91
    :ARG1 (w / walk-01
        :ARG0 (w2 / we)
        :destination (h / home))
    :ARG2 (r / rain-01))
```

have-concession-91
:ARG1 *main clause*
:ARG2 *'although' clause*

- For **list-like** discourse connectives, we use an **abstract concept** with any number of sequential **:op** roles:

"apples and bananas"

```
(a / and
    :op1 (a2 / apple)
    :op2 (b / banana)
```

and
:op1 *1st thing*
:op2 *2nd thing*
:op3 *3rd thing*
(etc.)

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- **Practice - Walking through a few AMRs**
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Practice - Let's Try some Sentences

- Feel free to annotate by hand (or ponder how you'd want to represent them)
  - *Edmund Pope tasted freedom today for the first time in more than eight months.*

Practice - Let's Try some Sentences

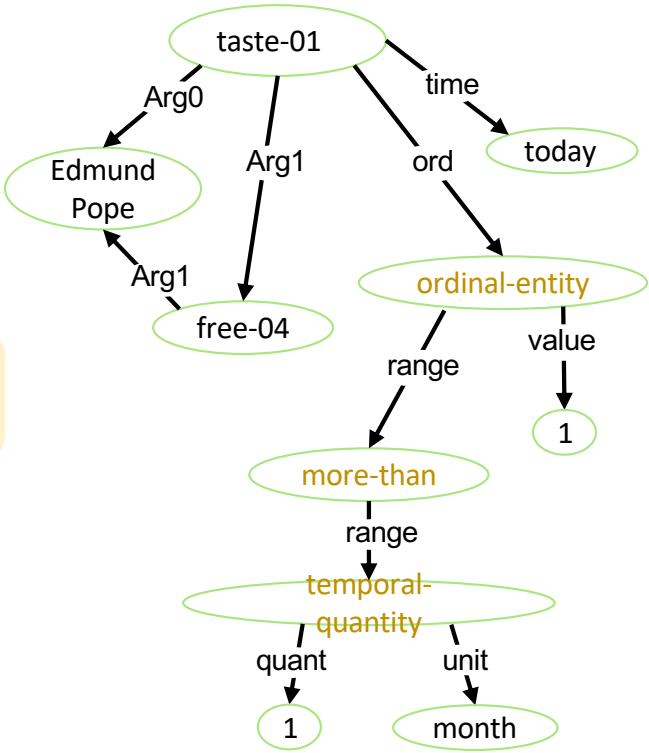
- *Edmund Pope tasted freedom today for the first time in more than eight months.*

```
(t / taste-01
    :ARG0 (p / person :wiki "Edmund_Pope"
        :name (n / name :op1 "Edmund" :op2 "Pope"))
    :ARG1 (f / free-04
        :ARG1 p)
    :time (t / today)
    :ord (o / ordinal-entity :value 1
        :range (m / more-than
        :range (m / more-than)))
            :op1 (t2 / temporal-quantity :quant 8
                :unit (m2 / month)))))
```

taste-01
:ARG0 *experiencer*
:ARG1 *stimulus*

free-04
:ARG0 *free entity*
:ARG1 *free from what*
:ARG2 *free to do what*

:time
:ord
:value
:range



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- **Multi-sentence AMRs**
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A final component in AMR: Multi-sentence!

- AMR 3.0 release contains *Multi-sentence AMR annotations*
- Document-level coreference:
  - Connecting mentions that co-refer
  - Connecting some partial coreference (bridging)
  - Making cross-sentence implicit semantic roles

- *John* took his car to the store.
- He *bought milk* [from the store].
- He *put it in* the trunk.

A final component in AMR: Multi-sentence!

Coreference annotation:

- Annotations track relations between AMR variables, not raw text

1. *"John took his car to the store."*

```
(s1t / take-01
     :ARG0 (s1p / person
          :name (n / name :op1 "John"))
     :ARG1 (s1c / car
          :poss s1p)
     :ARG3 (s1s / store)
```

1. *"He bought milk."*

```
(s2b / buy-01
     :ARG0 (s2h / he)
     :ARG1 (s2m / milk))
```

identity chain:
'John'

s1p
s2h

A final component in AMR: Multi-sentence!

Partial coreference (bridging) annotation:

- Annotations track relations between AMR variables, not raw text

1. *"John took his **car** to the store."*

```
(s1t / take-01
      :ARG0 (s1p / person
            :name (n / name :op1 "John"))
      :ARG1 (s1c / car
            :poss s1p)
      :ARG3 (s1s / store)
```

3. *"He put it in the **trunk**."*

```
(s3p / put-01
      :ARG0 (s3h / he)
      :ARG1 (s3i2 / it)
      :ARG2 (s3t / trunk)
```

whole entity:
s1c *"car"*

parts:
s3t *"trunk"*

A final component in AMR: Multi-sentence!

Implicit roles:

- After sentence-level annotation, unused numbered arguments are added back into the graphs
- Available for coreference annotation

1. *"John took his car to the store [from his house]."*

```
(s1t / take-01
    :ARG0 (s1p / person
          :name (n / name :op1 "John"))
    :ARG1 (s1c / car
          :poss s1p)
    :ARG2 [s1x / implicit :op1 "taken from, start point"]
    :ARG3 (s1s / store)
```

1. *"He bought milk [from the store]."*

```
(s2b / buy-01
    :ARG0 (s2h / he)
    :ARG1 (s2m / milk)
    :ARG2 [s2x / implicit :op1 "seller"])
```

identity chain:
'the store'

s1s
s2x

A final component in AMR: Multi-sentence!

Implicit roles:

- Worth considering for meaning representation, especially for languages other than English
- Null subject (and sometimes null object) constructions are very cross-linguistically common, can carry lots of information
- Arguments of nominalizations can carry a lot of assumed information in scientific domains

Special Note on Special Domain AMR Extensions

- **Spatial AMR** (Bonn et al., 2020):
  - Fine grained, multimodal extension of AMR for grounded corpora
  - Annotates frame of reference
  - Minecraft Dialogue Corpus
  - Used for downstream Human-robot interaction applications

- **THYME colon cancer medical corpus** (Wright-Bettner et al, 2019)
  - Fine grained cross-document temporal relations
  - Greatly expanded Medical PropBank lexicon
  - Handling of complex multi-word expressions

Multi-sentence, implicit annotation is vitally important in these special domains!

Acknowledgements

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