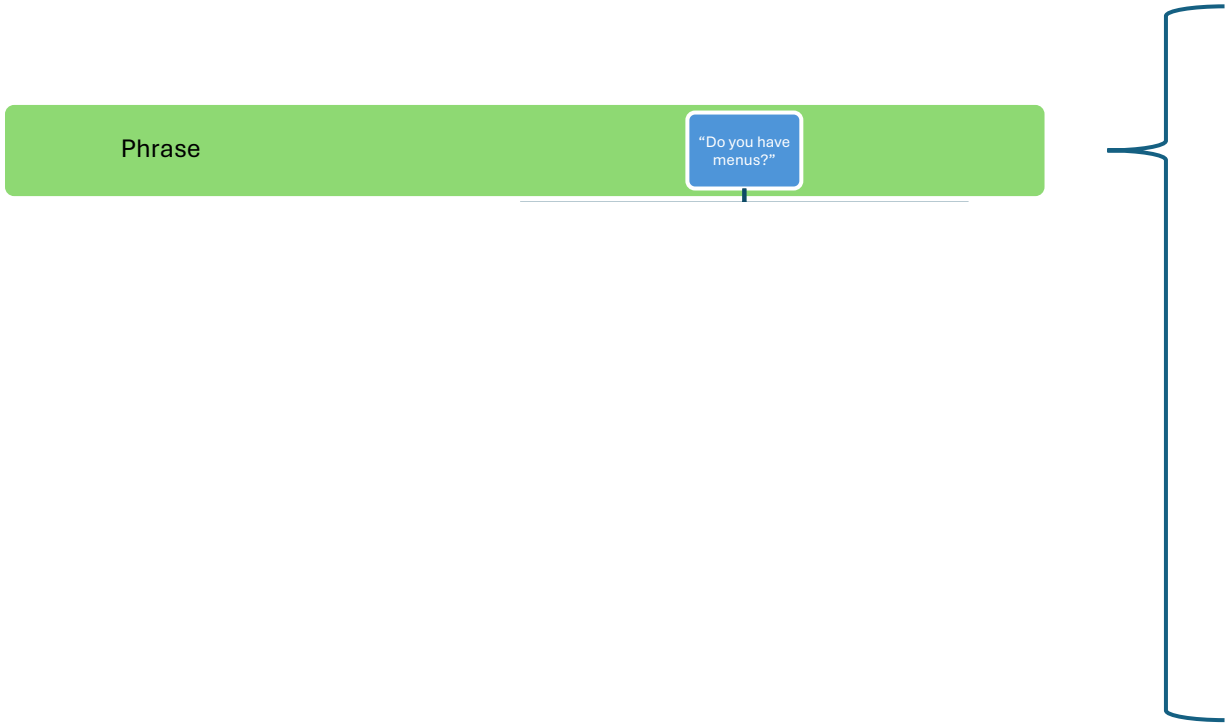
Perplexity Interpretations

Particular and General, Literal and Pragmatic

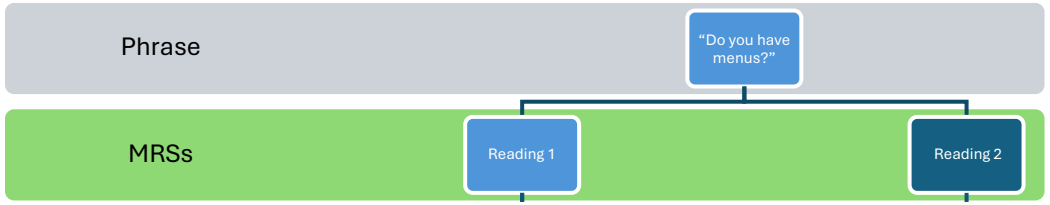
Review: Perplexity Execution Flow

Using the English Restaurant example …

Review: Perplexity Flow

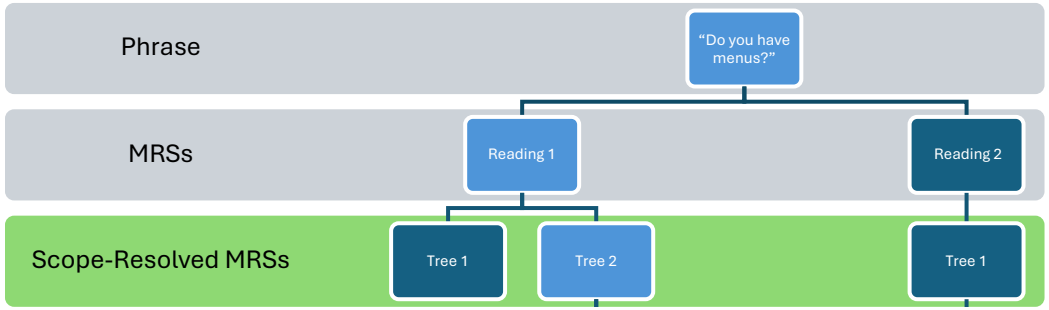


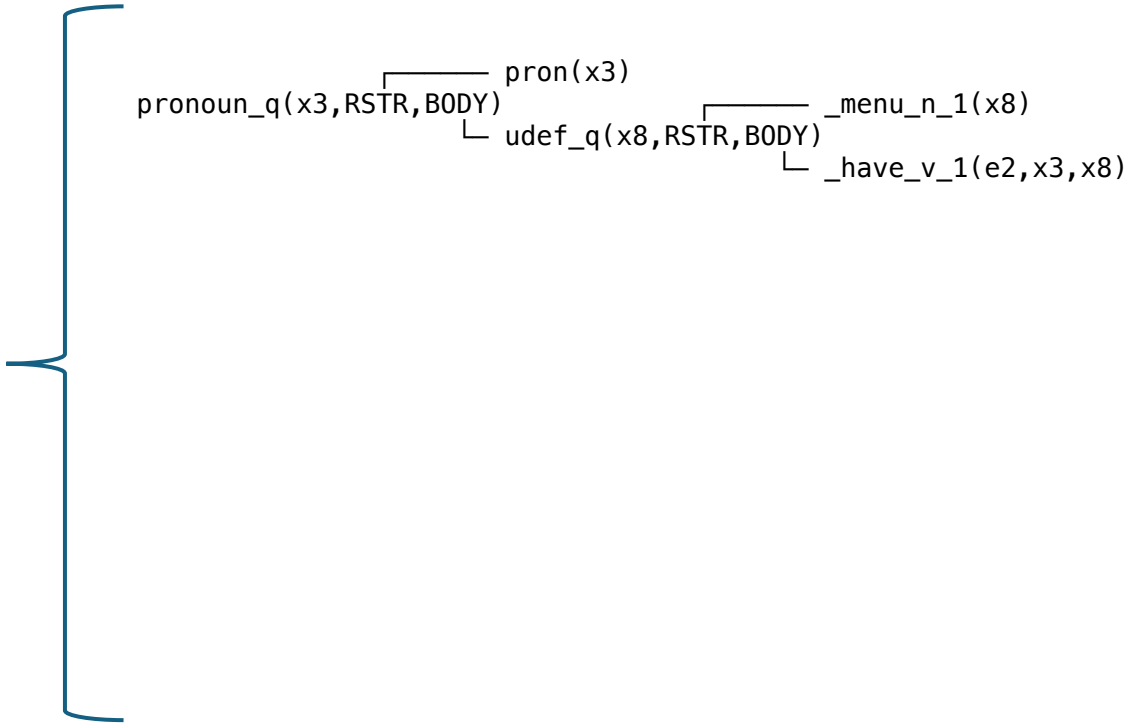
Review: Perplexity Flow



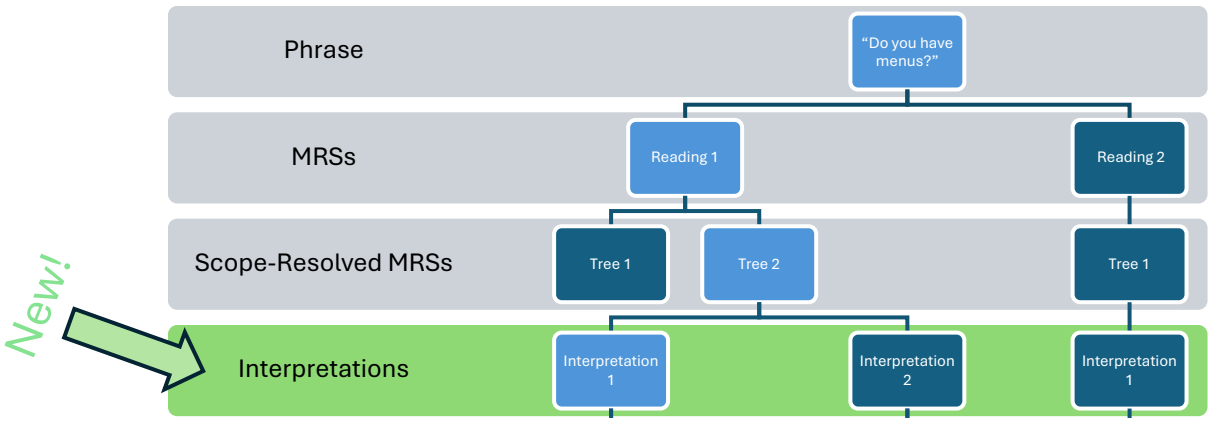
["Do you have menus?"
TOP: h0
INDEX: e2
[e SF: ques TENSE: pres MOOD: indicative PROG: - PERF: -]
RELS: < [pron<3:6> LBL: h4 ARG0: x3 [x PERS: 2 IND: + PT: std]]
[pronoun_q<3:6> LBL: h5 ARG0: x3 RSTR: h6 BODY: h7]
[_have_v_1<7:11> LBL: h1 ARG0: e2 ARG1: x3 ARG2: x8
[x PERS: 3 NUM: pl IND: +]]
[udef_q<12:18> LBL: h9 ARG0: x8 RSTR: h10 BODY: h11]
[_menu_n_1<12:17> LBL: h12 ARG0: x8] >
HCONS: < h0 qeq h1 h6 qeq h4 h10 qeq h12 >]

Review: Perplexity Flow





Review: Perplexity Flow



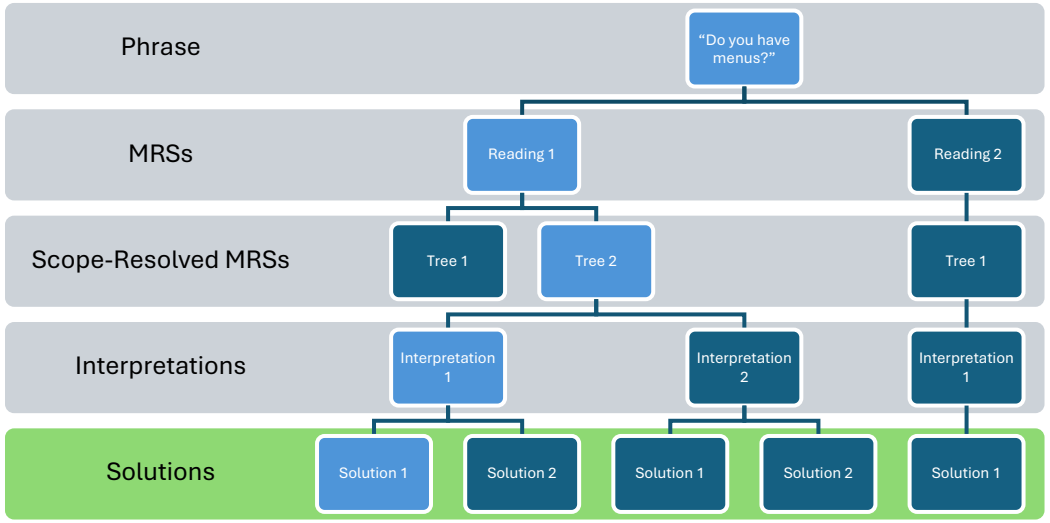

```
                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)                ┌──── _menu_n_1(x8)
                    └─ udef_q(x8,RSTR,BODY)
                                       └─ _have_v_1_order(e2,x3,x8)

                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)                ┌──── _menu_n_1(x8)
                    └─ udef_q(x8,RSTR,BODY)
                                       └─ _have_v_1_list(e2,x3,x8)

                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)                ┌──── _menu_n_1(x8)
                    └─ udef_q(x8,RSTR,BODY)
                                       └─ _have_v_1_able(e2,x3,x8)

...
```

Review: Perplexity Flow



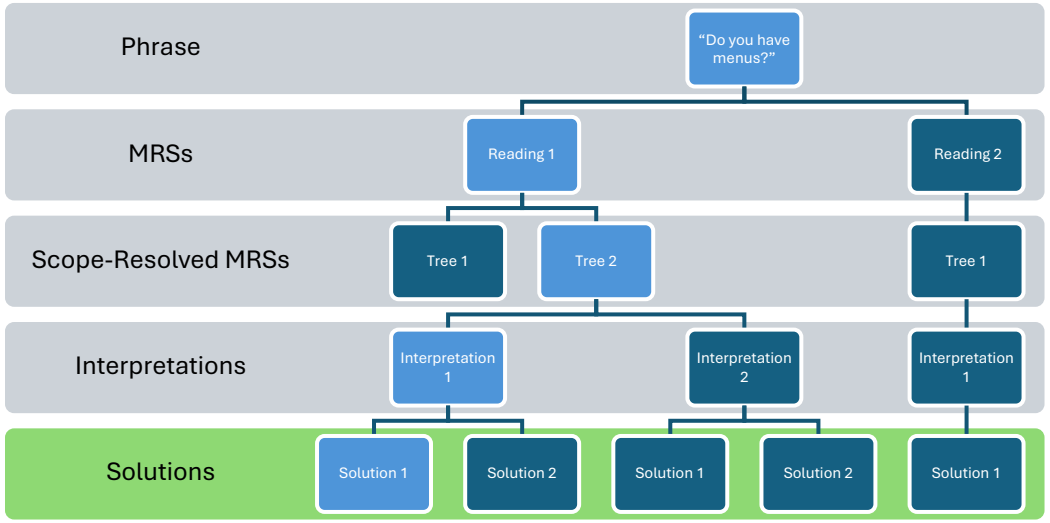

```
                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)                ┌──── _menu_n_1(x8)
                    └─ udef_q(x8,RSTR,BODY)
                                       └─ _have_v_1_order(e2,x3,x8)
```

Individuals	Facts
waiter	waiter has menu1 waiter has menu2
menu1	
menu2	

Solver Input:

- Scope-resolved MRS with a specific interpretation per predication
- World state

Review: Perplexity Flow




```
                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)                ┌──── _menu_n_1(x8)
                    └─ udef_q(x8,RSTR,BODY)
                                       └─ _have_v_1_order(e2,x3,x8)
```

Individuals
waiter
menu1
menu2

Facts
waiter has menu1
waiter has menu2

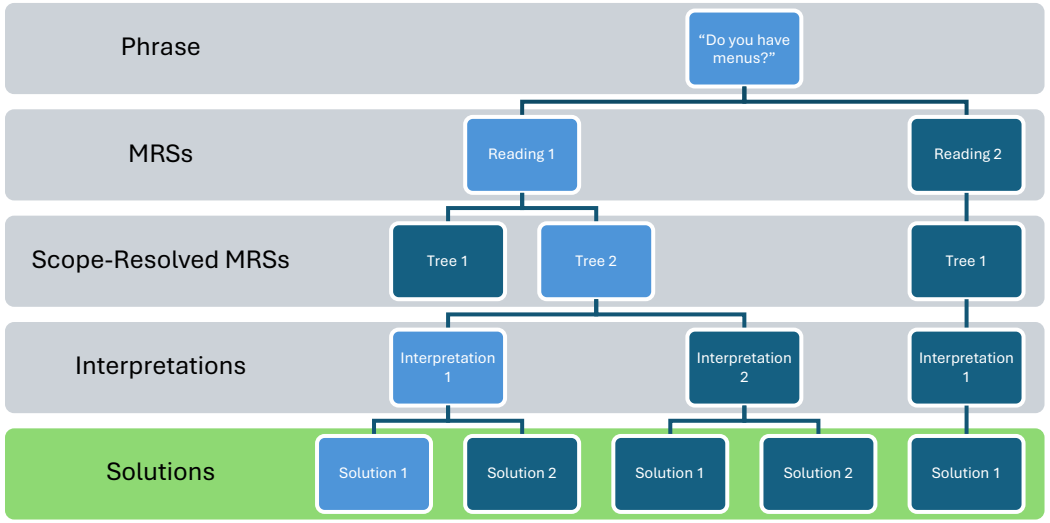
Solution 1	
x3	[waiter]
x8	[menu1]

Solution 2	
x3	[waiter]
x8	[menu2]

Solver Phase 1:

- Generate all solutions
- Solution: Single assignment of a value to every variable such that every predication succeeds
- Ignore cross-solution criteria, such as plurality
- A solution is independently true but needs to be combined with others to match uttered phrase

Review: Perplexity Flow




```
                    ┌──── pron(x3)
pronoun_q(x3,RSTR,BODY)
                    └─ udef_q(x8,RSTR,BODY)
                                  ┌──── _menu_n_1(x8)
                                  └─ _have_v_1_order(e2,x3,x8)
```

Individuals
waiter
menu1
menu2

Facts
waiter has menu1
waiter has menu2

Solution Group

Solution 1	
x3	[waiter]
x8	[menu1]

Solution 2	
x3	[waiter]
x8	[menu2]

Solver Phase 2:

- Group solutions into *Solution Groups* …
- Group must meet cross-solution criteria (e.g. plurality) using one of the counting algorithms (collective, distributive, cumulative)

Literal Response

Customer: “Do you have menus?”

Waiter: “Yes!”

Limitations to Current Approach

- *Particular* objects are simple
  - Developer checks truth of facts
  - Solver handles cross-solution criteria (e.g. plurality)
- *General* objects are harder
  - ”I want a steak”, “Do you have menus?”, “I want a well-done ostrich steak”
  - Need to represent something akin to the *referring expression* to manipulate *general object*

Introducing “Concepts”

- Previously: Perplexity only had *particular* objects
  - Individuals like: menu1, menu2
  - General notion of “lunch menu I saw last time” unrepresentable
- Now: *General* objects represented by “Concept” object
  - Represents something akin to a referring expression
  - Opaque to the solver
  - Implementation is app specific
- Solver records (but does not check) Concept cross-solution constraints
  - Developer must check cross-solution constraints based on interpretation
  - E.g. “Do you have menus?”
    - Developer must check if there are enough menus to give the customer
    - Party of 1 only needs 1 menu (even though they said “menus”)

“Do you have [particular or general] menus?”

Create two _menu_n_1 interpretations:

- _menu_n_1_instances: “menu1”, “menu2”, etc.
- _menu_n_1_concepts: yields a single object: Concept(“menu”)

“Do you have [particular or general] menus?”

Create two _menu_n_1 interpretations:

- _menu_n_1_instances: “menu1”, “menu2”, etc.
- _menu_n_1_concepts: yields a single object: Concept(“menu”)

Create all the needed _have_v_1 interpretations:

- _have_v_1_particular_literal(e2, x3, x8): “is x3 holding/carrying a menu?”
- _have_v_1_general_pragmatic (e2, x3, x8): “give me a menu.”
- etc.

“Do you have [particular or general] menus?”

Create two _menu_n_1 interpretations:

- _menu_n_1_instances: “menu1”, “menu2”, etc.
- _menu_n_1_concepts: yields a single object: Concept(“menu”)

Create all the needed _have_v_1 interpretations:

- _have_v_1_particular_literal(e2, x3, x8): “is x3 holding/carrying a menu?”
- _have_v_1_general_pragmatic (e2, x3, x8): “give me a menu.”
- etc.

Because it doesn’t know which interpretation is meant, the solver tries all combinations:

- ~~pronoun_q(x3,pron(x3),udef_q(x8,_menu_n_1_concepts(x8), _have_v_1_particular_literal(e2,x3,x8)))~~
- pronoun_q(x3,pron(x3),udef_q(x8,_menu_n_1_instances(x8), _have_v_1_ particular_literal(e2,x3,x8)))
- pronoun_q(x3,pron(x3),udef_q(x8,_menu_n_1_concepts(x8), _have_v_1_general_pragmatic(e2,x3,x8)))
- ~~pronoun_q(x3,pron(x3),udef_q(x8,_menu_n_1_instances(x8), _have_v_1_general_pragmatic(e2,x3,x8)))~~

Which runs first is context dependent.

First success wins!

[Demo] “Having Menus” Interpretations

_have_v_1(e2, x3, x8)

The solver generates all combinations of values for x3 and x8:

X3	x8
Concept(you)	Concept(menu)
Concept(you)	menu1
Person1	Concept(menu)
Person1	menu1

Every combination is tried with each interpretation of _have_v_1 (in an order based on context):

Interpretation	Phrase
_have_v_1_order	I will have a [general] menu
_have_v_1_request_order	Do you have a [general] menu?
_have_v_1_request_order (special case)	Do you have any [general] vegetarian items?
_have_v_1_fact_check	Do I have a [particular] menu?
_have_v_1_able	Can I have a [general] menu?

[Demo] “Having Menus” Interpretations

_have_v_1(e2, x3, x8)

The solver generates all combinations of values for x3 and x8:

X3	x8
Concept(you)	Concept(menu)
Concept(you)	menu1
Person1	Concept(menu)
Person1	menu1

Every combination is tried with each interpretation of _have_v_1 (in an order based on context):

Interpretation	Phrase	Pragmatic Behavior	Literal (for reference)
_have_v_1_order	I will have a [general] menu	“Give me a menu”	“OK! Let me know when.”
_have_v_1_request_order	Do you have a [general] menu?	“Give me (maybe us) a menu”	“Yes”
_have_v_1_request_order (special case)	Do you have any [general] vegetarian items?	“Describe the list of vegetarian dishes”	“Yes”
_have_v_1_fact_check	Do I have a [particular] menu?	“Yes”	“Yes”
_have_v_1_able	Can I have a [general] menu?	“Give me a menu”	“Yes”

Implementing Interpretations

Particular and General, Literal and Pragmatic

The English Restaurant Concept Object

- State stored as triples: *(“object”, “relationship”, “target”)*
  (”soup”, “on”, “menu”)
  (“salmon”, “isAdj”, “grilled”)
- Concept has criteria: e.g. Concept(”my menu”)
  (object, “is”, “menu”)
  &
  (“person1”, “has”, object)
- Operations:
  - List all individuals that meet criteria
  - Concept entails X
    - E.g. “Brunch Menu” entails “Menu”?
    - Prove it “formally” (in very limited cases)
    - .. or *approximate* using induction:
      exhaustively check if all instances of this concept are also instances of X

The English Restaurant Planner

- Hierarchical Task Network (HTN)
- Well researched, simple planner, expressive enough for restaurant
  - Erol, Kutluhan. *Hierarchical task network planning: formalization, analysis, and implementation*. University of Maryland, College Park, 1995.
  - D. Nau, Y. Cao, A. Lotem, and H. Muñoz-Avila. "SHOP: Simple Hierarchical Ordered Planner." In IJCAI-99, pp. 968-973, 1999. Describes SHOP.
  - Georgievski, Ilche, and Marco Aiello. "An overview of hierarchical task network planning." *arXiv preprint arXiv:1403.7426* (2014).
- https://blog.inductorsoftware.com/blog/htnoverview

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

1. Declare required predicates and properties

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

1. Declare required predicates and properties

```
@Predication(vocabulary,
             names=["_have_v_1”],
             phrases={"Let's have a menu":   {'SF': 'comm', 'TENSE': 'pres’,
                                              'MOOD': 'indicative', 'PROG': '–', 'PERF': '–’},
                      "I will have a steak": {'SF': 'prop', 'TENSE': 'fut’,
                                              'MOOD': 'indicative', 'PROG': '–', 'PERF': '–’}})
def _have_v_1_order(context, state, e_introduced, x_actors, x_objects):
    …
```

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

2. “Solution handler” evaluates predication (same as always)
   - Actor is one or more customer individuals
   - Object is a Concept that entails something orderable:
     Food, Drink, Table, Menu, Bill

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

2. “Solution handler” evaluates predication
   - Actor is one or more customer individuals
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@Predication(vocabulary,
             names=["_have_v_1”],
             phrases={"Let's have a menu":   {'SF': 'comm', 'TENSE': 'pres’,
                                              'MOOD': 'indicative', 'PROG': '–', 'PERF': '–’},
                      "I will have a steak": {'SF': 'prop', 'TENSE': 'fut’,
                                              'MOOD': 'indicative', 'PROG': '–', 'PERF': '–’}})
def _have_v_1_order(context, state, e_introduced, x_actors, x_objects):
        valid_requests = [ESLConcept("food"), ESLConcept("drink"), ESLConcept("table"),
                          ESLConcept("menu"), ESLConcept("bill"), ESLConcept("check")]
        if is_user_individual(x_actors) and entails_any(x_objects, valid_requests):
                yield state
```

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

3. “Solution group handler” checks cross-solution criteria for group of solutions (“Phase 2”), implements behavior

- Criteria check: Make sure the group has as many as they asked for
- Behavior: Planner attempts to give the customers what they asked for if it is available
- Behavior in general: change state or respond to user

Anatomy of an Interpretation

_have_v_1_order(e, actor, object)

3. “Solution group handler” checks cross-solution criteria for group of solutions (“Phase 2”), implements behavior
    - Criteria check: Make sure the group has as many as they asked for
    - Behavior: Planner attempts to give the customers what they asked for if it is available
    - Behavior in general: change state or respond to user

```
@Predication(vocabulary,
             names=["solution_group__have_v_1”],
             handles_interpretation=[_have_v_1_order])
def _have_v_1_order_group(context, state_list, e_group, x_actor_group, x_object_group):
    # All solutions are a customer individual asking to have something orderable
    final_state = do_plan(context,
                          state_list[0],
                          'satisfy_want’,
                          x_actor_group,
                          x_object_group,
                          min_from_variable_group(x_object_group)) # Planner checks quantification
    if final_state:
        yield [final_state]
```

_have_v_1_request_order(e, actor, object)

Pragmatic ordering via “Do you have …”

1. Required predicates and properties

"Do you have a table?"	{'SF': 'ques', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-'}
"What do you have?"	{'SF': 'ques', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-’}

2. “Solution handler” evaluates predication
   - Actor is the waiter individual
   - Object is a concept that entails something you can ask for:
     Food, Drink, Table, Menu, Bill
3. “Solution group handler” checks cross-solution criteria for group of solutions, implements behavior
   - Criteria check: Make sure the group has as many as they asked for
   - Ask planner to give the customers what they asked for
     - Special case “What do you have?” to give a menu
     - If all requested objects are menu items, give a menu item
     - If all requested objects are specials describe the specials
     - Otherwise: give what was asked for

_have_v_1_fact_check(e, actor, object)

Literal interpretation: Does actor contain/own/carry object?

1. Required predicates and properties

"We have 2 menus"	{'SF': 'prop', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-'}
”Do you have a kitchen?"	{'SF': 'ques', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-’}

2. “Solution handler” evaluates predication
   - Both arguments must be individuals
   - Actor must have a “have” relationship with Object
3. “Solution group handler” checks cross-solution criteria for group of solutions, implements behavior
   - Requires individuals so system can check cross-solution criteria
   - Thus, no custom handler needed
   - Default solution group handler prints: “This is correct” or “That isn’t true”

_have_v_1_able(e, actor, object)

Literal and pragmatic answers to “Can x have y?”

1. Required predicates and properties

”Could I have a steak?”	{'SF': 'ques', 'TENSE': 'tensed', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-'}
“Can I have a steak?”	{'SF': 'ques', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-'}
“Can the salad have nuts?"	{'SF': 'ques', 'TENSE': 'pres', 'MOOD': 'indicative', 'PROG': '-', 'PERF': '-'}

2. “Solution handler” evaluates predication
   - If Actor is a customer: object must be something they can ask for:
     Food, Drink, Table, Menu, Bill
   - Otherwise: True if any instance of Actor “has” Object because that proves it is “able to”
     e.g. ”Can a person have an arm?”
3. “Solution group handler” checks cross-solution criteria for group of solutions , implements behavior
   - If this is a non-wh question, with Actor = customers, then: it is also a request for something
     - Ask planner to give the customers what they asked for
   - Otherwise: literal interpretation: “yes that is true”, etc.

Summary: Interpretations in Perplexity

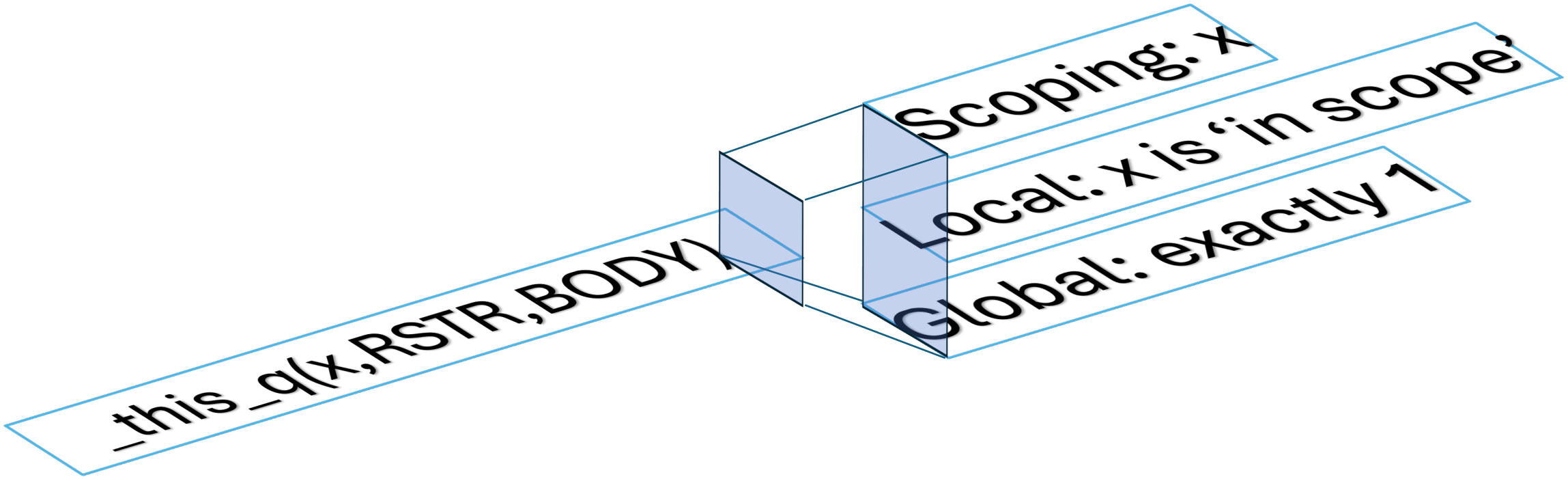
- Support “general” vs. “particular” via the Concept Object
- Support literal and pragmatic interpretations via multiple handlers
- Handlers
  - Phase 1: Solution handlers evaluate predications
    - Declarations indicate required properties and predicates
  - Phase 2: Solution Group handlers checks cross-solution criteria for group of solutions and implement behavior

Appendices

Learnings

- The general public thinks natural language interfaces are everywhere and solved
- People have a hard time talking “naturally” to a computer
  - Especially when typing
  - Especially when they are addressing the computer as a computer
- Natural language can be a drag for frequent/complicated tasks
  - Try pretending to use natural language for something on your file system
- People often group communication into multiple sentences at a time, at least when they are addressing another person
  - “Thanks for the menu! I’ll take the salad. My son will take the salmon”

Predication “Semantic Layers”



* Properties like “NUM” can add global restrictions too …

Predication “Semantic Layers”

Predications can contribute scoping, local or global constraints

Predicate	Scoping	Local	Global
_large_a_1(e,x)	<none>	True for “large” x	<none>
udef_q(x,RSTR,BODY)	x	<none>	<none>
_a_q(x,RSTR,BODY)	x	<none>	Exactly 1
_the_q(x,RSTR,BODY)* *… one of several meanings	x	<none>	1 or more Where all rstr satisfy the body
_this_q(x,RSTR,BODY)	x	True if x is “in scope”* *… among other meanings	Exactly 1
card(CARG,e,x)	<none>	<none>	At least CARG
a_few_a_1(e,x)	<none>	<none>	Between 3 and 5* *top value is debatable
and_c(x,x1,x2)	<none>	<none>	Exactly N where N is total of x1 and x2