Introduction to dynamic semantics

Session 1: Discourse representation theory

Wenkai Tay

21 Jun 2024

taywenkai.com

Outline

Learning outcomes

1. To become comfortable with discourse representation structures
2. To develop some intuitions about plurals and anaphora

Outline

Language as a meaning machine

Agnetha smiled. $\rightarrow$

Static semantics

Agnetha smiled.

Static semantics

$[\![\text{Agnetha smiled.}]\!]$

Static semantics

$[\![\text{Agnetha smiled.}]\!]^M$

M

Static semantics

$[\![\text{Agnetha smiled.}]\!]^M = \text{TRUE}$

M

Static semantics

$[\![\text{Agnetha smiled.}]\!]^M = \text{TRUE}$

M

What is wrong with this picture?

Static semantics vs dynamic semantics

"**Two conceptions of meaning** have dominated formal semantics of natural language.

Static semantics vs dynamic semantics

"**Two conceptions of meaning** have dominated formal semantics of natural language.

- The first of these sees meaning principally as that which determines **conditions of truth**. This notion, whose advocates are found mostly among **philosophers** and **logicians**, has inspired the disciplines of truth-theoretic and model-theoretic semantics.

Static semantics vs dynamic semantics

"**Two conceptions of meaning** have dominated formal semantics of natural language.

- The first of these sees meaning principally as that which determines **conditions of truth**. This notion, whose advocates are found mostly among **philosophers** and **logicians**, has inspired the disciplines of truth-theoretic and model-theoretic semantics.
- According to the second conception meaning is, first and foremost, that which a language user grasps when he understands the words he hears or reads. This second conception is implicit in many studies by **computer scientists** (especially those involved with **artificial intelligence**), **psychologists** and **linguists** –studies which have been concerned to articulate the structure of the **representations which speakers construct in response to verbal inputs**.

Static semantics vs dynamic semantics

- “It appears that **these two conceptions**, and with them the theoretical concerns that derive from them, **have remained largely separated** for a considerable period of time.

Static semantics vs dynamic semantics

- “It appears that **these two conceptions**, and with them the theoretical concerns that derive from them, **have remained largely separated** for a considerable period of time.
- **This separation has become an obstacle** to the development of semantic theory, impeding progress on either side of the line of division it has created.

Static semantics vs dynamic semantics

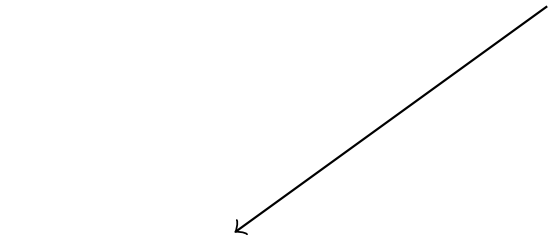
- "It appears that **these two conceptions**, and with them the theoretical concerns that derive from them, **have remained largely separated** for a considerable period of time.
- **This separation has become an obstacle** to the development of semantic theory, impeding progress on either side of the line of division it has created.
- The theory presented here is an attempt to **remove this obstacle**."

(adapted from Kamp 1981)

Outline

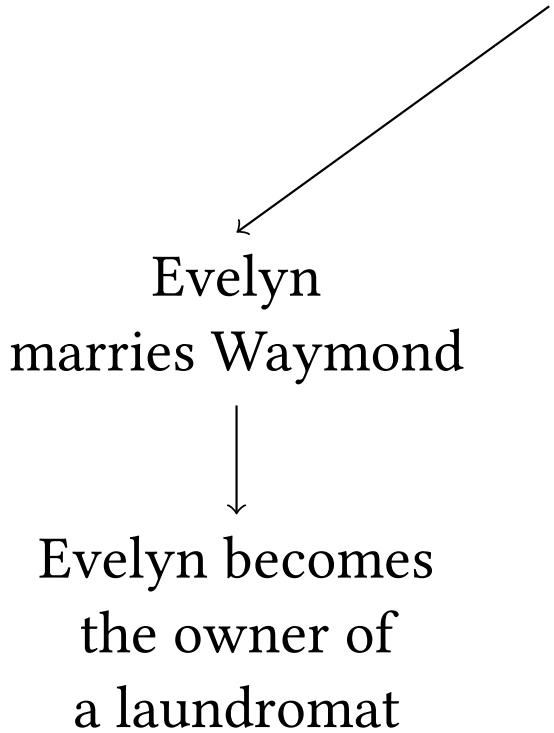
Parallel universes

Parallel universes

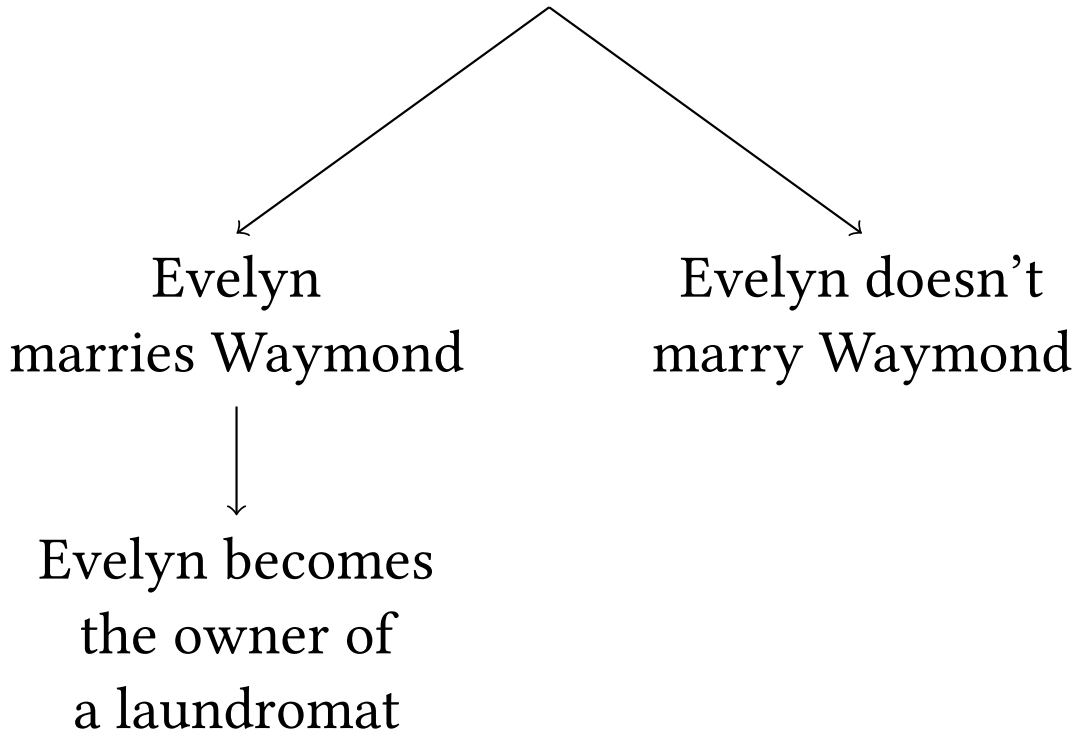


Evelyn
marries Waymond

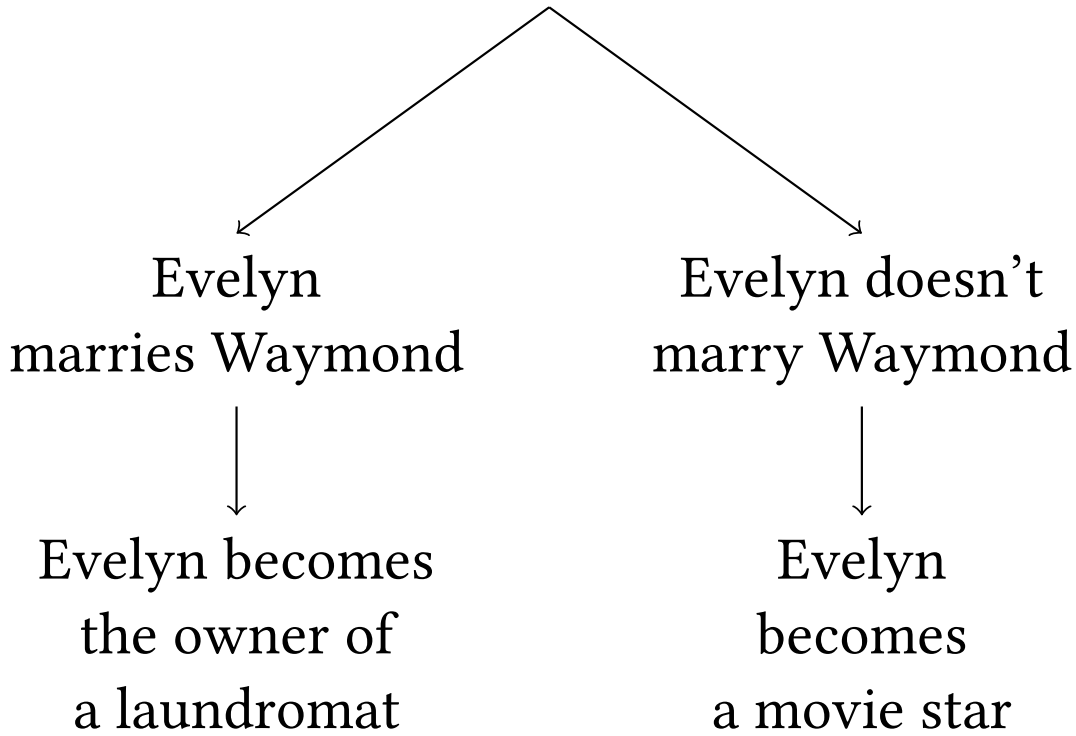
Parallel universes



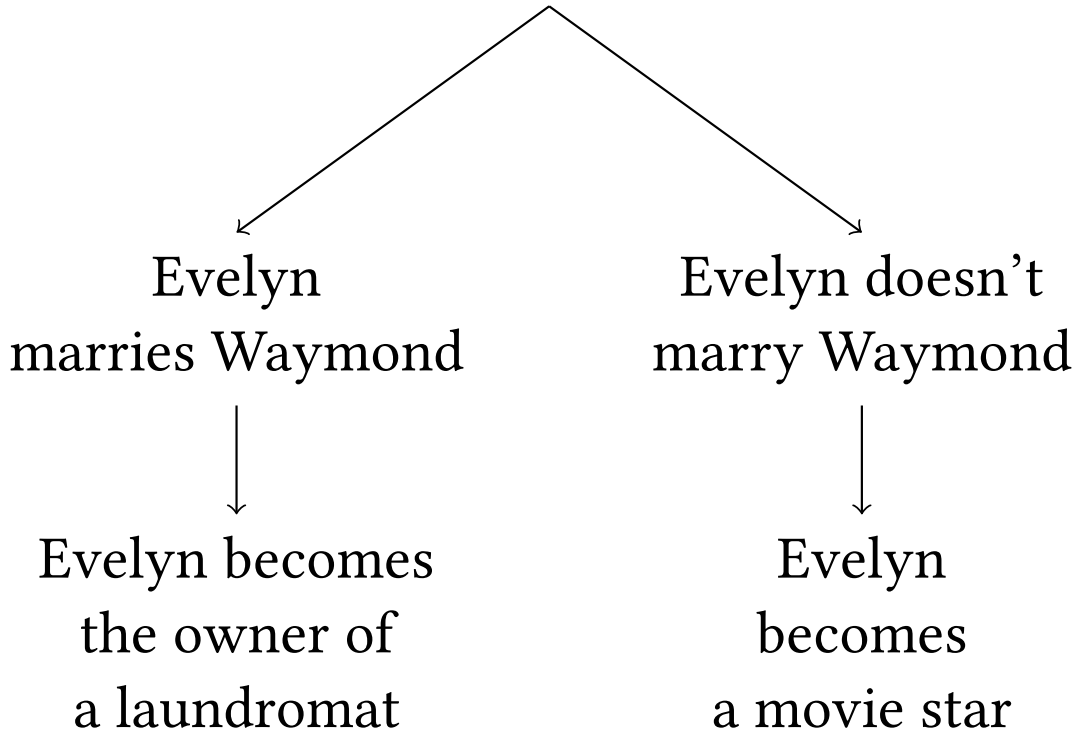
Parallel universes



Parallel universes



Parallel universes



Evelyn's life choices are what determine
which alternate universe she finds herself in.

Parallel universes

1
marries 2 owns a laundromat

2
marries 1 owns a laundromat

3
does not marry 2 becomes a movie star

Parallel universes

1
marries 2 owns a laundromat

2
marries 1 owns a laundromat

3
does not marry 2 becomes a movie star

w_1

1 = Evelyn

2 = Waymond

3 = Michelle

Parallel universes

1
marries 2 owns a laundromat

2
marries 1 owns a laundromat

3
does not marry 2 becomes a movie star

w_1
1 = Evelyn
2 = Waymond
3 = Michelle

w_2
1 = Michelle
2 = Waymond
3 = Evelyn

Parallel universes

w_1:

1	2	3
Evelyn marries 2 owns a laundromat	Waymond marries 1 owns a laundromat	Michelle does not marry 2 becomes a movie star

Parallel universes

w_1:

1	2	3
Evelyn marries 2 owns a laundromat	Waymond marries 1 owns a laundromat	Michelle does not marry 2 becomes a movie star

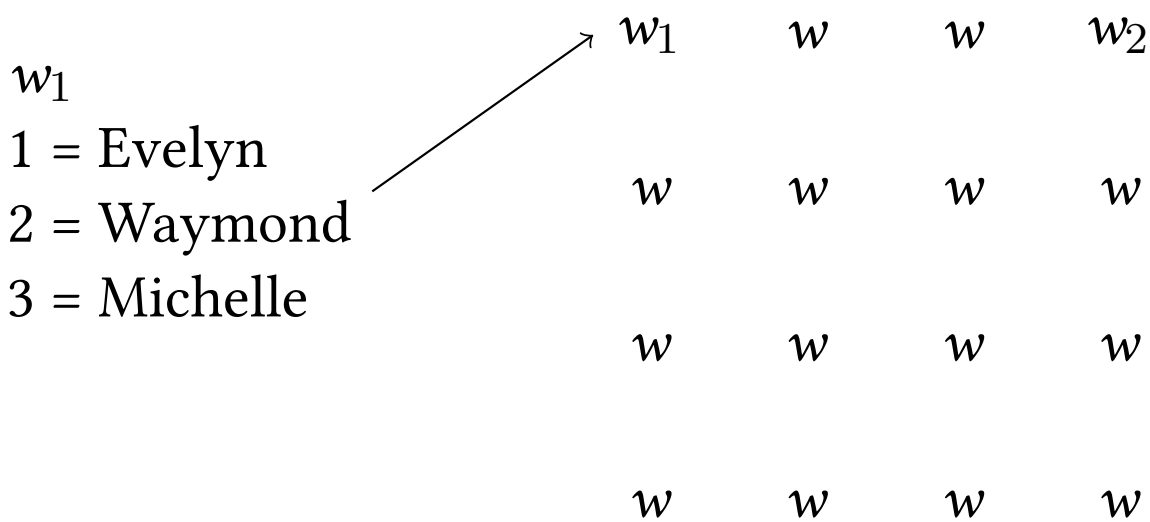
w_2:

1	2	3
Michelle marries 2 owns a laundromat	Waymond marries 1 owns a laundromat	Evelyn does not marry 2 becomes a movie star

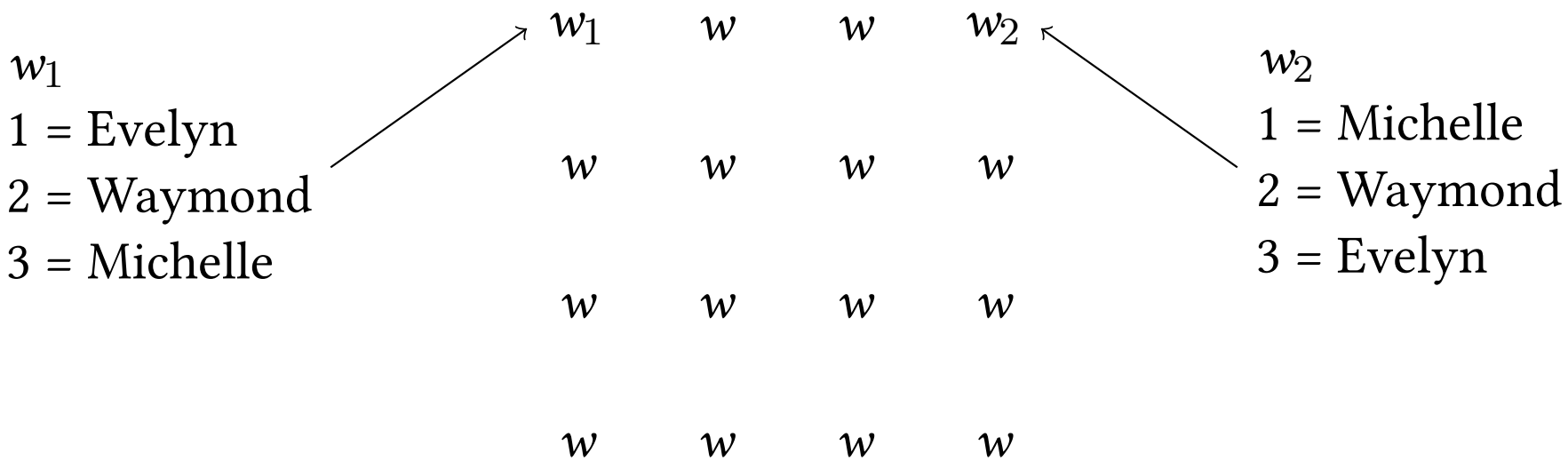
The multiverse

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

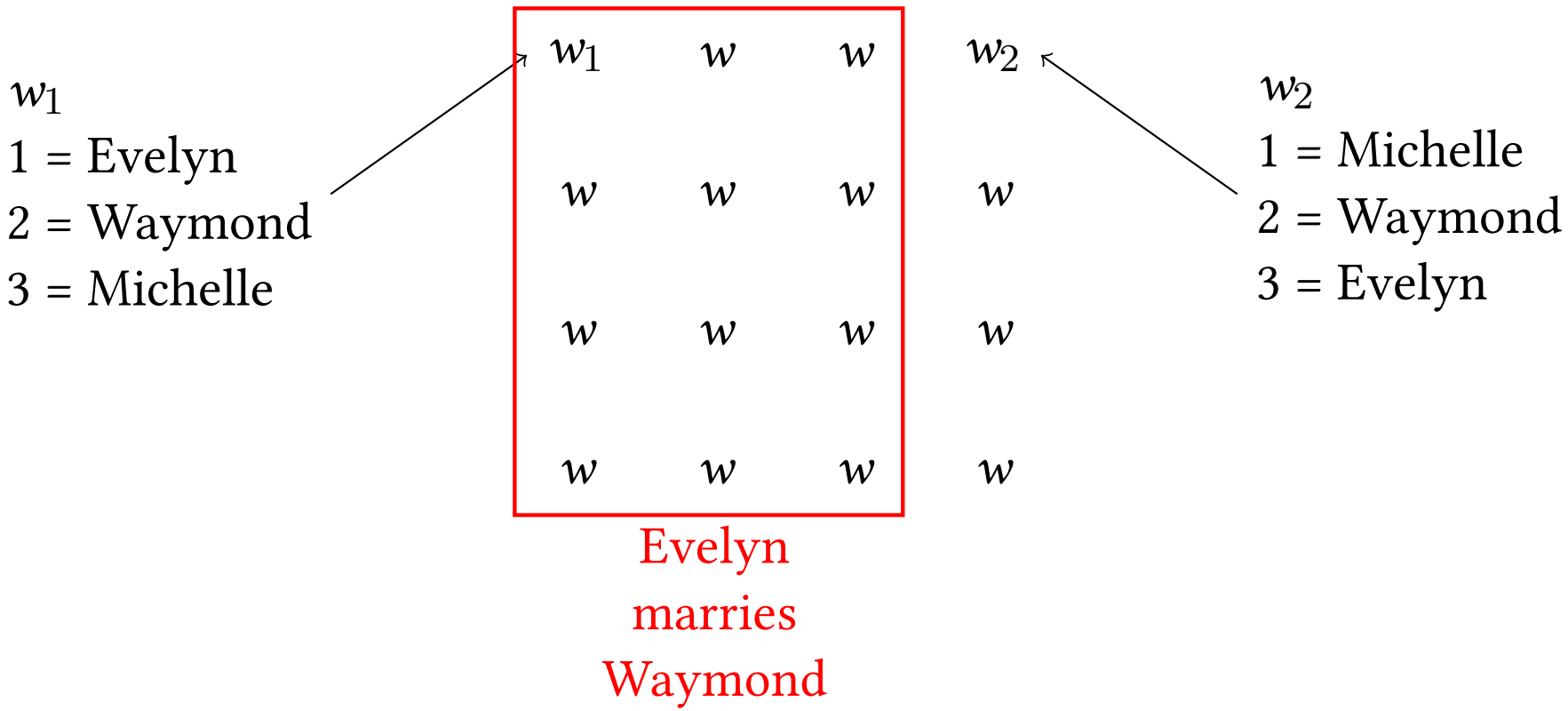
The multiverse



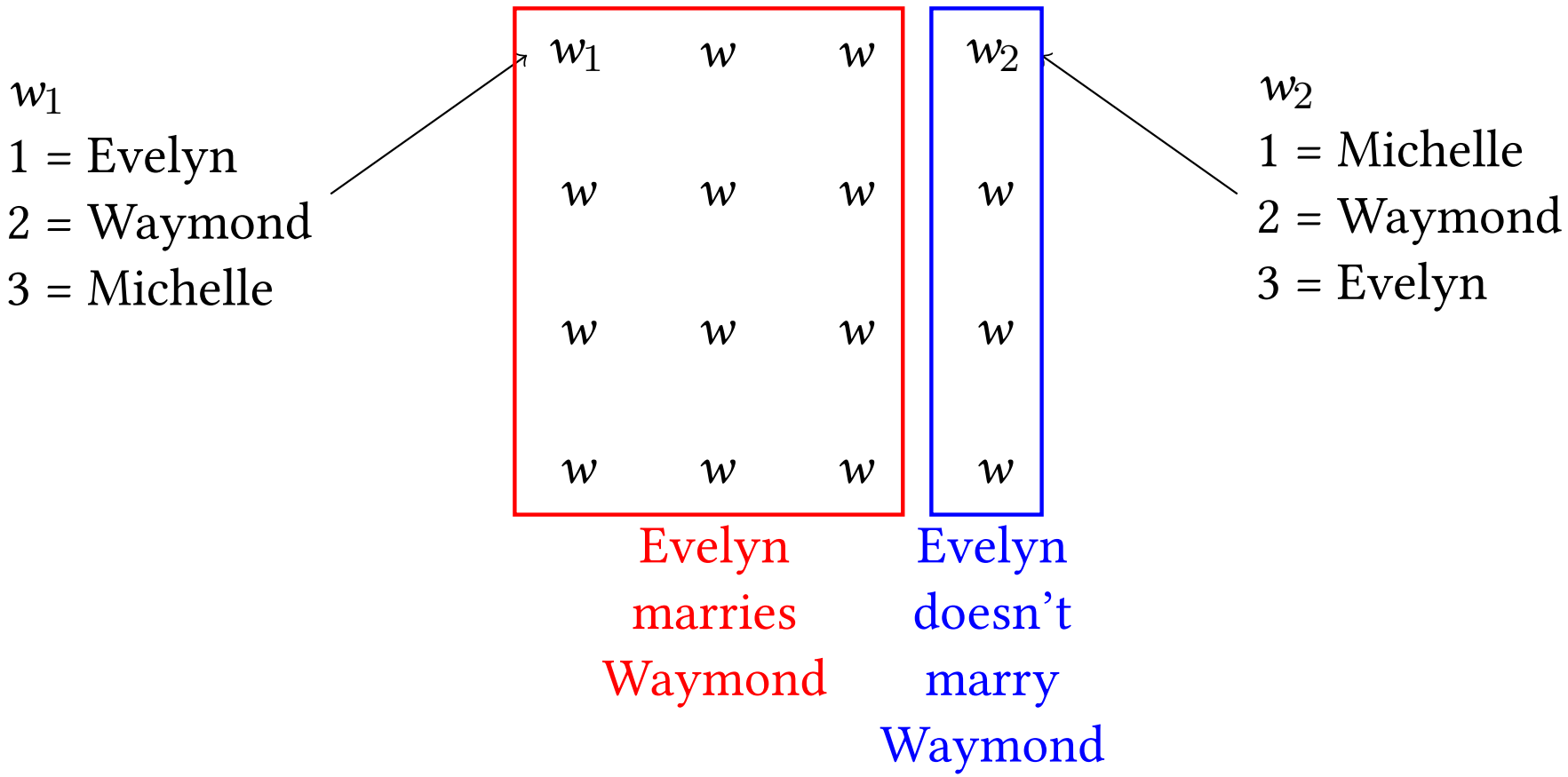
The multiverse



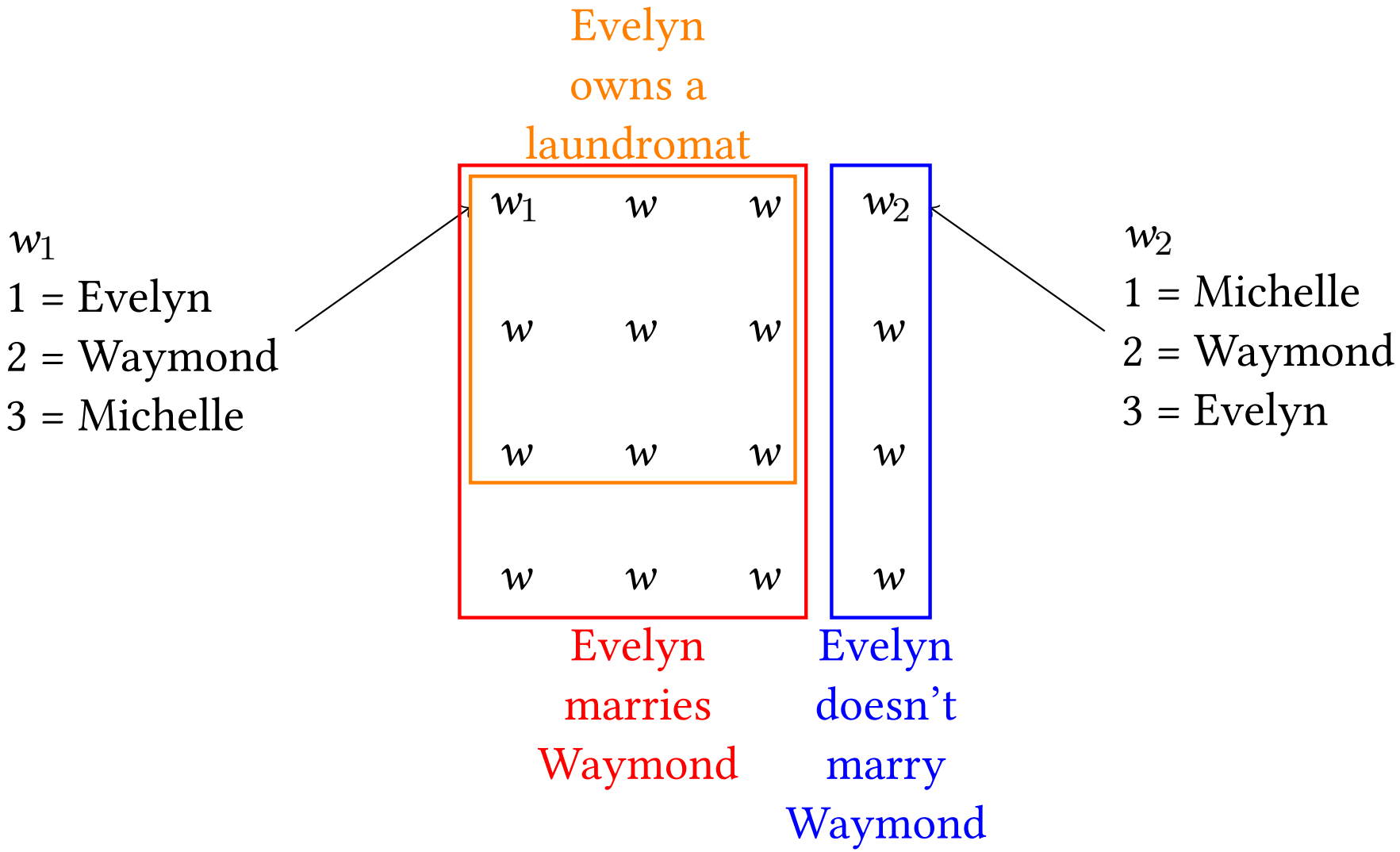
The multiverse



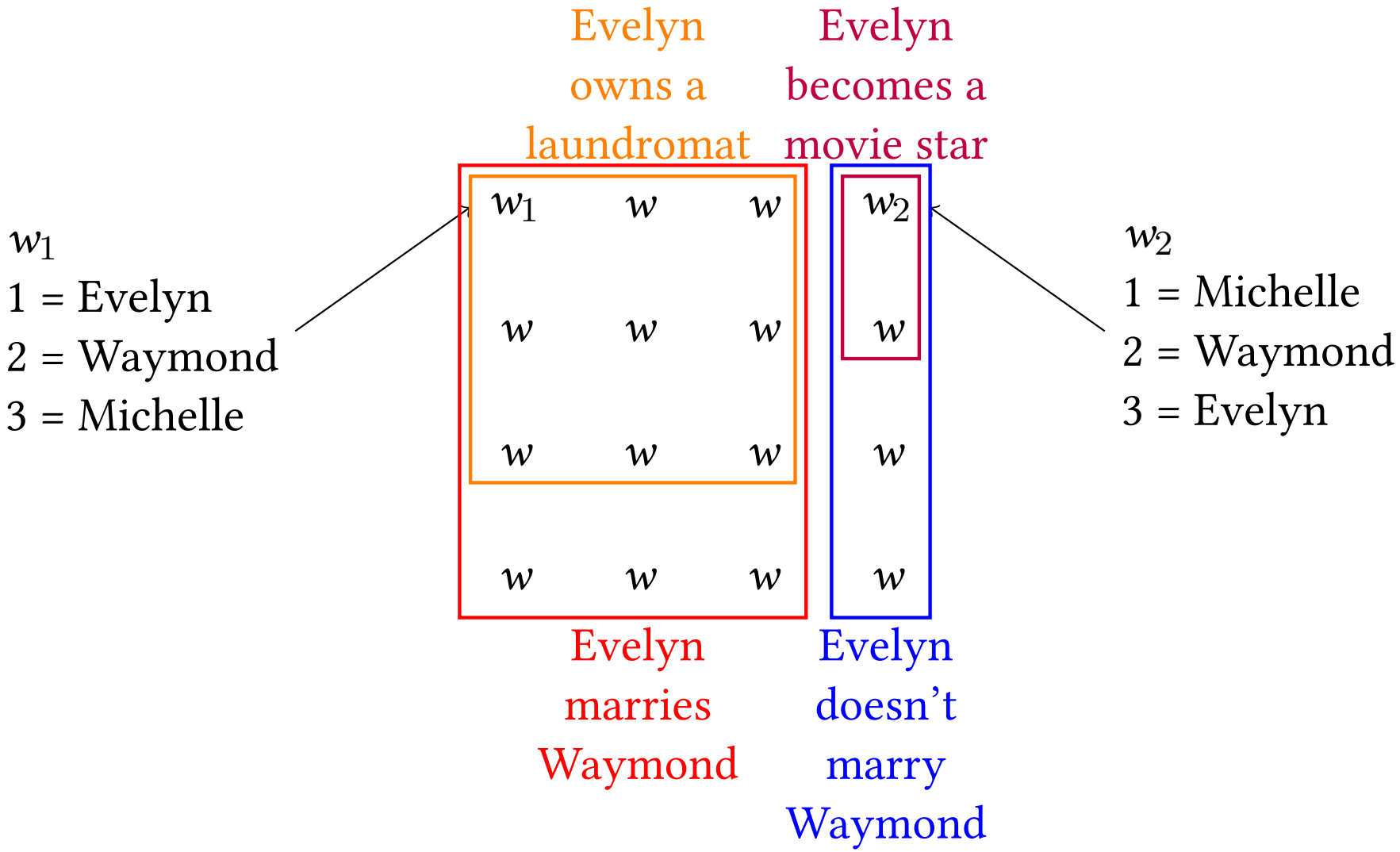
The multiverse



The multiverse



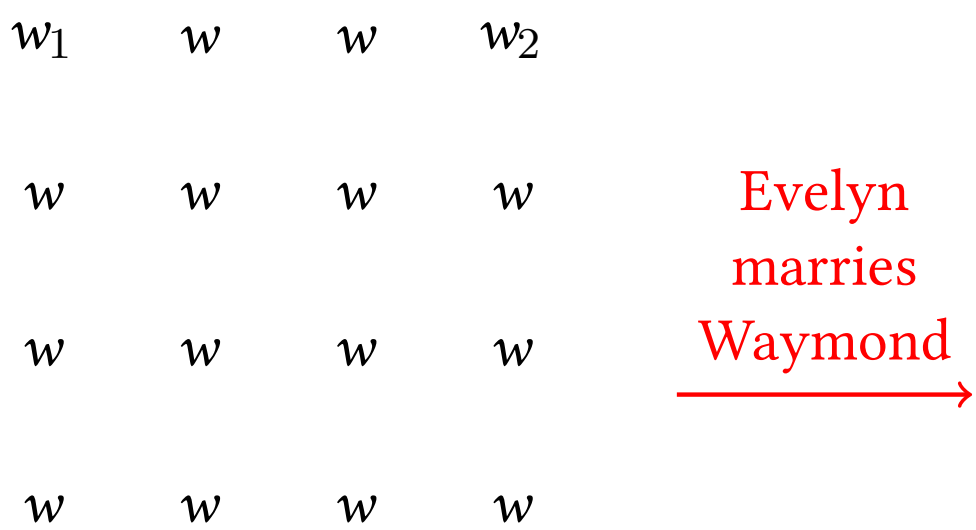
The multiverse



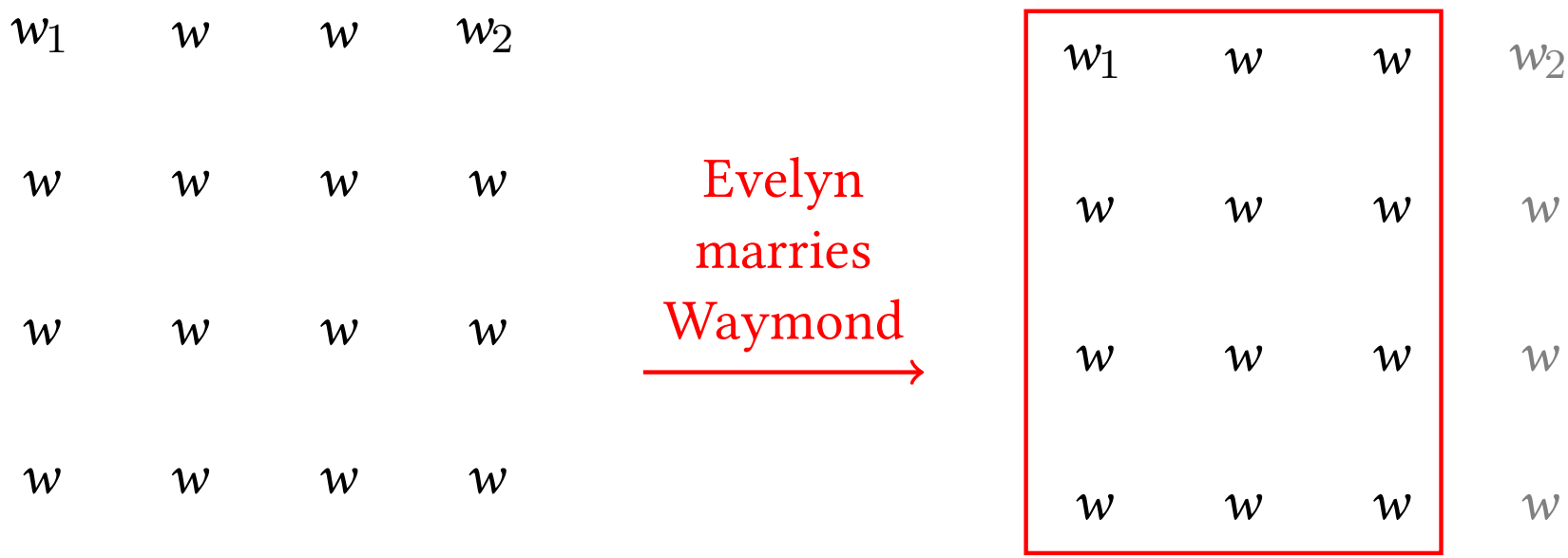
The multiverse

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

The multiverse



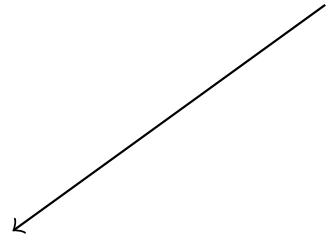
The multiverse



Outline

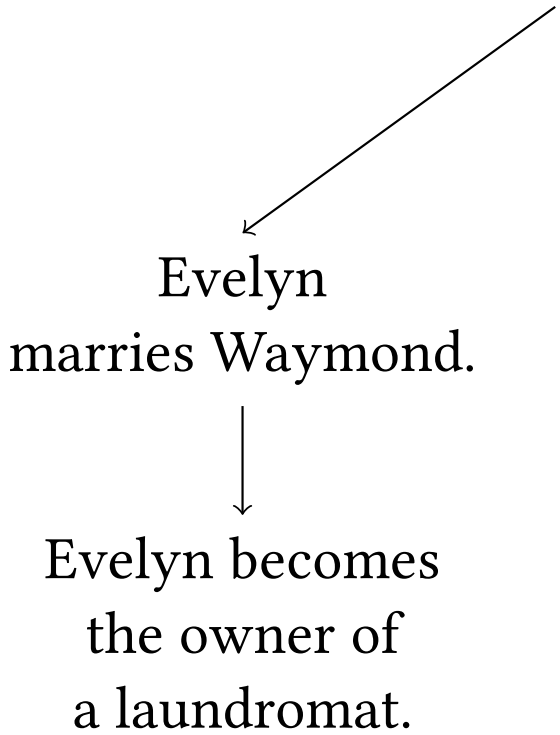
Dynamic semantics

Dynamic semantics

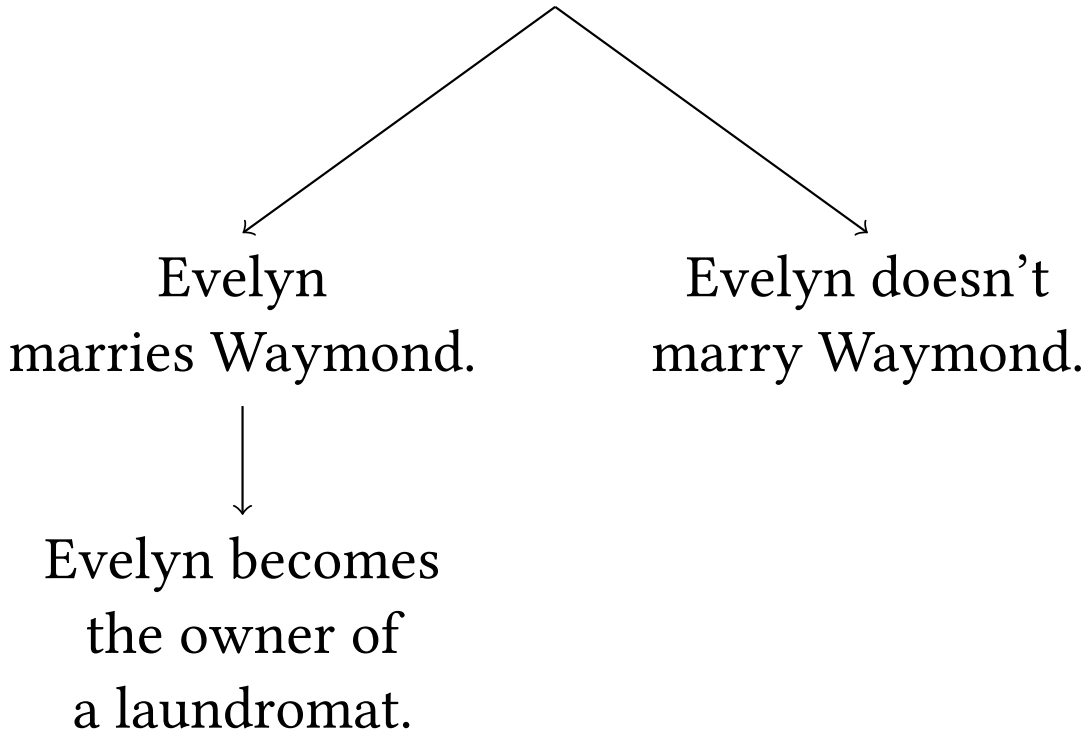


Evelyn
marries Waymond.

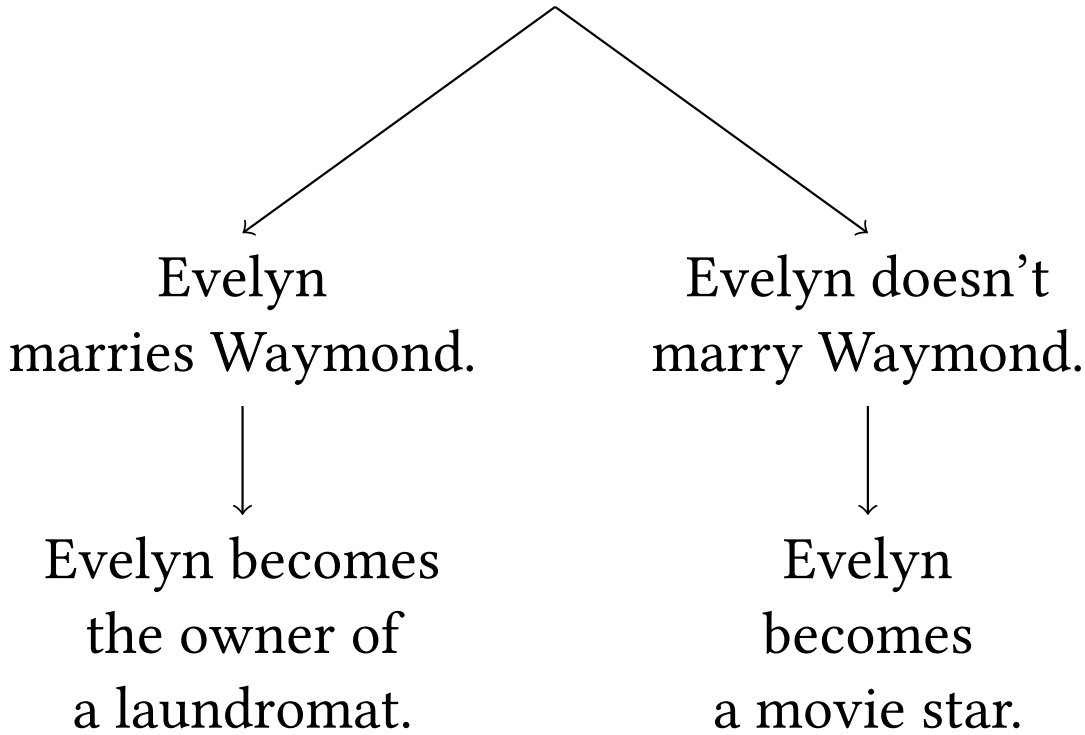
Dynamic semantics



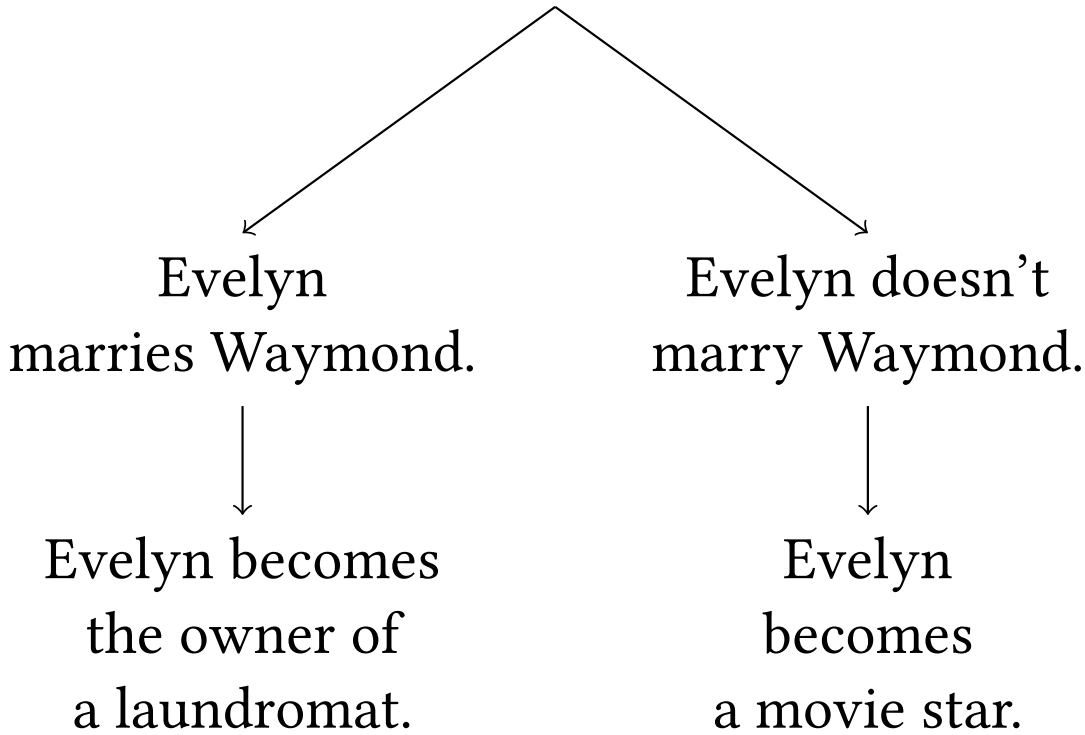
Dynamic semantics



Dynamic semantics



Dynamic semantics



Each sentence takes us to a different possible world.

Dynamic semantics

Each sentence reduces the **context (set)** = the set of possible worlds.

w w w w

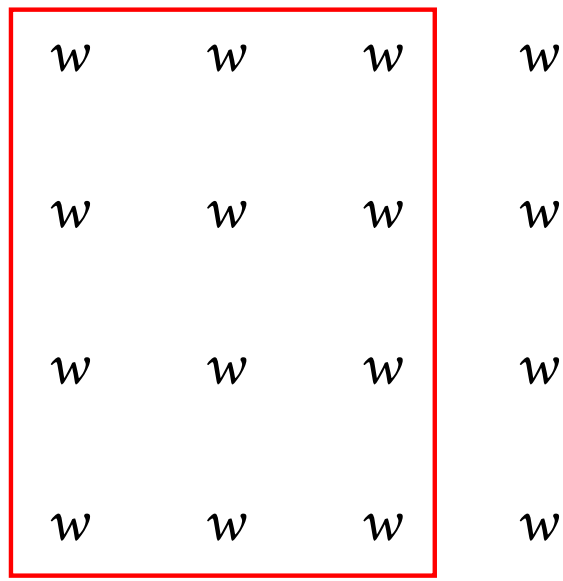
w w w w

w w w w

w w w w

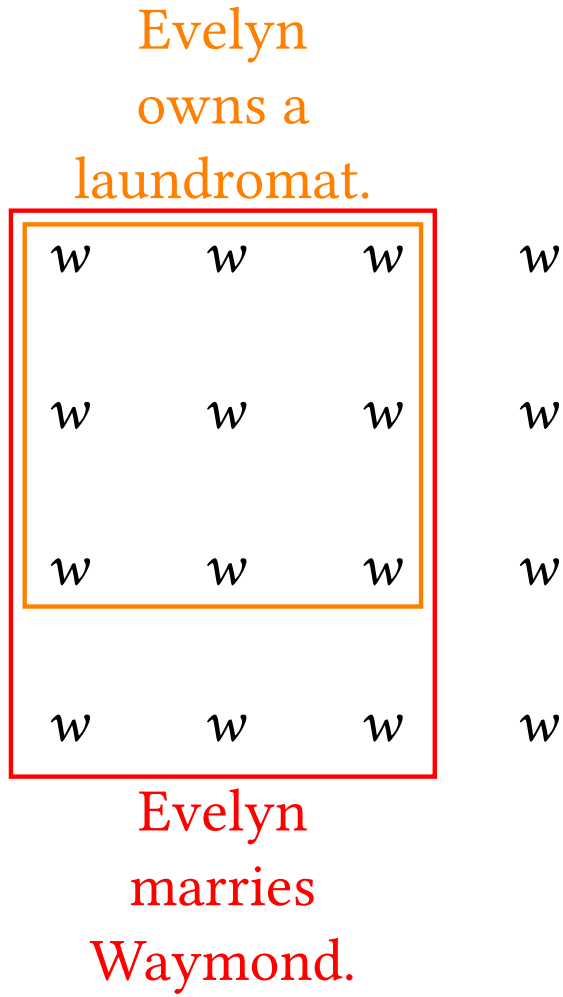
Dynamic semantics

Each sentence reduces the **context (set)** = the set of possible worlds.



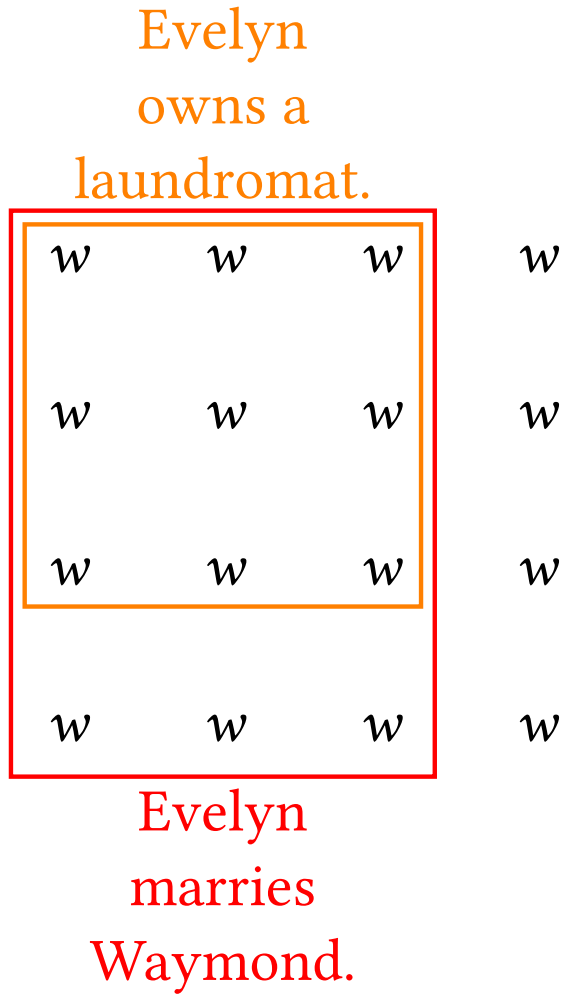
Dynamic semantics

Each sentence reduces the **context (set)** = the set of possible worlds.



Dynamic semantics

Each sentence reduces the **context (set)** = the set of possible worlds.



A sentence has the potential to change / update the context.

The multiverse

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

The multiverse

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

Evelyn marries Waymond. →

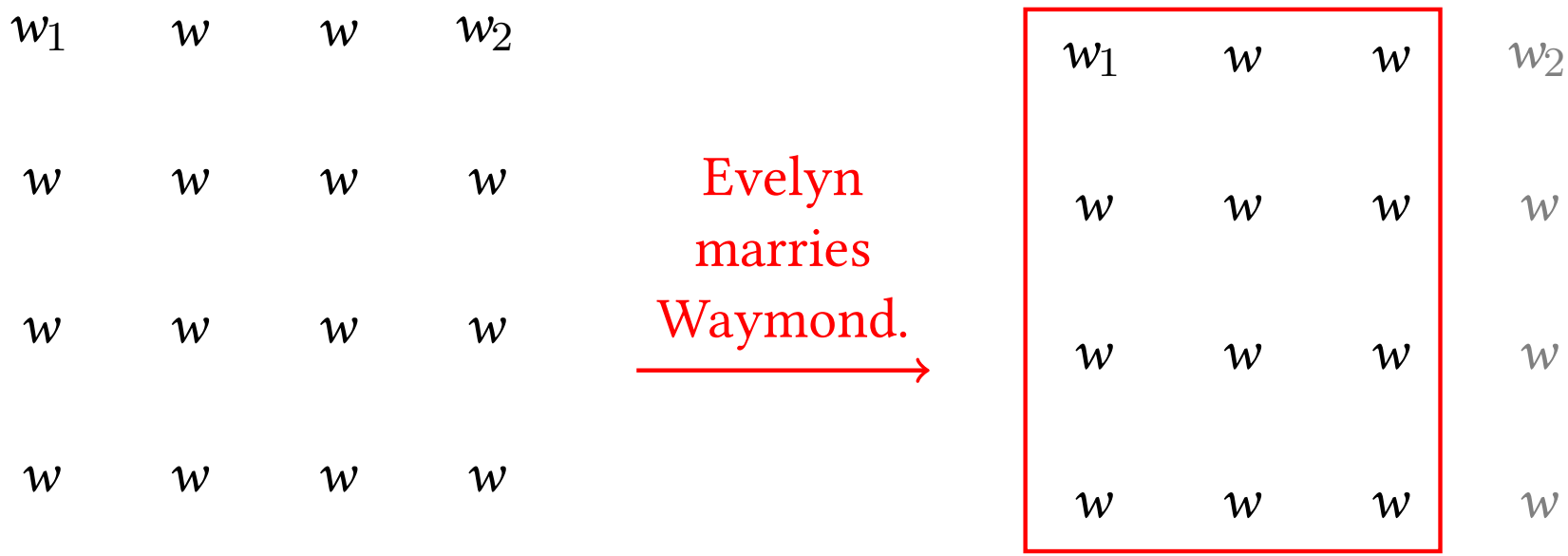
The multiverse

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

Evelyn marries Waymond. →

w_1	w	w	w_2
w	w	w	w
w	w	w	w
w	w	w	w

The multiverse



A sentence is a function that takes us from one context to another.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

- "Consider a device designed to **read a text in some natural language**, interpret it, and store the content in some manner, say, for the purpose of being able to **answer questions about it**.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

- "Consider a device designed to **read a text in some natural language**, interpret it, and store the content in some manner, say, for the purpose of being able to **answer questions about it**.
- To accomplish this task, the machine will have to fulfill at least the following basic requirement. It has to be able to **build a file that consists of records of all the individuals**, that is, events, objects, etc., mentioned in the text, and, **for each individual, record whatever is said about it**.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

- "Consider a device designed to **read a text in some natural language**, interpret it, and store the content in some manner, say, for the purpose of being able to **answer questions about it**.
- To accomplish this task, the machine will have to fulfill at least the following basic requirement. It has to be able to **build a file that consists of records of all the individuals**, that is, events, objects, etc., mentioned in the text, and, **for each individual, record whatever is said about it**.
- Of course, for the time being at least, it seems that such a text interpreter is not a practical idea, but this should not discourage us from studying in abstract what kind of capabilities the machine would have to possess..."

(adapted from Karttunen 1976)

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

(1) Evelyn marries Waymond.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

(1) Evelyn marries Waymond.

1
Evelyn marries 2

2
Waymond marries 1

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

(1) Evelyn marries Waymond.

1
Evelyn marries 2

2
Waymond marries 1

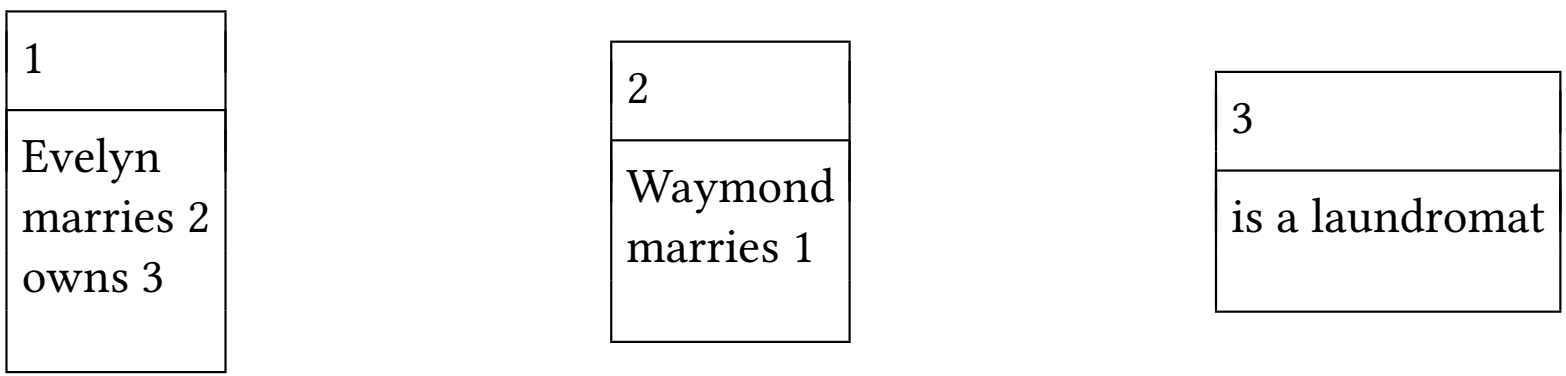
(2) Evelyn owns a laundromat.

Dynamic semantics

Sentences introduce **discourse referents** and **conditions** on these drefs.

(1) Evelyn marries Waymond.

(2) Evelyn owns a laundromat.



Dynamic semantics

The contribution of a sentence can be represented as a **discourse representation structure (DRS)**.

A DRS combines multiple cards into one.

Dynamic semantics

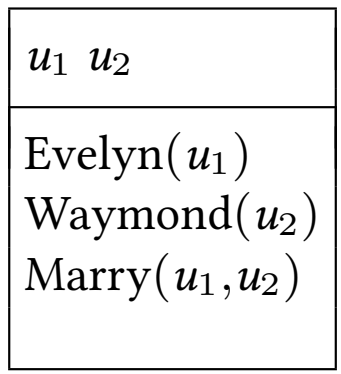
The contribution of a sentence can be represented as a **discourse representation structure (DRS)**.
A DRS combines multiple cards into one.

(3) Evelyn marries Waymond.

Dynamic semantics

The contribution of a sentence can be represented as a **discourse representation structure (DRS)**.
A DRS combines multiple cards into one.

(3) Evelyn marries Waymond.



Dynamic semantics

The contribution of a sentence can be represented as a **discourse representation structure (DRS)**.
A DRS combines multiple cards into one.

(3) Evelyn marries Waymond.

u_1 u_2
Evelyn(u_1) Waymond(u_2) Marry(u_1, u_2)

(4) Evelyn owns a laundromat.

Dynamic semantics

The contribution of a sentence can be represented as a **discourse representation structure (DRS)**.
A DRS combines multiple cards into one.

(3) Evelyn marries Waymond.

u_1 u_2
Evelyn(u_1) Waymond(u_2) Marry(u_1, u_2)

(4) Evelyn owns a laundromat.

u_3
Laundromat(u_3) Own(u_1, u_3)

Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

(5) Evelyn marries Waymond. Evelyn owns a laundromat.

Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

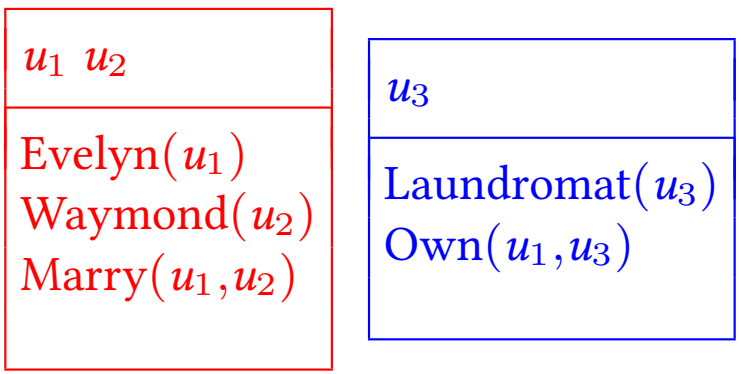
(5) Evelyn marries Waymond. Evelyn owns a laundromat.

u_1 u_2
Evelyn(u_1) Waymond(u_2) Marry(u_1,u_2)

Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

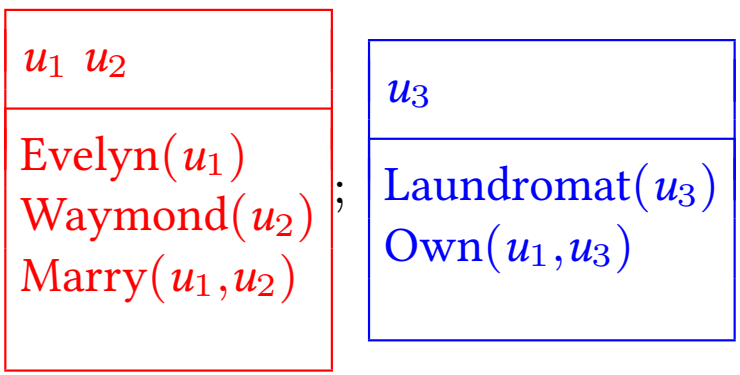
(5) Evelyn marries Waymond. Evelyn owns a laundromat.



Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

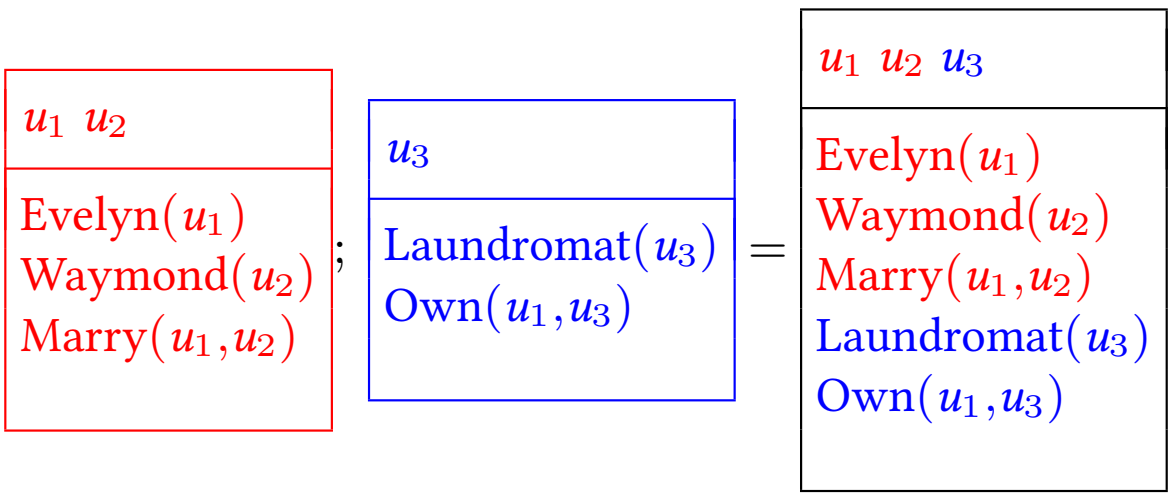
(5) Evelyn marries Waymond. Evelyn owns a laundromat.



Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

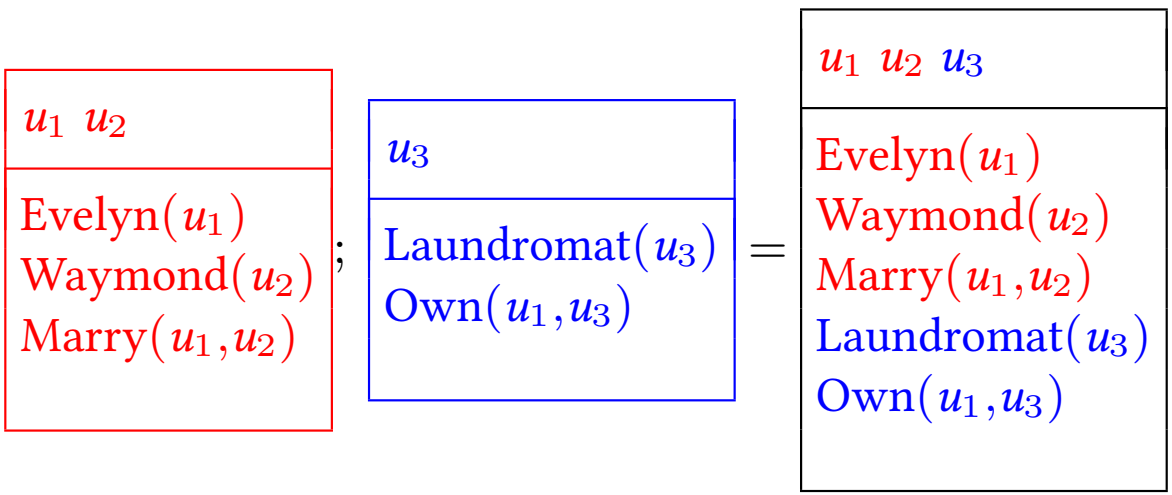
(5) Evelyn marries Waymond. Evelyn owns a laundromat.



Dynamic semantics

DRSs can be combined using **dynamic conjunction** (;).

(5) Evelyn marries Waymond. Evelyn owns a laundromat.

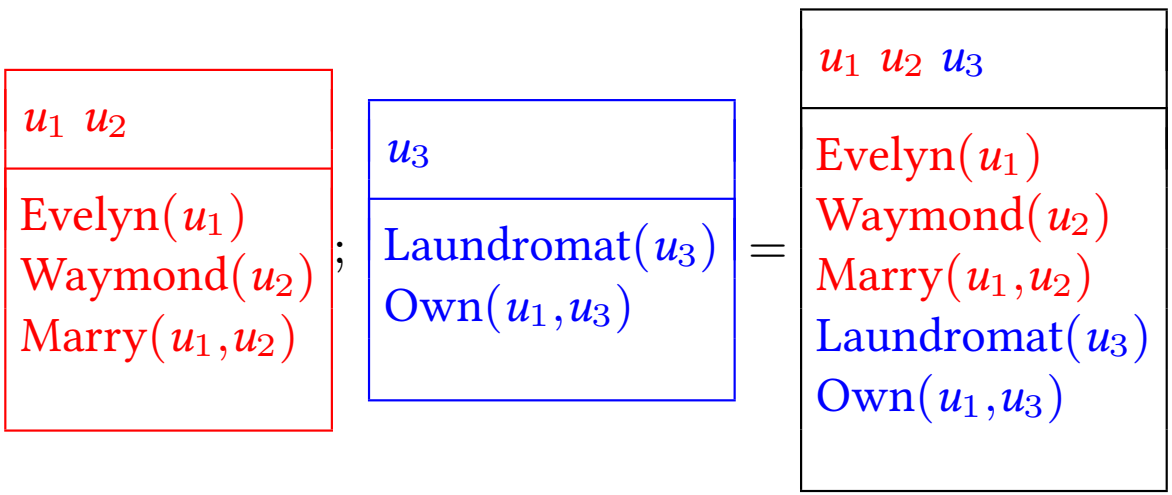


Q: Does Evelyn in the second sentence introduce its own dref?

Dynamic semantics

DRSs can handle **cross-sentential anaphora**.

(6) Evelyn$_1$ marries Waymond. She^1 owns a laundromat.



A programming analogy

```
x = 3;
y = x + 2;
```

Dynamic semantics

Myth: DRSs are nothing more than pretty pictures.

Dynamic semantics

Myth: DRSs are nothing more than pretty pictures.
Fact: DRSs can be made fully compositional.

Dynamic semantics

Myth: DRSs are nothing more than pretty pictures.
Fact: DRSs can be made fully compositional.

Myth: Dynamic semantics is only useful for discourse analysis.

Dynamic semantics

Myth: DRSs are nothing more than pretty pictures.
Fact: DRSs can be made fully compositional.

Myth: Dynamic semantics is only useful for discourse analysis.
Fact: Dynamic semantics was originally developed to tackle problems with reference and anaphora *within* sentences.

Module outline

Outline

Practice: single sentences

(7) Evelyn is an Asian woman.

(8) Waymond is a kind man who loves Evelyn.

(9) A farmer owns a donkey.

Practice: multiple sentences

(10) Evelyn is a woman. She is Asian.

(11) Waymond is a kind man. He loves Evelyn.

(12) A farmer owns a donkey. He loves it.

Practice: negation & embedding

(13) Joy does not like Evelyn.

(14) Evelyn thinks that Joy hates her.

Summary

Summary

- The “meaning” of a sentence is its **potential to update the context**.

Summary

- The "meaning" of a sentence is its **potential to update the context**.
- The contribution of a sentence can be represented as a **discourse representation structure** (DRS): discourse referents and conditions on drefs.

Summary

- The "meaning" of a sentence is its **potential to update the context**.
- The contribution of a sentence can be represented as a **discourse representation structure** (DRS): discourse referents and conditions on drefs.
- DRSs can be combined using **dynamic conjunction** (;).

Summary

- The "meaning" of a sentence is its **potential to update the context**.
- The contribution of a sentence can be represented as a **discourse representation structure** (DRS): discourse referents and conditions on drefs.
- DRSs can be combined using **dynamic conjunction** (;).
- DRSs can handle **cross-sentential anaphora**.

Suggested reading

1. Coppock and Champollion (2023) ch 9
2. Karttunen (1976)
3. Kamp (1981)
4. Heim (1982)

References I

Coppock, Elizabeth, and Lucas Champollion. 2023. *Invitation to formal semantics*. Ms. https://eecoppock.info/bootcamp/semantics-boot-camp.pdf.

Heim, Irene. 1982. The semantics of definite and indefinite noun phrases. Doctoral dissertation, University of Massachusetts Amherst.

Kamp, Hans. 1981. A theory of truth and semantic representation. In *Formal Methods in the Study of Language*, ed. Jeroen Groenendijk, Theo Janssen, and Martin Stockhof, 277–322. Amsterdam: Mathematical Centre Tracts.

Karttunen, Lauri. 1976. Discourse referents. In *Notes from the Linguistic Underground*, ed. James D. McCawley. New York: Academic Press.

Image credits

- Agnetha Fältskog: Stockholm Pride, CC BY 3.0
- Björn Ulvaeus: Västerviks kommun from Västervik, Sweden, CC BY 2.0

via Wikimedia Commons