Fluid Construction Grammars

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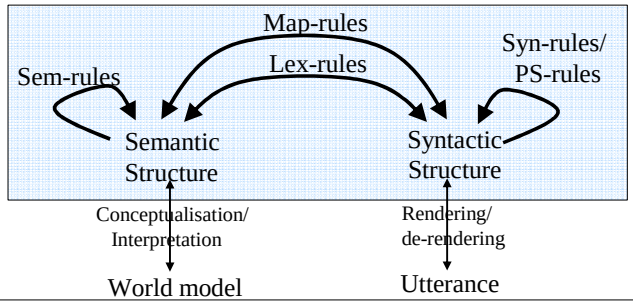
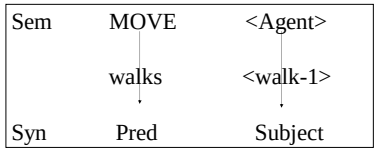
Goal:
Develop a formalism for construction grammar and computational mechanisms for parsing and production
Should be usable in multi-agent simulations of language evolution.

Requirements:
- Linguistic Requirements:
  - ✓ Representation of constructions (meaning-form mappings)
  - ✓ Representation of hierarchical categorisation rules (syntactic and semantic)
  - ✓ No formal distinction between lexicon and grammar
- Processing Requirements:
  - ✓ No distinction between parsing and production
  - ✓ Multiple hypotheses tracked in parallel
  - ✓ Partial analysis if rules are missing or violated
- Adaptation Requirements:
  - ✓ New categories can be added or changed at any time
  - ✓ New constructions can be added at any time
  - ✓ Rules are in competition for dominance in the population

Approach:
- Lexicon and grammar are expressed by constraints on feature structures
- Construction application through matching + unification over feature structures
- All form aspects are represented in a declarative way
- Multi-tasking to explore multiple hypotheses



Ex: ((walk ev1 true) (walk-1 ev1 obj1) (john obj1)) <==> "John walks"



Lex-rules: relate part of semantic structure to lexemes (words):

```
(def-lex walk-entry
  ((?unit (referent ?event)
     (meaning
       (== (walk ?event ?truth)
           (walk-1 ?event ?object)))))
↔
  ((?unit (form (== (string ?unit "walks"))))))
```

```
(def-lex john-entry
  ((?unit (referent ?obj)
     (meaning (== (john ?obj)))))
↔
  ((?unit
     (form
       (== (string ?unit "john"))))))
```

Map-rules: relate part of semantic structure to syntactic

```
(def-map SV-construction
  ((?parent-unit (referent ?ev1)
                 (sem-subunits (== ?event-unit ?agent-unit)))
   (?event-unit  (referent ?ev1)
                 (sem-cat (== (move ?ev1) (agent ?ev1 ?obj))))
   (?agent-unit  (referent ?obj))
↔
  ((?parent-unit (syn-cat (== SV-sentence)))
   (?event-unit  (syn-cat (== (subject ?parent-unit ?agent-unit))))
   (?agent-unit  (syn-cat (== (predicate ?parent-unit ?event-unit)))))))
```

Syn-rules: categorise aspects of syntactic structure:

```
(def-syn  john-noun
  ((?unit
    (form (== string ?unit "john"))))
 →
  ((?unit
    (syn-cat (== noun
                 (number singular))))))
```

```
(def-syn  walk-verb
  ((?unit
    (form (== (string ?unit "walks")))))
→
  ((?unit
    (syn-cat (== verb
                 (number singular))))))
```

Ps-rules: relate constructions to phrase structure

```
(def-ps SV-sentence
 ((?top-unit (syn-cat (== SV-sentence)))
  (?subject-unit (syn-cat (== (subject ?top-unit ?subject-unit))))
  (?predicate-unit (syn-cat (== (predicate ?top-unit ?predicate-unit)))))
↔
 ((?top-unit (syn-cat (== sentence))
             (form (== (precedes ?subject-unit ?predicate-unit))))
  (?subject-unit (syn-cat (== noun (number ?number))))
  (?predicate-unit (syn-cat (== verb (number ?number))))))
```

Sem-rules: categorise aspects of semantic structure

```
(def-sem  walk-1-agent
  ((?event-unit  (referent ?event)
                 (meaning (== (walk ?event ?true) (walk-1 ?event ?object)))))
 -->
  ((?event-unit  (sem-cat (== (move ?event) (agent ?event ?object)))))))
```

Semantic Structure:

```
((top-unit
   (sem-subunits (unit-1 unit-2)))
 (unit-1 (referent obj1)
         (meaning ((john obj1)))
 (unit-2 (referent ev1)
   (meaning ((walk ev1 true)
             (walk-1 ev1 obj1)))
```

Syntactic structure:

```
((top-unit
   (syn-subunits (unit-1 unit-2))
   (syn-cat (sentence))
 (unit-1
   (form ((string unit-1 "john"))))
 (unit-2
   (form ((string unit-2 "walks")))))
```

```
((top-unit
   (sem-subunits (unit-1 unit-2)))
 (unit-1  (referent obj1)
   (meaning ((john ?obj1)))
 (unit-2  (referent ev1)
   (meaning ((walk ev1 truth)
             (walk-1 ev1 obj1)))
   (sem-cat ((move ev1)
             (agent ev1 obj1)))))
```

```
((top-unit
   (syn-subunits (unit-1 unit-2)))
 (unit-1
   (form ((string unit-1 "john")))
   (syn-cat (noun (number singular))))
 (unit-2
   (form ((string unit-2 "walks")))
   (syn-cat (verb (number singular))))
```

Semantic Structure:

```
((top-unit
   (sem-subunits (unit-1 unit-2)))
 (unit-1
   (referent obj1)
   (meaning ((john obj1)))
 (unit-2 (referent ev1)
   (sem-cat ((move ev1)
             (agent ev1 obj1)))
   (meaning ((walk ev1 true)
             (walk-1 ev1 obj1)))))
```

Syntactic Structure:

```
((top-unit
   (syn-subunits (unit-1 unit-2))
   (syn-cat (sentence SV-sentence))
   (form ((precedes unit-1 unit-2))))
 (unit-1
   (syn-cat (subject top-unit unit-1)
            (noun (number singular)))
   (form ((string unit-1 "john"))))
 (unit-2
   (syn-cat (predicate top-unit unit-2)
            (verb (number singular)))
   (form ((string unit-2 "walks")))))
```

((walk ev1 true)
(walk-1 ev1 obj1)
(john obj1)) ↔ "John walks"