Towards machines that mean what they say

Paul Piwek
Centre for Research in Computing
The Open University
Milton Keynes, UK

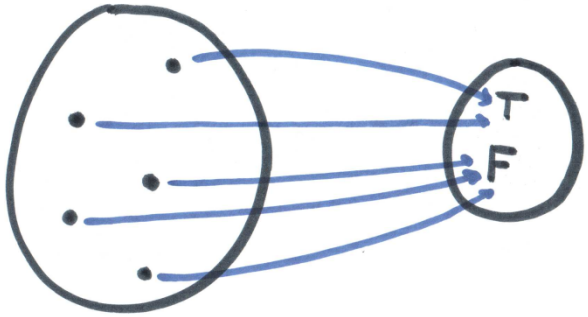
Plan

- The traditional view:
  - Sentence meaning as truth-conditions
  - Speaker meaning as intention (psychological)

- Inferentialist dialogical view:
  - Sentence meaning as inferential practice
  - Speaker meaning as taking responsibility for one's assertions (social)

Truth Conditions & Meaning

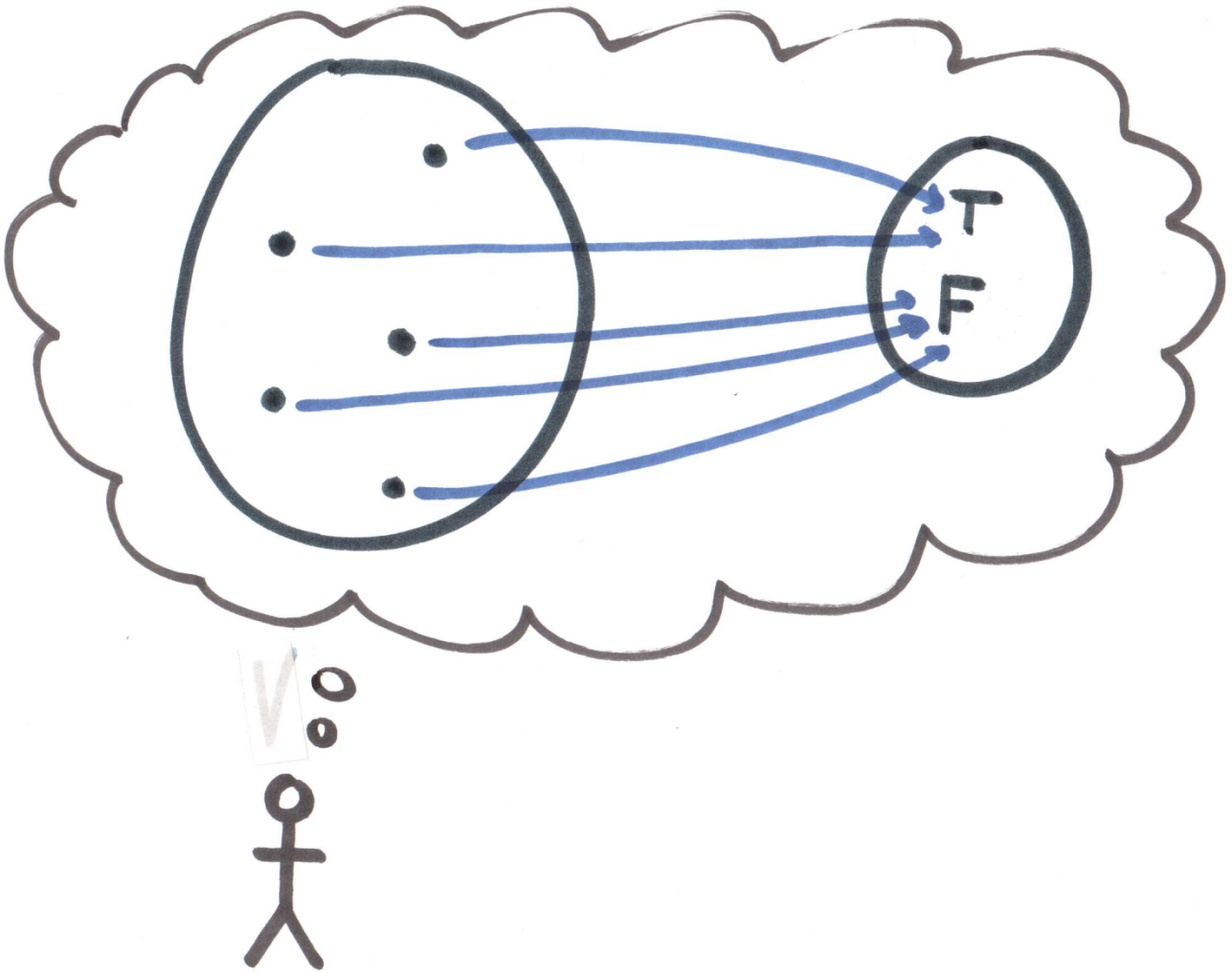
- Underpins formal semantics (Montague, 1974)
- Knowing the meaning of a declarative sentence boils down to being able to tell, given a situation/world, whether that sentence is true or false.



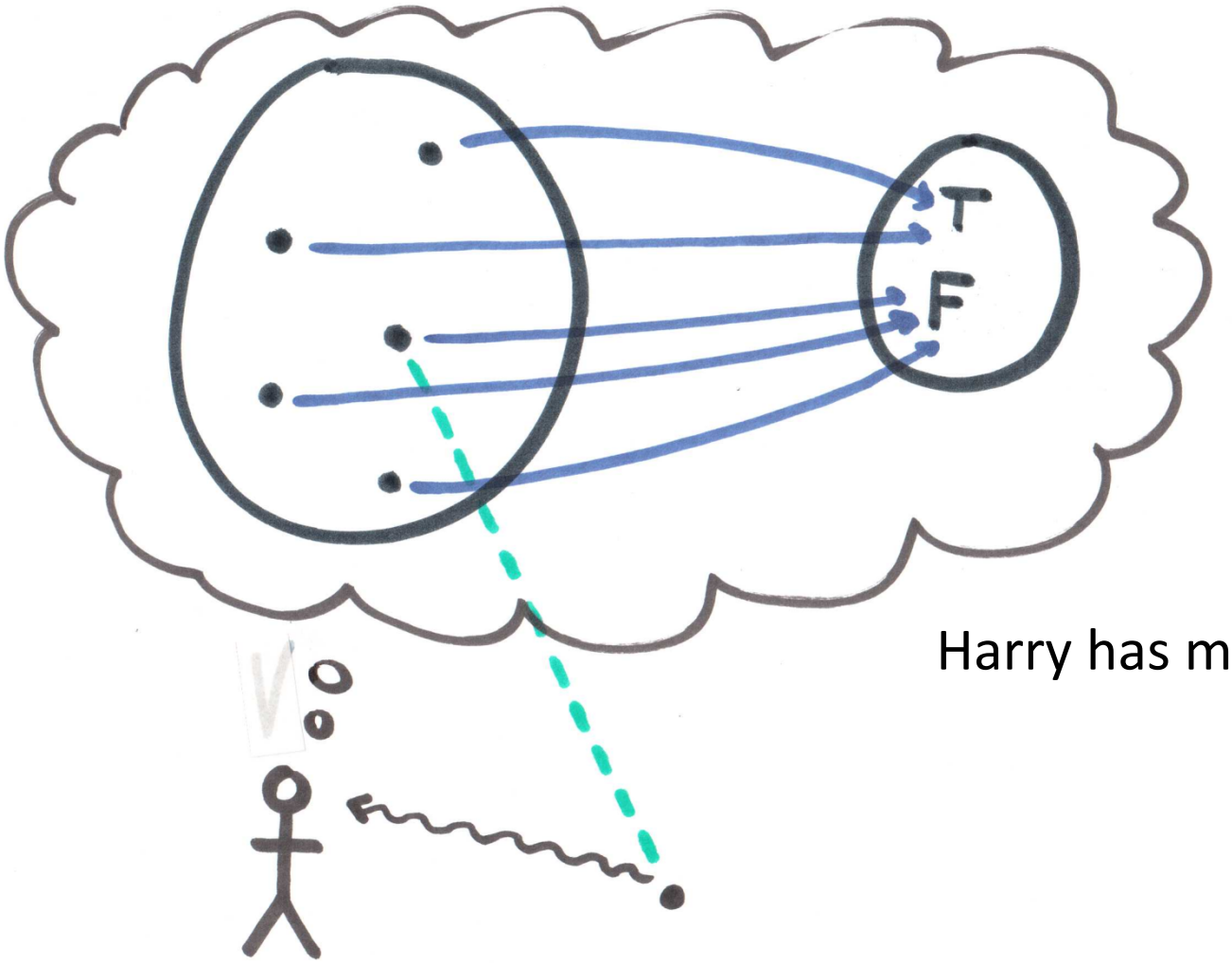
Truth Conditions & Meaning

- The dynamic turn (e.g. Hans Kamp, Irene Heim, Amsterdam School) hasn't really changed this: though the meaning of a sentence is now characterised in terms of its contribution to a discourse representation, the meaning of the latter is still in terms of its 'world-directed, truth-value determining aspect'.

Truth conditions & Perception



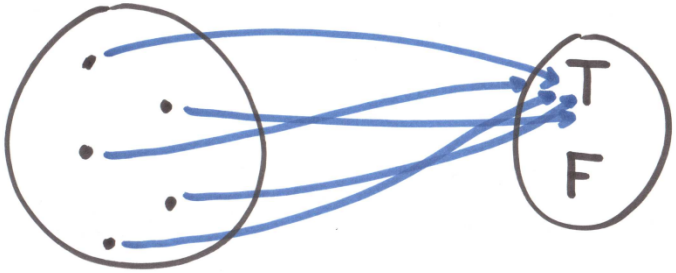
Truth conditions & Perception



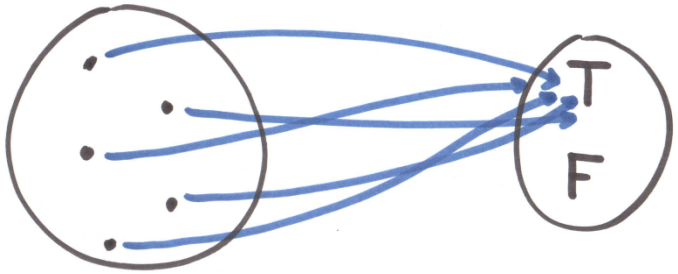
Harry has measles.

Truth conditions & Use

2+2 = 4

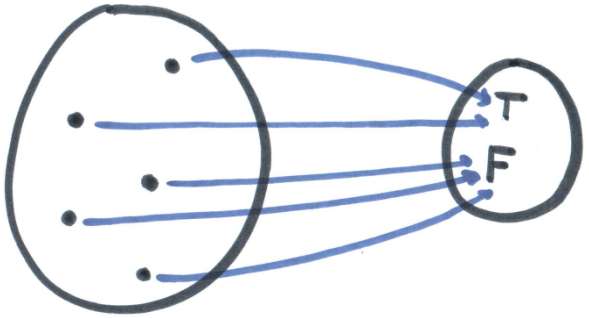


Any effectively generated theory capable of expressing elementary arithmetic cannot be both consistent and complete. In particular, for any consistent, effectively generated formal theory that proves certain basic arithmetic truths, there is an arithmetical statement that is true, but not provable in the theory.



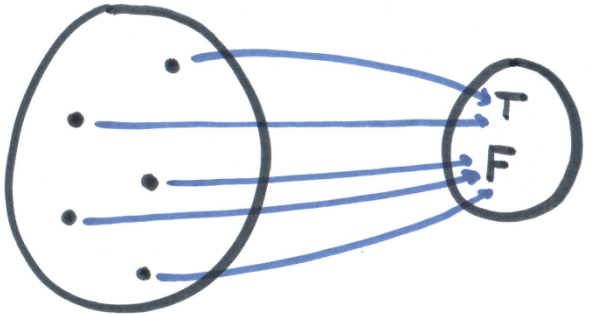
Truth conditions & Use

John sees the Morning star



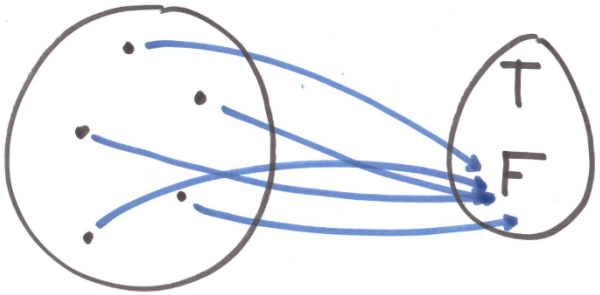
=

John sees the Evening star.



Truth conditions & Use

Phlogiston is released.



Speaker meaning and intention

Natural meaning: “Smoke means fire.”, “A rash means measles”, ...

Non-Natural meaning: “Those three rings on the bell (of the bus) mean that the ‘bus is full.’”

(Grice, 1957)

Speaker meaning and intention

First attempt: '*x* was intended by its utterer to induce a belief in some "audience"'

Problem: "I might leave *B*'s handkerchief near the scene of a murder in order to induce the detective to believe that *B* was the murderer; but we should not want to say that the handkerchief (or my leaving it there) $meant_{NN}$ anything or that I had $meant_{NN}$ by leaving it that *B* was the murderer."

Speaker meaning and intention

(1) I show Mr. X a photograph of Mr. Y displaying undue familiarity to Mrs. X.

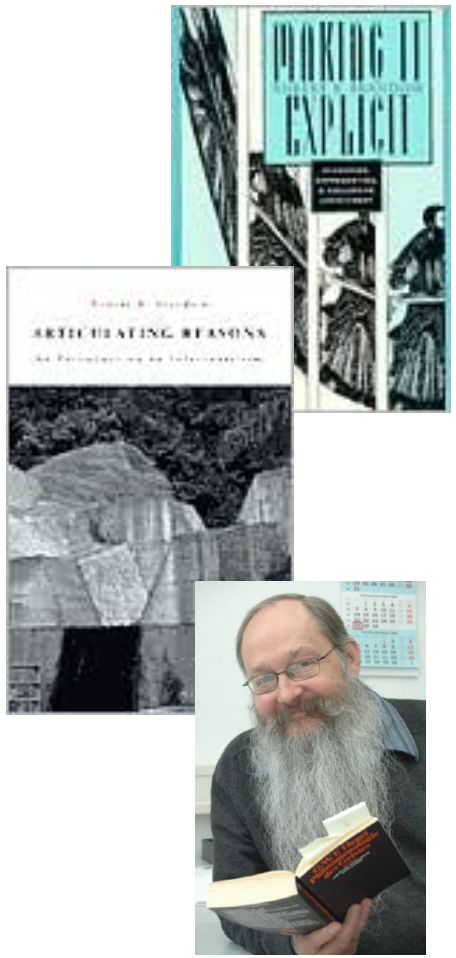
(2) I draw a picture of Mr. Y behaving in this manner and show it to Mr. X

"A uttered *x* with the intention of inducing a belief by means of the recognition of this intention."

A change of the starting point: discursive practices

What practices should someone be able to engage with to count as meaning what they say?

Someone's verbal actions count as meaningful assertions if they are open to scrutiny in a game of giving and asking for reasons.



Brandom (1994, 2000)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like
a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

J: Tweety flies.
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like
a penguin.

(Piwek, 2014; AISB50)

Brandom's discursive practices

Language consists of many games, but the game of giving and asking for reasons is pivotal.

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

Score board recording

- acknowledged public commitments
- challenges

Verbal moves (with pre and postconditions):

- Assertions/denials:
  - pre: new information
  - post: commitment recorded
- Challenges
  - pre: other commitment and challenge not (yet) resolved
  - post: challenge recorded
- Retractions
  - pre: self commitment
  - post: removed

Entry and exit moves

- Observations
- Actions

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

Score board recording

- acknowledged public commitments
- challenges

Verbal moves (with pre and postconditions):

- Assertions/denials:
  - pre: new information
  - post: commitment recorded
- Challenges
  - pre: other commitment and challenge not (yet) resolved
  - post: challenge recorded
- Retractions
  - pre: self commitment
  - post: removed

Entry and exit moves

- Observations
- Actions

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

Score board recording

- acknowledged public commitments
- challenges

Verbal moves (with pre and postconditions):

- Assertions/denials:
  - pre: new information
  - post: commitment recorded
- Challenges
  - pre: other commitment and challenge not (yet) resolved
  - post: challenge recorded
- Retractions
  - pre: self commitment
  - post: removed

Entry and exit moves

- Observations
- Actions

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

Score board recording

- acknowledged public commitments
- challenges

Verbal moves (with pre and postconditions):

- Assertions/denials:
  - pre: new information
  - post: commitment recorded
- Challenges
  - pre: other commitment and challenge not (yet) resolved
  - post: challenge recorded
- Retractions
  - pre: self commitment
  - post: removed

Entry and exit moves

- Observations
- Actions

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

- **Derived statuses**:
  - Open challenge: challenge, commitment and *not* (defeasibly) supported
  - Entitlement: commitment and *not* dependent on open challenges
- **Sanctionable behaviour**: inconsistent support and open challenges
- Support (i.e. affirmation and refutation) underwritten by (defeasible) **Inferential practices**

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

- **Derived statuses**:
  - Open challenge: challenge, commitment and *not* (defeasibly) supported
  - Entitlement: commitment and *not* dependent on open challenges
- **Sanctionable behaviour**: inconsistent support and open challenges
- Support (i.e. affirmation and refutation) underwritten by (defeasible) **Inferential practices**

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

- **Derived statuses**:
  - Open challenge: challenge, commitment and *not* (defeasibly) supported
  - Entitlement: commitment and *not* dependent on open challenges
- **Sanctionable behaviour**: inconsistent support and open challenges
- Support (i.e. affirmation and refutation) underwritten by (defeasible) **Inferential practices**

Game of giving and asking for reasons

(Piwek, 2014; AISB50)

- **Derived statuses**:
  - Open challenge: challenge, commitment and *not* (defeasibly) supported
  - Entitlement: commitment and *not* dependent on open challenges
- **Sanctionable behaviour**: inconsistent support and open challenges
- Support (i.e. affirmation and refutation) underwritten by (defeasible) **Inferential practices**

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments		
Challenges		
Open challenges		

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety	
Challenges		
Open challenges		

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety	
Challenges	fly_tweety	
Open challenges	fly_tweety	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety bird_tweety	
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety bird_tweety	
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety	fly_tweety
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	fly_tweety

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	~~fly_tweety~~

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	~~fly_tweety~~

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety penguin_tweety	fly_tweety
Open challenges	~~fly_tweety~~ penguin_tweety	~~fly_tweety~~

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety look_penguin_tweety	fly_tweety
Challenges	fly_tweety penguin_tweety	fly_tweety
Open challenges	~~fly_tweety~~ ~~penguin_tweety~~	~~fly_tweety~~

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety look_penguin_tweety	fly_tweety
Challenges	fly_tweety penguin_tweety	fly_tweety
Open challenges	~~fly_tweety~~ ~~penguin_tweety~~	~~fly_tweety~~

Commitments: positive and negative

$$\Gamma = \langle \Gamma^{+}, \Gamma^{-} \rangle$$

Commitments: positive and negative

$$\Gamma = \langle \Gamma^+, \Gamma^- \rangle$$

Assertion gives rise to update of positive commitments.
Denial gives rise to update of negative commitments.

Judgements

(Affirmation) $\Gamma \vdash \phi$

(Refutation) $\Gamma \dashv \phi$

Inferential Practices

- **Frege**: An inference is correct if it preserves truth from premises to the conclusions
- **Brandom**: Truth is that which is preserved in correct inferences.

Aberdeen is to the north of Eastbourne.

Eastbourne is to the south of Aberdeen.

Inferential Practices

- **Frege**: An inference is correct if it preserves truth from premises to the conclusions
- **Brandom**: Truth is that which is preserved in correct inferences.

X is to the north of Y.

Y is to the south of X.

Inferential Practices - Entry

$$\frac{Test}{Judgement}$$

$$\frac{\phi \in \Gamma^{+}}{\langle \Gamma^{+}, \Gamma^{-} \rangle \vdash \phi}$$

Inferential Practices - Entry

$$\frac{Test}{Judgement}$$

$$\frac{\phi \in \Gamma^{-}}{\langle \Gamma^{+}, \Gamma^{-} \rangle \dashv \phi}$$

Inferential Practices - Entry

$$\frac{Test}{Judgement}$$

$$\frac{Observation^{+}(\phi)}{\langle \Gamma^{+}, \Gamma^{-} \rangle \vdash \phi}$$

Fregean conceptual content

- Conceptual content: That which is the same in two judgements ⊢A and ⊢B, if:

  {⊢C : ⊢C follows from ⊢A (…)} =

  {⊢C : ⊢C follows from ⊢B (…)}

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash penguin\_tweety}{\Gamma \vdash bird\_tweety}$$

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash bird\_tweety}{\Gamma \dashv mammal\_tweety}$$

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash bird\_tweety \quad \Gamma \vdash scope\_bird\_tweety\_fly}{\Gamma \vdash fly\_tweety}$$

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash penguin\_tweety \quad \Gamma \vdash scope\_penguin\_tweety\_fly}{\Gamma \dashv fly\_tweety}$$

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash penguin\_tweety}{\Gamma \dashv scope\_bird\_tweety\_fly}$$

Inferential Practices - Rules

$$\frac{Judgement_1 \ \ldots \ Judgement_n}{Judgement} \text{ with } n \geq 1$$

$$\frac{\Gamma \vdash look\_penguin\_tweety \quad \Gamma \vdash scope\_look\_penguin\_tweety}{\Gamma \vdash penguin\_tweety}$$

Defeasible inference

(Non-monotonic affirmation) $\langle \Gamma^+, \Gamma^- \rangle \vdash_{NM} \phi$ *iff* there is a subset SC of sc(**B**) such that (a) $\langle \Gamma^+ \cup SC, \Gamma^- \rangle \vdash \phi$, (b) $\langle \Gamma^+ \cup SC, \Gamma^- \rangle$ is consistent, and (c) not $\langle \Gamma^+, \Gamma^- \rangle \dashv_{NM} \phi$

(Non-monotonic refutation) $\langle \Gamma^+, \Gamma^- \rangle \dashv_{NM} \phi$ *iff* there is a subset SC of sc(**B**) such that (a) $\langle \Gamma^+ \cup SC, \Gamma^- \rangle \dashv \phi$, (b) $\langle \Gamma^+ \cup SC, \Gamma^- \rangle$ is consistent, and (c) not $\langle \Gamma^+, \Gamma^- \rangle \vdash_{NM} \phi$

Playing the game - again

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments		
Challenges		
Open challenges		

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety	
Challenges		
Open challenges		

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety	
Challenges	fly_tweety	
Open challenges	fly_tweety	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety bird_tweety	
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

$$\frac{\Gamma \vdash bird\_tweety \quad \Gamma \vdash scope\_bird\_tweety\_fly}{\Gamma \vdash fly\_tweety}$$

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	fly_tweety bird_tweety	
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety	fly_tweety
Challenges	fly_tweety	
Open challenges	~~fly_tweety~~	

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	fly_tweety

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	~~fly_tweety~~

$$\frac{\Gamma \vdash penguin\_tweety \quad \Gamma \vdash scope\_penguin\_tweety\_fly}{\Gamma \dashv fly\_tweety}$$

$$\frac{\Gamma \vdash penguin\_tweety}{\Gamma \dashv scope\_bird\_tweety\_fly}$$

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety	fly_tweety
Open challenges	~~fly_tweety~~	~~fly_tweety~~

Playing the game

J: Tweety flies
M: Why?
J: It's a bird.
J: Wait no.
M: Why?
J: It's a penguin.
M: Why?
J: It looks like a penguin.

John's score		
	Positive	**Negative**
Commitments	~~fly_tweety~~ bird_tweety penguin_tweety	fly_tweety
Challenges	fly_tweety penguin_tweety	fly_tweety
Open challenges	~~fly_tweety~~ penguin_tweety	~~fly_tweety~~

From Truth-conditions to Inferences

- Understanding the meaning of an utterance means having a grasp of what entitles one to it and what it commits one to.
- Entitlement is defeasible, so we can avoid the problem with perception.
- We can work out our entitlements and commitments in dialogue (constrained by consistency and perception).

From intention to norms

- The speaker meant what they said if the had the right intention (private state).

- The speaker meant what they said if they act as being bound by the norms of the language community (public practice).

Summary and beyond

- Inferential practices instead of truth conditions
- Norms instead of instead of intentions
- Logical connectives, beyond propositional logic, ambiguity, ...

Papers

Brandom's game of giving and asking for reasons and defeasible inference formalised:

> Piwek (2014). **Towards a Computational Account of Inferentialist Meaning**. *AISB50*.

Expressivism about logic (to account for logical operators) formalised:

> Piwek (2011). **Dialogue Structure and Logical Expressivism**. *Synthese*.

`http://mcs.open.ac.uk/pp2464/`