Generative Lexicon Theory: Integrating Theoretical and Empirical Methods

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Course Outline

- **July 11:** Introduction to GL and Data Analytics
- **July 12:** Qualia Structure
- **July 13:** Event Structure
- **July 14:** Argument Structure
- **July 15:** Meaning Composition
Introduction to Generative Lexicon

- Basic concepts in GL
  - Motivation
  - Notation and Language: typed feature structures
  - Meaning Composition in GL
- Polysemy and the Lexicon-Pragmatics Interface
- Evidence-based linguistics and data analytics
Qualia Structure

- What is a Quale?
- What motivates Qualia?
- Default Qualia and context updating
- Methodology to identify Qualia
- Data for each Quale
- Qualia and Conventionalized Attributes
- Qualia for Verbs

Lab on Qualia identification and extraction
Event Structure

- Events as Structured Objects
- Event Types
  - States
  - Transitions
  - Point Verbs
  - Processes
- Events as Labeled Transition Systems
- Dynamic Event Models

Lab on identification of event types
Argument Structure

- Argument Types in GL
  - True Arguments
  - Shadow Arguments
  - Hidden Arguments

- Argument Structure Representation

- Arguments and Defaulting

Lab on hidden and shadow arguments
Meaning composition

- Basic Assumptions
- Simple Function Application
- Coercion
- Subselection
- Co-composition

Lab or assignment on coercion
Lecture 3: Event Structure

- Feedback on Qualia extraction Lecture 2
- Lexical redundancy
- Classic Event Structure
- Making ES dynamic
- Dynamic Event Models in GL
Qualia values for F relation.
Qualia values for C relation.
Qualia values for T relation.
Qualia values for A relation.
Some word combinations are not possible because they are redundant.
That is, a member of the combination somehow repeats a piece of lexical information provided by another member.
Lexical Redundancy

- Verbs with incorporated arguments are a case in point.
- They entail one or more participants that, being already incorporated in the verb, cannot be expressed, unless they are more specifically described.
- *He smelled gas with his nose.
- *We were swimming in water.
- We were swimming in cold water.
- I saw it with my own eyes!
Lexical Redundancy

- adjective-noun combinations
- rapid explosion
- invited guest
- mental thought
- round circle
- final end
Lexical Redundancy

- verb-adverb combinations
- He devoured his portion voraciously.
- They were whispering softly.
- You are now ready to begin collaborating together.
Aktionsarten – conceptual categories of event types

- Stative vs. Non-stative
- States -Conceived of as not changing over time, as well as extended in time and permanent.

(1) a. John is tall.
   b. Mary knows the answer.
   c. It is 8:00 p.m.
   d. ! John is being tall.

Generally only compatible with simple present, but notice extended use of progressive and subtle meaning differences:

(2) . a. The statue stands in the square.
    b. The statue is standing in the square.

Structural vs. Phenomenal distinction – Goldsmith and Woisetschlager (1979)
Temporary vs. permanent states

As seen with the English progressive marking before, states are not always permanent. Other languages also mark these differences (but not always for the same concepts).

- Spanish – *ser* vs. *estar*

  (3) a. Soy enfermo (I am a sickly person)
  b. Estoy enfermo (if I have a cold)
Processes

Involve change and are extended in time. In present tense they need to be used in the progressive (unless habitual)

(4)  a. John ran a mile in under four minutes.
    b. Sheila wrote three letters in an hour.
    c. John ran a mile for six minutes.
    d. Sheila ate an apple for ten minutes.

(5)  a. John ran for twenty minutes.
    b. Sheila ate apples for two days straight.
    c. John ran in twenty minutes.
    d. Sheila ate apples in two days.
Activities: Atelic i.e. have no natural endpoint or goal (e.g. *I’m running in the park*) Compatible with a durative adverbial (e.g. *for*) that profiles the amount of time the activity takes.

Accomplishments: Telic i.e. have a natural endpoint of goal (e.g. *I’m running a mile*) Compatible with a container adverbial (e.g. *in*) that profiles the amount of time taken to reach the desired goal.
Some languages are more systematic than English in distinguishing indicators of actual and potential terminal points. Thus Swedish use different prepositions:

(6) Jeg reser till Frankrike på två månader.  
    I(’m) going to France for two months.

(7) Jeg reste i Frankrike i två månader.  
    I traveled in France for two months.
Achievements and points

Achievements: Events that are conceived of as instantaneous. Often, however, there is an underlying activity that causes a change of state. Their point-like nature tends to require them to be described in the past tense or narrative present.

(8) a. John shattered the window.
   b. ! John shatters/is shattering the window.
   c. The canals froze.
   d. Mary found her keys.
   e. *Mary is finding her keys.
   f. John reached the top.
Points: Similar to achievements in being conceived as instantaneous, but without the underlying run-up activity that characterizes gradual achievements

(9)  a. Bill coughed.
    b. The light flashed.
    c. Bill is coughing.
    d. The light is flashing.

(c) and (d) have an iterative interpretation. Compare with the gradual achievements *John is reaching the top* or *The canals are freezing.*
Vendler Event Classes + Semelfactive

- **STATE**: John loves his mother.
- **ACTIVITY**: Mary played in the park for an hour.
- **ACCOMPLISHMENT**: Mary wrote a novel.
- **ACHIEVEMENT**: John found a Euro on the floor.
- **POINT**: John knocked on the door (for 2 minutes).
Bach Eventuality Typology (Bach, 1986)

eventualities

states
  dynamic (a)
  static (b)

non-states
  processes (c)
  events
    protracted (d)
    momentaneous
      happenings (e)
      culminations (f)
Event Transition Graph (Moens and Steedman 1988)
“Certain NP’s measure out the event. They are direct objects consumed or created in increments over time (cf. *eat an apple* vs. *push a chart*)” (Tenny 1994).

In *Mary drank a glass of wine* “every part of the glass of wine being drunk corresponds to a part of the drinking event” (Krifka 1992)

“Incremental themes are arguments that are completely processed only upon termination of the event, i.e., at its end point” (Dowty 1991).
Verbs with variable aspectual behavior: they seem to be change of state verbs like other achievements, but allow *durational adverbs* (Dowty 1979, Hay, Kennedy and Levin 1999, Rappaport Hovav 2008).

No implication that exactly the same change of state took place over and over again (no semelfactives).

**Scalar predicates**: verbs which lexically specify a change along a scale inasmuch as they denote an ordered set of values for a property of an event argument (Hay, Kennedy and Levin 1999, Rappaport Hovav 2008).

For example *cool*, *age*, *lenghten*, *shorten*; *descend*.

*Let the soup cool* for 10 minutes.

*I went on working until the soup cooled.*
Moens and Steedman 1988 analyze point expressions as those that are not normally associated to a consequent state (consequent state defined as no transition to a new state in the world – according to Moens and Steedman a point is an event whose consequences are not at issue in the discourse).

**Semelfactives** (Smith 1990, Rothstein 2004).

*arrived/landed for five minutes, knocked/tapped for five minutes.*

Points admit iterative readings under coercive contexts (Moens and Steedman 1988).
Bare plurals and mass-terms arguments can make a sentence with a telic predicate behave as if it were 'durative' or 'imperfective' in aspect (Verkuyl 1972).

- *John drank a glass of beer* (perfective).
- *John drank beer* (imperfective).
Aspectual Coercion

- “A person leads somebody somewhere” (PROCESS) vs. “A road leads somewhere” (STATE)
- “An object falls to the ground” (TRANSITION) vs. “A case falls into a certain category” (STATE)
Subatomic Event Structure
Pustejovsky (1991)

(10) a. EVENT → STATE | PROCESS | TRANSITION
b. STATE: → e
c. PROCESS: → e₁…eₙ
d. TRANSITION_{ach}: → STATE STATE
e. TRANSITION_{acc}: → PROCESS STATE
Qualia Structure for Causative
Pustejovsky (1995)

\[
\begin{align*}
\text{kill} & \quad \text{EVENTSTR = } \\
\text{ARGSTR = } & \\
\text{QUALIA = }
\end{align*}
\]

\[
\begin{align*}
E_1 &= e_1: \text{process} \\
E_2 &= e_2: \text{state} \\
\text{RESTR} &= <_\infty \\
\text{HEAD} &= e_1 \\
\text{ARG1} &= 1 \\
\text{ARG2} &= 2 \\
\text{QUALIA} &= \text{cause-lcp} \\
\text{FORMAL} &= \text{dead}(e_2, 2) \\
\text{AGENTIVE} &= \text{kill}\_\text{act}(e_1, 1, 2)
\end{align*}
\]
(11) \textit{kill} \\\
\begin{center}
\begin{tikzpicture}
\node (e) at (0,0) {$e$};
\node (e1) at (-2,2) {$e_1^*$};
\node (e2) at (2,2) {$e_2$};
\draw (e) -- (e1) node[midway, above] {\textit{kill\_act}(x, y)};
\draw (e) -- (e2) node[midway, above] {\textit{dead}(y)};
\node (n1) at (-3,4) {$\neg\textit{dead}(y)$};
\draw (e1) -- (n1);
\end{tikzpicture}
\end{center}

(12) \textit{break} \\
\begin{center}
\begin{tikzpicture}
\node (e) at (0,0) {$e$};
\node (e1) at (-2,2) {$e_1$};
\node (e2) at (2,2) {$e_2$};
\draw (e) -- (e1) node[midway, above] {\textit{break\_act}(x, y)};
\draw (e) -- (e2) node[midway, above] {\textit{broken}(y)};
\node (n1) at (-3,4) {$\neg\textit{broken}(y)$};
\draw (e1) -- (n1);
\end{tikzpicture}
\end{center}
Qualia Structure with Opposition Structure

\[
\begin{align*}
\text{kill} & \quad \text{EVENTSTR} = \\
\{ & E_0 = e_0: \text{state} \\
\{ & E_1 = e_1: \text{process} \\
\{ & E_2 = e_2: \text{state} \\
\{ & \text{RESTR} = <\infty \\
\{ & \text{HEAD} = e_1 \\
\} & \text{ARG1} = \boxed{1} \quad \text{ind} \\
\{ & \text{FORMAL} = \text{physobj} \\
\} & \text{ARG2} = \boxed{2} \quad \text{animate} \_ \text{ind} \\
\} & \text{QUALIA} = \\
\{ & \text{FORMAL} = \text{dead}(e_2, 2) \\
\{ & \text{AGENTIVE} = \text{kill} \_ \text{act}(e_1, 1, 2) \\
\{ & \text{PRECOND} = \neg \text{dead}(e_0, 2) \\
\} & \end{align*}
\]
Opposition is Part of Event Structure

\[
\begin{align*}
\text{kill}_{\text{act}}(x, y) & \quad \neg \text{dead}(w) \\
\neg \text{dead}(w) & \quad \text{dead}(w) \\
\bar{P} & \quad P \\
\emptyset S &
\end{align*}
\]

\[
\begin{align*}
\text{kill}_{\text{act}}(x, y) & \quad \neg \text{dead}(y) \\
\end{align*}
\]
Dynamic Extensions to GL

- **Qualia Structure**: Can be interpreted dynamically
- **Dynamic Selection**: Encodes the way an argument participates in the event
- **Tracking change**: Models the dynamics of participant attributes
Parameters of a verb, $P$, extend over sequential frames of interpretation (subevents).

$P$ is decomposed into different subpredicates within these events:

$$\text{Verb}(\text{Arg}_1 \text{Arg}_2) \implies \lambda y \lambda x \quad A\text{P}_1(x,y) \quad F\text{P}_2(y)$$
Frame-based Event Structure

State (S)

Transition (T)

Process (P)

Derived Transition

2nd Conference on CTF, Pustejovský (2009)
Dynamic Event Structure

- Events are built up from multiple (stacked) layers of primitive constraints on the individual participants.
- There may be many changes taking place within one atomic event, when viewed at the subatomic level.
Dynamic Interval Temporal Logic

(Pustejovsky and Moszkowicz, 2011)

- **Formulas**: \( \phi \) propositions. Evaluated in a state, \( s \).
- **Programs**: \( \alpha \), functions from states to states, \( s \times s \). Evaluated over a pair of states, \((s, s')\).
- **Temporal Operators**: \( \bigcirc \phi \), \( \diamond \phi \), \( \square \phi \), \( \phi U \psi \).
- **Program composition**:
  1. They can be ordered, \( \alpha; \beta \) (\( \alpha \) is followed by \( \beta \));
  2. They can be iterated, \( \alpha^* \) (apply \( \alpha \) zero or more times);
  3. They can be disjoined, \( \alpha \cup \beta \) (apply either \( \alpha \) or \( \beta \));
  4. They can be turned into formulas
     \( [\alpha] \phi \) (after every execution of \( \alpha \), \( \phi \) is true);
     \( \langle \alpha \rangle \phi \) (there is an execution of \( \alpha \), such that \( \phi \) is true);
  5. Formulas can become programs, \( \phi ? \) (test to see if \( \phi \) is true, and proceed if so).
(13) a. Mary was sick today.
b. My phone was expensive.
c. Sam lives in Boston.

We assume that a *state* is defined as a single frame structure (event), containing a proposition, where the frame is temporally indexed, i.e., \( e^i \rightarrow \phi \) is interpreted as \( \phi \) holding as true at time \( i \). The frame-based representation from Pustejovsky and Moszkowicz (2011) can be given as follows:
Propositions can be evaluated over subsequent states, of course, so we need an operation of concatenation, $+$, which applies to two or more event frames, as illustrated below.

$$\phi^i_e + \phi^j_e = \phi^{[i,j]}_e$$

Semantic interpretations for these are:

1. $\llbracket \phi_{M,i} \rrbracket = 1$ iff $V_{M,i}(\phi) = 1$.
2. $\llbracket \phi_{M,(i,j)} \rrbracket = 1$ iff $V_{M,i}(\phi) = 1$ and $V_{M,j}(\phi) = 1$, where $i < j$. 
(17)

\[ e^i + e^j = e^{[i,j]} \]

Tree structure for event concatenation:
Labeled Transition System (LTS)

The dynamics of actions can be modeled as a Labeled Transition Systems (LTS).

An LTS consists of a 3-tuple, \( \langle S, Act, \rightarrow \rangle \), where

(18) a. \( S \) is the set of states;
   b. \( Act \) is a set of actions;
   c. \( \rightarrow \) is a total transition relation: \( \rightarrow \subseteq S \times Act \times S \).

(19) \( (e_1, \alpha, e_2) \in \rightarrow \)

Labeled Transition System (LTS)

An action, $\alpha$ provides the labeling on an arrow, making it explicit what brings about a state-to-state transition.

As a shorthand for

(20) a. $(e_1, \alpha, e_2) \in \rightarrow$, we will also use:

b. $e_1 \xrightarrow{\alpha} e_3$

```
\begin{align*}
S_1 & \quad \text{p} \\
\quad \quad A \\
\quad \quad \quad \text{p} \\
S_2 & \quad \text{p}
\end{align*}
```
If reference to the state content (rather than state name) is required for interpretation purposes, then as shorthand for:

\((\{\phi\}_{e_1}, \alpha, \{-\phi\}_{e_2}) \in \rightarrow\), we use:

\[
(21) \quad \phi_{e_1} \xrightarrow{\alpha} -\phi_{e_2}
\]
With temporal indexing from a Linear Temporal Logic, we can define a Temporal Labeled Transition System (TLTS). For a state, $e_1$, indexed at time $i$, we say $e_1@i$.

$\left( \{\phi\}_{e_1@i}, \alpha, \{\neg\phi\}_{e_2@i+1} \right) \in \rightarrow (i,i+1)$, we use:

(22) $\begin{array}{c}
\phi \\
\hline
\downarrow
\end{array}_{e_1}^i \xrightarrow{\alpha} \begin{array}{c}
\neg\phi \\
\hline
\downarrow
\end{array}_{e_2}^{i+1}$
Dynamic Event Structure

(23)

\[ e_i \xrightarrow{\alpha} e_{i+1} \]

\[ e_{[i,i+1]} \]

\[ e_i \]

\[ e_{i+1} \]

\[ \phi \]

\[ \neg \phi \]
(24) Mary awoke from a long sleep.

The state of being asleep has a duration, \([i, j]\), who’s valuation is gated by the waking event at the “next state”, \(j + 1\).

(25)
(26) $x := y$ \textit{(}\nu\text{-transition)}

"$x$ assumes the value given to $y$ in the next state."

$\langle \mathcal{M}, (i, i + 1), (u, u[x/u(y)]) \rangle \models x := y$

iff $\langle \mathcal{M}, i, u \rangle \models s_1 \land \langle \mathcal{M}, i + 1, u[x/u(y)] \rangle \models x = y$

(27)

$$
\begin{array}{c}
e_{[i,i+1]} \\
\downarrow \\
e_i^i \\
\downarrow \\
A(z) = x \\
\downarrow \\
\downarrow \\
\downarrow \\
\downarrow \\
A(z) = y
\end{array}
$$
With a \( \nu \)-transition defined, a process can be viewed as simply an iteration of basic variable assignments and re-assignments:

\[
\begin{align*}
&\quad e \\
&\rightarrow e_1 \xrightarrow{\nu} e_2 \xrightarrow{\nu} \ldots \xrightarrow{\nu} e_n
\end{align*}
\]
Spatial Relations in Motion Predicates

- **Topological Path Expressions**
  arrive, leave, exit, land, take off

- **Orientation Path Expressions**
  climb, descend

- **Topo-metric Path Expressions**
  approach, near, distance oneself

- **Topo-metric orientation Expressions**
  just below, just above
Manner construction languages
Path information is encoded in directional PPs and other adjuncts, while verb encode manner of motion
English, German, Russian, Swedish, Chinese

Path construction languages
Path information is encoded in matrix verb, while adjuncts specify manner of motion
Modern Greek, Spanish, Japanese, Turkish, Hindi
(29) a. The event or situation involved in the change of location; b. The object (construed as a point or region) that is undergoing movement (the figure); c. The region (or path) traversed through the motion; d. A distinguished point or region of the path (the ground); e. The manner in which the change of location is carried out; f. The medium through which the motion takes place.
Manner Predicates

(30) $\text{S}$

$$\text{NP} \quad \text{figure} \quad \text{VP}$$

John $\quad V \quad \text{biked}$

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Path Predicates

(31) $\text{S} \\
\text{NP} \rightarrow \text{figure} \rightarrow \text{VP} \\
\text{John} \rightarrow \text{V} \rightarrow \text{ground} \rightarrow \text{NP} \\
\text{departed} \rightarrow \text{trans} \rightarrow \text{Boston}$
Manner with Path Adjunction

(32)

\[
\begin{array}{c}
S \\
\downarrow \text{figure} \\
NP \\
\uparrow \\
\text{John} \\
\end{array} \quad \begin{array}{c}
VP \\
\downarrow \text{ground} \\
V \\
\uparrow \\
biked \\
\end{array} \quad \begin{array}{c}
PP \\
\uparrow \text{trans} \\
to the store \\
\end{array}
\]
(33) John figure trans departed - ground VP

NP

S

NP

PP

act

by car

Boston

departed

ground

trans

Figure

S

NP

PP

act

by car

Boston

departed

ground

trans

figure

John

NP

VP

S

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(34) a. Isabel climbed for 15 minutes.
    b. Nicholas fell 100 meters.

(35) a. There is an action (e) bringing about an iterated non-distinguished change of location;
    b. The figure undergoes this non-distinguished change of location;
    c. The figure creates (leaves) a path by virtue of the motion.
    d. The action (e) is performed in a certain manner.
    e. The path is oriented in an identified or distinguished way.
Unlike pure manner verbs, this class of predicates admits of two compositional constructions with adjuncts.

(36) **Manner of motion verb with path adjunct;**
    John climbed to the summit.

(37) **Manner of motion verb with path argument;**
    John climbed the mountain.
(38) S
   / \ figure
  NP  VP
 /     |
John  V
  |     \ ground
  | act
  \ climbed
      PP
          to the summit

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With Path Argument

(39)

```
S
  \|--|-
  NP figure VP
    |       |
  John   V path NP
        |     |
             | trans climbed the mountain
```
Tracking Motion with RCC8: example of enter
Dynamic Interval Temporal Logic

- **Path** verbs designate a distinguished value in the change of location, from one state to another. The change in value is **tested**.

- **Manner of motion** verbs iterate a change in location from state to state. The value is **assigned** and reassigned.
Directed Motion

(40)  \[ \text{loc}(z) = x e_1 \xrightarrow{\nu} \text{loc}(z) = y e_2 \]

When this test references the ordinal values on a scale, \( C \), this becomes a directed \( \nu \)-transition (\( \vec{\nu} \)), e.g., \( x \preceq y \), \( x \succeq y \).

(41)  \( \vec{\nu} =_{df} \text{e}_i \xrightarrow{\nu} \text{e}_{i+1} \)
Directed Motion

(42)

\[ e^{[i,i+1]} \]

\[ x \leq y? \]

\[ e_i \]

\[ x := y \]

\[ e_{i+1} \]

\[ \mathcal{A}(z) = x \]

\[ \mathcal{A}(z) = y \]
Manner-of-motion verbs introduce an assignment of a location value:
\[ \text{loc}(x) := y; y := z \]

Directed motion introduces a dimension that is measured against:
\[ d(b, y) < d(b, z) \]

Path verbs introduce a pair of tests:
\[ \neg \phi? \ldots \phi? \]
The execution of a change in the value to an attribute $A$ for an object $x$ leaves a trail, $\tau$.

For motion, this trail is the created object of the path $p$ which the mover travels on;

For creation predicates, this trail is the created object brought about by order-preserving transformations as executed in the directed process above.
(43) **Motion leaving a trail:**

a. Assign a value, $y$, to the location of the moving object, $x$.
   
   \[ \text{loc}(x) := y \]

b. Name this value $b$ (this will be the beginning of the movement);
   
   \[ b := y \]

c. Initiate a path $p$ that is a list, starting at $b$;
   
   \[ p := (b) \]

d. Then, reassign the value of $y$ to $z$, where $y \neq z$
   
   \[ y := z, y \neq z \]

e. Add the reassigned value of $y$ to path $p$;
   
   \[ p := (p, z) \]

e. Kleene iterate steps (d) and (e);
Quantifying the Resulting Trail

Figure: Directed Motion leaving a Trail

(44) a. The ball rolled 20 feet.
\[ \exists p \exists x[ [\text{roll}(x, p) \land \text{ball}(x) \land \text{length}(p) = [20, \text{foot}]] \]
b. John biked for 5 miles.
\[ \exists p [ [\text{bike}(j, p) \land \text{length}(p) = [5, \text{mile}]] \]
We generalize the Path Metaphor to the analysis of the creation predicates.

We analyze creation predicates as predicates referencing two types of scales.
Type of Creation Verbs

(45) a. John wrote a letter.
    b. Sophie wrote for hours.
    c. Sophie wrote for an hour.

(46) a. John built a wooden bookcase.
    b. *John built for weeks.
Some verbs expressing change are associated with a scale while others are not (scalar vs. non-scalar change).

There is a single scale domain (ordinal scale), which varies with respect to mereological complexity (two-point vs. multi-point) and specificity of the end point (bounded vs. unbounded).

Scales are classified on the basis of the attribute being measured:

- PROPERTY SCALES: often found with change of state verbs.
- PATH SCALES: most often found with directed motion verbs.
- EXTENT SCALES: most often found with incremental theme verbs.
Various scholars have observed that for certain scalar expressions the scale appears not to be supplied by the verb.
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Various scholars have observed that for certain scalar expressions the scale appears not to be supplied by the verb.

For example, Rappaport Hovav 2008, Kennedy 2009 claim that “the scale which occurs with incremental theme verbs (extent scale) is not directly encoded in the verb, but rather provided by the referent of the direct object”.

This has lead them to the assumption that when nominal reference plays a role in measuring the change, V is not associated with a scale (denoting a non-scalar change).
Challenge for Scalar Models

- Identify the source(s) of the measure of change.
- What is the basic classification of the predicate with respect to its scalar structure?
- What is the exact contribution of each member of the linguistic expression to the measurement of the change?
- What is the role of nominal reference in aspectual composition?
Verbs reference a specific scale.

We measure change according to this scale domain.

Scales are introduced by predication (encoded in a verb).

Scales can be introduced by composition (function application).

Verbs may reference multiple scales.
Nominal scales: composed of sets of categories in which objects are classified;

Ordinal scales: indicate the order of the data according to some criterion (a partial ordering over a defined domain). They tell nothing about the distance between units of the scale.

Interval scales: have equal distances between scale units and permit statements to be made about those units as compared to other units; there is no zero. Interval scales permit a statement of “more than” or “less than” but not of “how many times more.”

Ratio scales: have equal distances between scale units as well as a zero value. Most measures encountered in daily discourse are based on a ratio scale.
Use multiple scalar domains and the “change as program” metaphor proposed in Dynamic Interval Temporal Logic (DITL, Pustejovsky 2011, Pustejovsky & Moszkowicz 2011).
Use multiple scalar domains and the “change as program” metaphor proposed in Dynamic Interval Temporal Logic (DITL, Pustejovsky 2011, Pustejovsky & Moszkowicz 2011).

Define change as a transformation of state (cf. Galton, 2000, Naumann 2001) involving two possible kinds of result, depending on the change program which is executed:
Use multiple scalar domains and the “change as program” metaphor proposed in Dynamic Interval Temporal Logic (DITL, Pustejovsky 2011, Pustejovsky & Moszkowicz 2011).

Define change as a transformation of state (cf. Galton, 2000, Naumann 2001) involving two possible kinds of result, depending on the change program which is executed:

If the program is “change by testing”, Result refers to the current value of the attribute after an event (e.g., the house in build a house, the apple in eat an apple, etc.).
Use multiple scalar domains and the “change as program” metaphor proposed in Dynamic Interval Temporal Logic (DITL, Pustejovsky 2011, Pustejovsky & Moszkowicz 2011).

Define change as a transformation of state (cf. Galton, 2000, Naumann 2001) involving two possible kinds of result, depending on the change program which is executed:

If the program is “change by testing”, Result refers to the current value of the attribute after an event (e.g., the house in build a house, the apple in eat an apple, etc.).

If the program is “change by assignment”, Result refers to the record or trail of the change (e.g., the path of a walking, the stuff written in writing, etc.).
Scale shifting

- Scale Shifting is mapping from one scalar domain to another scalar domain.
  - ordinal $\Rightarrow$ nominal
  - nominal $\Rightarrow$ ordinal
  - ordinal $\Rightarrow$ interval
  - ...

- Scale Shifting may be triggered by:
  - Adjuncts: *for*/*in* adverbials, degree modifiers, resultative phrases, etc.
  - Arguments (selected vs. non-selected, semantic typing, quantification).
Accomplishments are Lexically Encoded Tests.
John built a house.

- Test-predicates for creation verbs
- build selects for a quantized individual as argument.
  \[\lambda z \lambda y \lambda x [\text{build}(x, z, y)]\]
- An ordinal scale drives the incremental creation forward
- A nominal scale acts as a test for completion (telicity)
Mary is building a table.
Change is measured over an **ordinal scale**.
Trail, $\tau$ is null.
Mary is building a table.
Change is measured over an **ordinal scale**.
Trail, $\tau = [A]$. 
Mary is building a table.

Change is measured over an **ordinal scale**.

Trail, $\tau = [A, B]$
Mary is building a table.
Change is measured over an **ordinal scale**.
Trail, $\tau = [A, B, C]$
Mary is building a table.

Change is measured over an **ordinal scale**.

Trail, $\tau = [A, B, C, D]$
• Mary built a table.
• Change is measured over a **nominal scale**.
• Trail, $\tau = [A, B, C, D, E]$; $table(\tau)$. 
Accomplishments

(47) a. John built a table.
   b. Mary walked to the store.

<table>
<thead>
<tr>
<th>$build(x, z, y)$</th>
<th>$build(x, z, y)^+$</th>
<th>$build(x, z, y), y = v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\neg table(v)$</td>
<td>$table(v)$</td>
<td></td>
</tr>
</tbody>
</table>

**Table:** Accomplishment: parallel tracks of changes
(48)

\[

d_1 \xrightarrow{\alpha} d_2 \xrightarrow{\phi} e
\]

\[
\ldots \xrightarrow{\alpha} d_{1k} \xrightarrow{\phi} e
\]
(49)

\[ e \xrightarrow{\text{build}} e_1 \xrightarrow{\neg \text{table?}} e_1 \xrightarrow{\text{build}} e_1 \xrightarrow{\cdots} e_1 \xrightarrow{\text{build}} e_1 \xrightarrow{\text{table}(v)} e_2 \]

Parallel Scales define an Accomplishment
Corpus Study of Detecting Aktionsarten

- [ V ... \textit{for} TIME EXPRESSION ]
  - "for" [word!="\."]{0,5}
    - \texttt{ lemma="second | minute | hour | day | week | month | year" }

- [ V ... \textit{in} TIME EXPRESSION ]
  - "in" [word!="\."]{0,5}
    - \texttt{ lemma="second | minute | hour | day | week | month | year" }