Detecting Meaning with Sherlock Holmes*

Quantification, Truth and Sentiment

Francis Bond
Division of Linguistics and Multilingual Studies
http://www3.ntu.edu.sg/home/fcbond/
bond@ieee.org

Location: LT25

Overview

- Revision of sentence meaning and compositionality
- Truth and Logic
- Quantification and Negation
- Sentiment and Connotation

Motivation

- The Holmes's stories have a lot of reasoning
  - Sherlock looks at the evidence
  - and forms conclusions

  We will look at how we can do this (Truth and Logic)

- Logic is expressed in sometimes unexpected ways in natural language, we will look at some of these examples (Quantification and Negation)

- Finally, the stories are partly fun to read because of the color: the way Doyle paints different characters as good or evil (Sentiment and Connotation)

Revision

Meaning is built up Compositionally

- **Compositional Semantics**: the meaning of the whole depends (only) on the meanings of the parts and the method of combination.
- The hearer/reader's **interpretation** brings in much more
  - we bring in our existing knowledge
  - we make inferences
- These inferences are based on (or constrained by) the semantics
- Intersective modification constrains the denotation

Sentences describe situations

- Semantic Roles describe interactions of the participants
  and possibly the location, time, manner, reason and so forth

- Roles are constrained by the verb (or adjective, …) but can also be used to generalize

- Verbs can appear with different roles filling different syntactic positions (alternations).
  I broke the window vs *The window broke*

Tense, Aspect and Modality

- We can talk about when things occurred (tense)

  (1) *I did it.*

- Whether they are still ongoing (aspect)

  (2) *I am doing it.*

- Whether we think something is true or should be (modality)

  (3) *I should probably go*
  (4) *I must have that*

Close Reading

- Reading (and often re-reading) a text to uncover multiple aspects of meaning that lead you to understand a text better
- This involves looking at what the text actually says, as well as the inferences you make from reading it
- After a close reading you should be able to support your conclusions with specific examples from the text
- You can consider many aspects of the text, we focus on word choice
- We do this in Projects 1 and 2.

Reasoning

SHERLOCK: *"You will not apply my precept," he said, shaking his head. "How often have I said to you that when you have eliminated the impossible, whatever remains, however improbable, must be the truth? We know that he did not come through the door, the window, or the chimney. We also know that he could not have been concealed in the room, as there is no concealment possible. When, then, did he come?"*

The Sign of the Four (SIGN)

Three Kinds of Reasoning

- **Deductive Reasoning** allows you to start from general premises or categories, then to prove a specific conclusion (100%).

- **Inductive Reasoning** is reasoning in which the premises give evidence for the degree of truth of the conclusion (probably).
  We balance probabilities and choose the most likely. It is the scientific use of the imagination. (HOUN)

- **Abductive Reasoning** goes from observation to hypothesis. The goal is to find the theory which best accounts for the observation, ideally seeking to find the simplest and most likely explanation.

Holmesian deduction is abductive reasoning:

- come up with explanations
- eliminate wrong ones (using deductive reasoning)
- the remaining one is the best explanation

Logic (Deductive Reasoning)

- Classical logic is an attempt to find valid principles of argument and inference.

a	Humans are mortal	**premise**
b	Socrates is human	**premise**
c	Socrates is mortal	**conclusion**

- Can we go from a and b to c? Yes

- Truth is **empirical**: The premises need to correspond with the facts of the world
  - Sentences have **truth values** (true, false or unknown)
  - The state of the world that makes a sentence true or false are its **truth conditions**

Logical Connectives

- **and** ($p \wedge q$)
- **or** ($p \vee q$: disjunction, inclusive or)
- **xor** ($p \oplus q$: exclusive or, either or)
- **if** ($p \rightarrow q$: if then, material implication)
- **iff** ($p \equiv q$: if and only if) ($(p \rightarrow q) \wedge (q \rightarrow p)$)
- **not** ($\neg p$: contradiction)

An **argument** is a connected series of statements attempting to establish a proposition.

- **entailment** ($\vdash$: logical consequence, $\therefore$) something logically follows from the preceding statements

Truth Tables

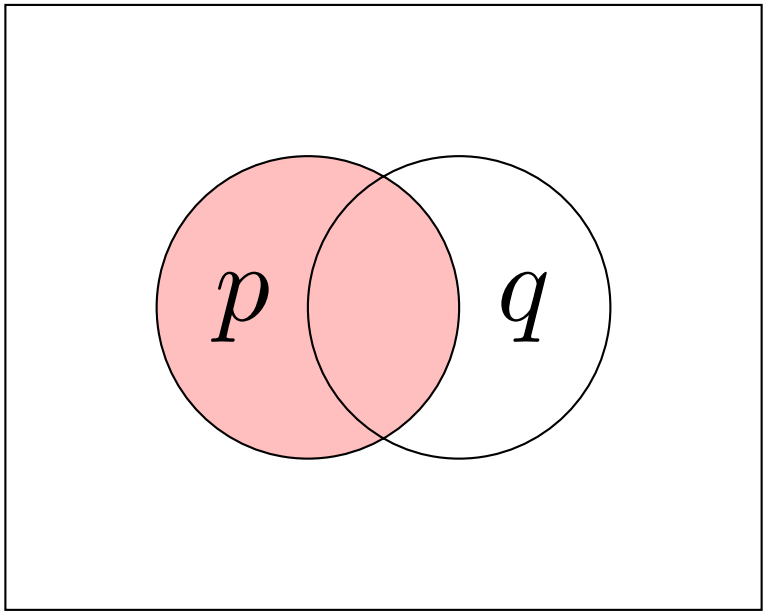
p	q	$p \rightarrow q$	$p \wedge q$	$p \vee q$	$p \oplus q$	$p \equiv q$	$\neg p$
		if	and	or	XOR	iff	not
T	T	T	T	T	F	T	F
T	F	F	F	T	T	F	F
F	T	T	F	T	T	F	T
F	F	T	F	F	F	T	T

- Words themselves often carry more implications
  I did A and B often implies *I did A first*

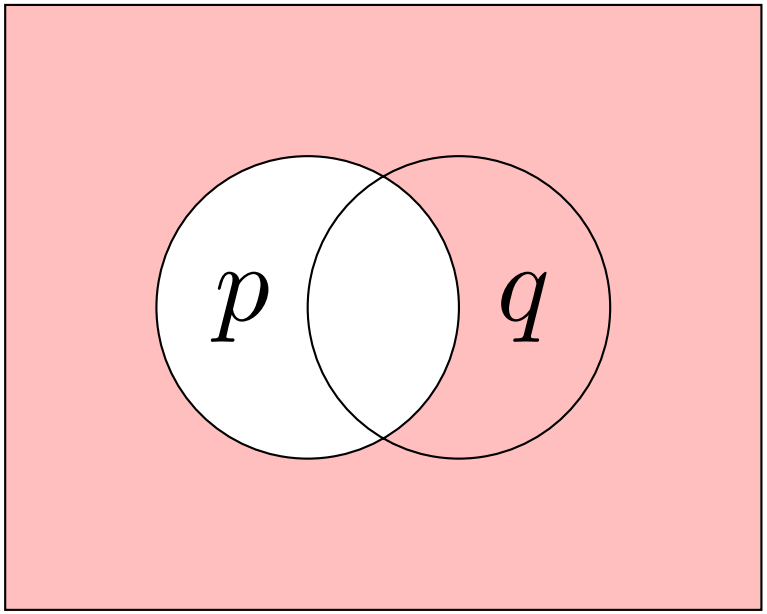
- There are many ways of saying the operations

Logical Connectives as Graphs (p and $\neg p$)

p

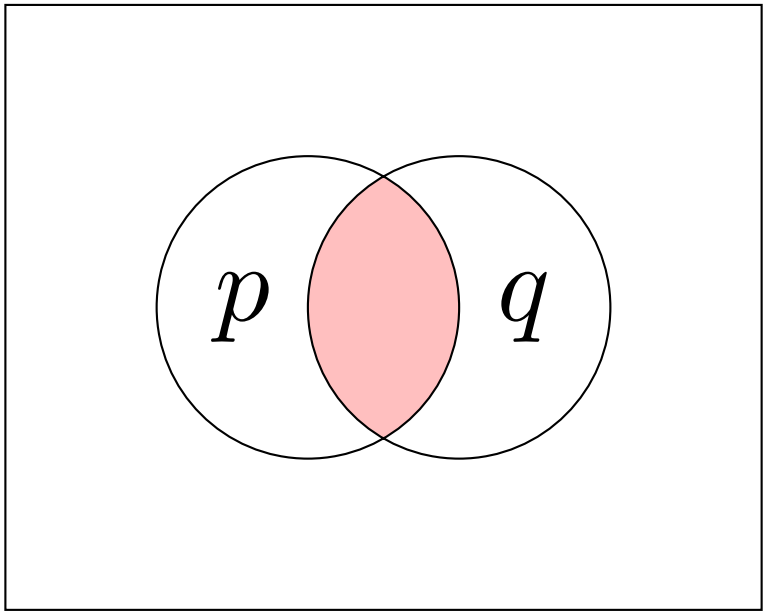


$\neg p$ “not”

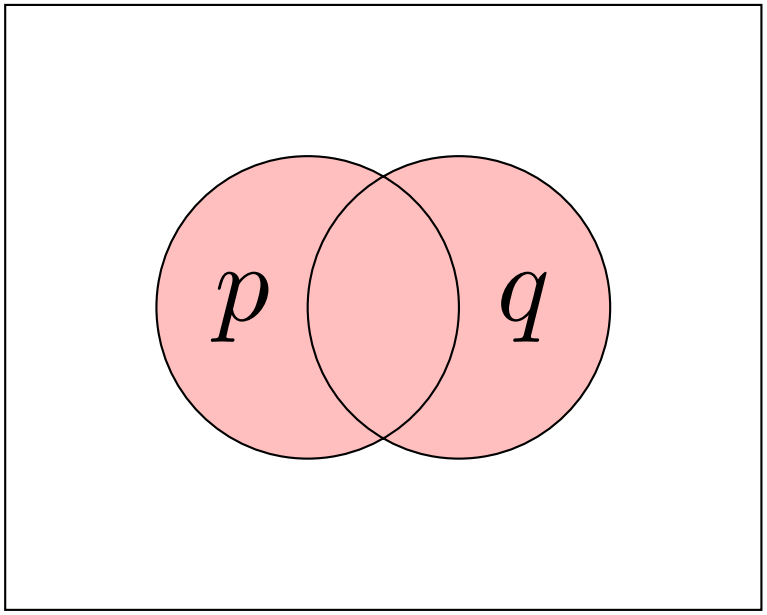


Logical Connectives as Graphs ($p \wedge q$ and $p \vee q$)

$p \wedge q$ "and"

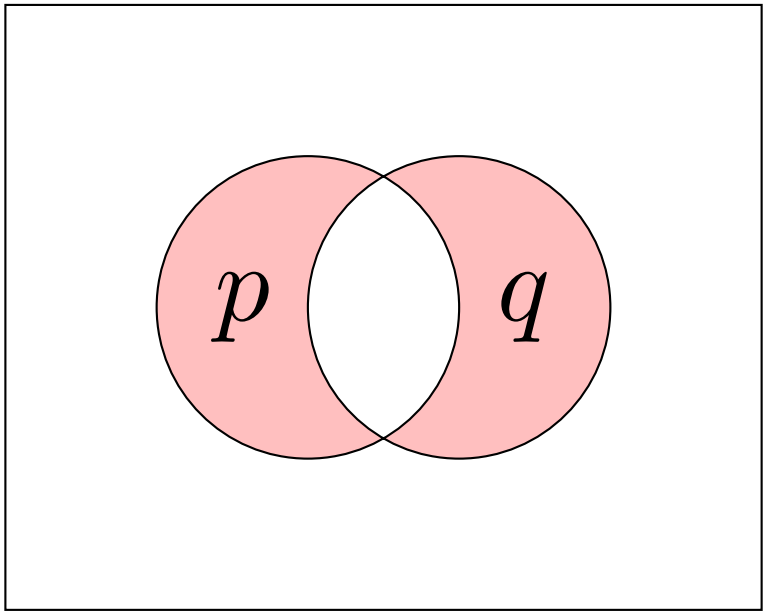


$p \vee q$ "or"

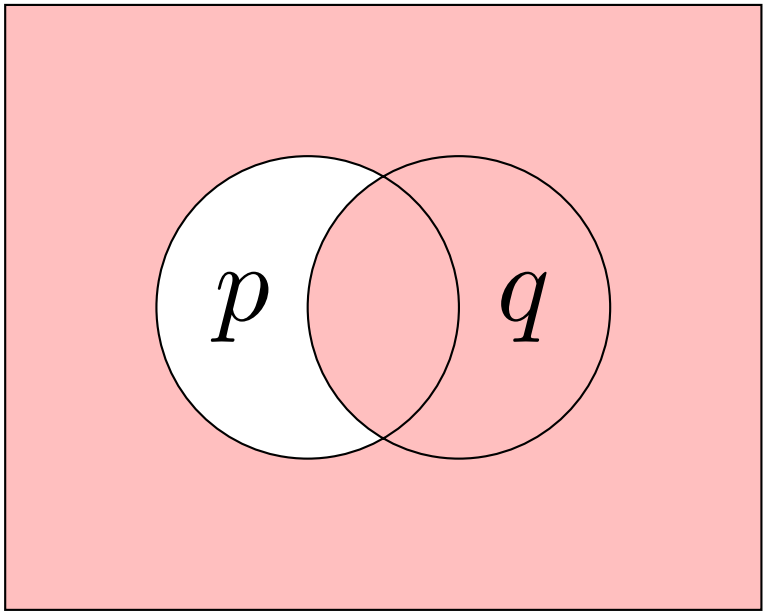


Logical Connectives as Graphs ($p \oplus q$ and $p \rightarrow q$)

$p \oplus q$ "exclusive or"

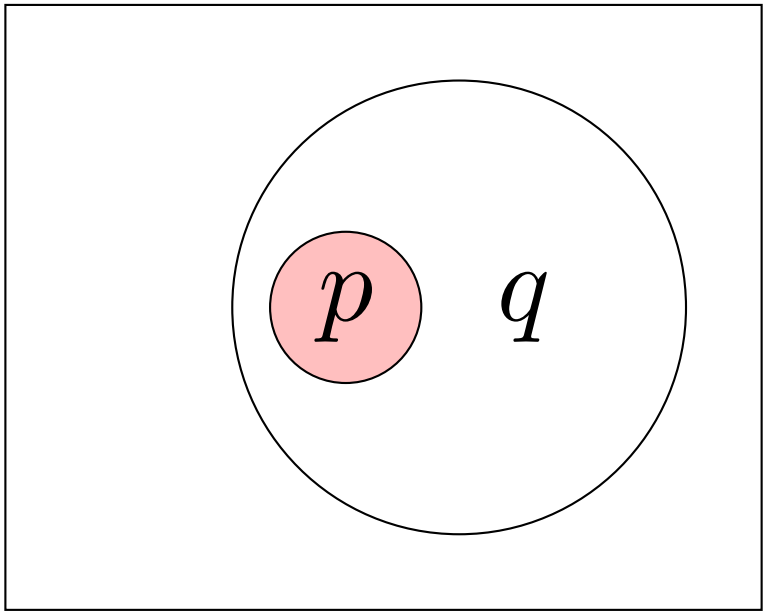


$p \rightarrow q$ "if"

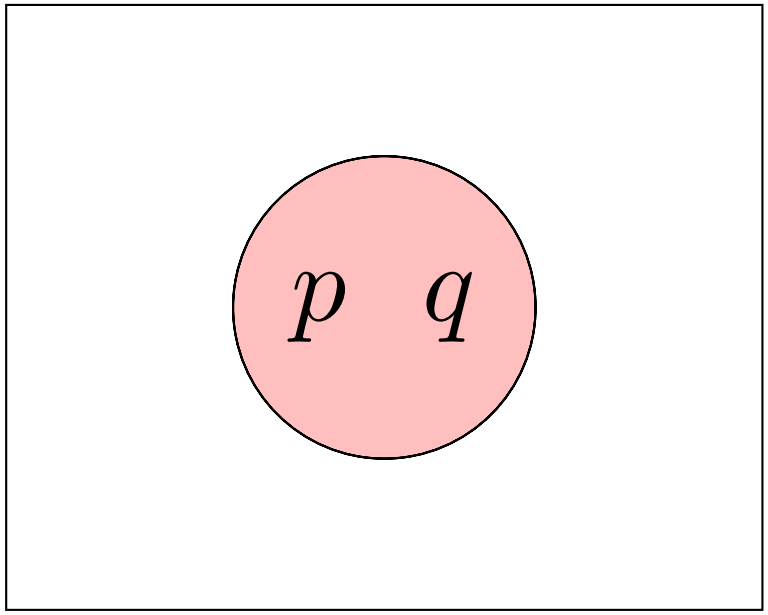


Semantic Relations as Graphs ($p \subset q$ and $p \sim q$)

$p \subset q$ `hypernym`



$p \sim q$ `synonym`



Modus ponens

a	All humans are mortal	$p \rightarrow q$	if someone is human then they are mortal
b	Socrates is human	p	
c	Therefore, Socrates is mortal	q	

p	q	$p \rightarrow q$
T	T	**T**
T	F	F
F	T	**T**
F	F	**T**

- The way that affirms by affirming (Latin)
- $p \rightarrow q, p \vdash q$
- **material implication** (Not quite the same as English ***if***)

Modus tollens

a	If something is human then it is mortal	$p \rightarrow q$
b	Zeus is not mortal	$\neg q$
c	Zeus is not human	$\neg p$

p	q	$p \rightarrow q$
T	T	**T**
T	**F**	F
F	T	**T**
F	**F**	**T**

- The way that negates by negating (Latin)
- $p \rightarrow q, \neg q \vdash \neg p$

Other types of syllogisms

➢ Hypothetical syllogism

a	If something is human then it is mortal
b	If something is mortal then it dies
c	If something is human then it dies

$p \rightarrow q, q \rightarrow r \vdash p \rightarrow r$

➢ Disjunctive syllogism

(modus tollendo ponens: affirm by denying)

p	Either a human is mortal or a human is immortal
q	A human is not immortal
r	A human is mortal

$p \oplus q, \neg p \vdash q$

These are all ways of proving something is true.

Bad Arguments

- Formal (can be disproved with truth tables)
  - **Affirming the consequent**: $p \to q, q \vdash p$
    professors talk too much, *you talk too much* $\vdash$ *you are a professor*
- Informal
  - **Equivocation**: The sign said *fine for parking here*, and since it was fine, I parked there.
  - **No True Scotsman**: X doesn't do Y; a is an X and does Y; a is not a true X
  - **Slippery Slope**: We mustn't allow text abbreviations or students will not be able to write normal text.
  - **False Dilemma**: You are with us or against us [or possibly don't care]
  - **Guilt by Association**: Hitler was a vegetarian $\vdash$ vegetarianism is bad

Arguments in Sherlock Holmes

- Most of the deduction in Sherlock Holmes depends on having a very restricted set of possibilities
  - partly a literary trick: the author controls the world they write about
    - Holmes is very lucky in his choice of theories
  - partly a reflection of the stratification of Victorian society
    - there are many hypotheses based on stereotypes
    - SHERLOCK: *There is no vehicle save a dog-cart which throws up mud in that way, and then only when you sit on the left-hand side of the driver.*

Arguments in Sherlock Holmes: Jabez

- *Beyond the obvious facts that* (conclusions)
  - *he has at some time done manual labour*,
    his right hand is stronger than his left
  - *he is a Freemason*,
    an arc and compass breastpin
  - *he has been in China*
    pink tattoo and coin
  - *he has done a considerable amount of writing lately*
    smooth patch on right cuff and left elbow

? Can you come up with alternative explanations?

Presupposition

Presuppositions

- Many statements assume the truth of something else

  (5) a. *Mary's sister bakes the best pies.*
  b. *Mary has a sister.*

- Negating the presupposing sentence a doesn't affect the presupposition b

- Names presuppose that their referents exist

- Triggers
  - Clefts (*it was X that Y*); Time adverbial; Comparative
  - Factive verbs: *realize*; some judgement verbs: *blame*; some change of state: *stop*

Semantic approach

- p *Mary's sister bakes the best pies* presupposing sentence
  q *Mary has a sister* presupposition

p		q
T	$\rightarrow$	T
F	$\rightarrow$	T
F, T	$\leftarrow$	T

- Also true of: $\neg p$ *Mary's sister doesn't bake the best pies*

- Is that different from this?

  a *I gave my dog a bath today.*
  b *I gave an animal a bath today.*

Presupposition versus entailment

- Negating the presupposing sentence does not affect the presupposition whereas negating an entailing sentence destroys the entailment.

- Can you think of other examples that show this difference?

Interactional approach

- Presupposition is one aspect of a speaker's strategy of organizing information for maximum clarity for the listener.

  (6) *Mary's sister bakes the best pies.*
  - a. Assertion 1: *Mary has a sister X.*
  - b. Assertion 2: *X bakes the best pies.*

- Assertion 1 is in the **background** (old information)

- Assertion 2 is in the **foreground** (new information)

Presupposition failure

➢ (7) *The King of France is bald.*

(8) *There is a King of France.* presupposition

➢ The problem with names and definite description is that they presuppose the existence of the named or described entities.

➢ Solution: A speaker's use of a name or definite description to refer usually carries a guarantee that the listener can identify the referent.

Presupposition triggers

➢ Cleft construction

(9) *It was his nonsense that irritated me.*

(10) *What irritated me was his nonsense.* (pseudo)

(11) *Something irritated me.* presupposition

➢ Time adverbial

(12) *I was working five jobs before you went to school*

(13) *You went to school.* presupposition

➢ Comparative

(14) *You are even more silly than he is.*

(15) *He is silly.* presupposition

Presupposition triggers: Lexical triggers

- **Factive verbs** presuppose the truth of their complement clauses.

(16) a. *The students realized that Alex was hungry.*
b. *The students thought that Alex was hungry.* no presupposition

(17) a. *Alex regretted not eating lunch.*
b. *Alex considered not eating lunch.* no presupposition

- **Verbs of judgement**

(18) *Kim blamed me for making a mistake*

- **Change of state** (sometimes)

(19) *Alex stopped talking to their imaginary friend.*
(20) *Have you stopped beating your dog?*

Presupposition and context

- Presuppositions are context dependent.

(21)	a.	*John ate before going to the movies.*	
	b.	*John went to the movies.*	presupposition
(22)	a.	??*John died before going to the movies*	
	b.	*John went to the movies.*	presupposition

- Presuppositions are **defeasible**: they can be canceled given the right context.

The Argument Clinic

- A sketch from episode 29 of Monty Python's Flying Circus
- *An argument is a connected series of statements intended to establish a proposition*

Quantification and Negation

Shades of meaning

- We can restrict the scope of statements with quantifiers
- We can change the polarity of statements using negation
- These interact with each other in interesting ways
- These interact with language in interesting ways

Simple Statements in Predicate Logic

- Consider simple sentences
  - Represent the **predicates** by a capital letter
    these can be n-ary
  - Represent the **individual constants** by lower case letters
  - Represent **variables** by lower case letters (x,y,z)

(23) *Bobbie is asleep*: A(b)

(24) *Freddie drinks*: D(f)

(25) *Freddie drinks beer*: D(f,b)

(26) *Freddie prefers beer to whiskey*: P(f,b,w)

(27) *Someone is asleep*: A(x) (A(x) $\wedge$ P(x))

Complex Statements in Predicate Logic

- Join simple sentences with logical connectives
  treat relative clauses as **and**

  (28) *Bobbie who is asleep writhes*: $A(b) \wedge W(b)$
  (29) *Bobbie is asleep and Freddie drinks*: $A(b) \wedge D(f)$
  (30) *Freddie drinks and sleeps*: $D(f) \wedge S(f)$
  (31) *Freddie doesn't drink beer*: $\neg D(f,b)$
  (32) *If Freddie drinks whiskey Bobbie sleeps*: $D(f,w) \rightarrow S(b)$

- If you run out of letters, use two, keep them unique in the world you are modeling

  (33) *Bobbie who is asleep snores*: $A(b) \wedge Sn(b)$

Quantifiers in Predicate Logic

- Quantifiers bind variables and scope over predications
  - **Universal Quantifier** ($\forall$: *each, every, all*)
  - **Existential Quantifier** ($\exists$: *some, a*)

    (34) *All students learn logic*: $\forall x\ (S(x) \rightarrow L(x,l))$

    (35) *A student learns logic*: $\exists x\ (S(x) \wedge L(x,l))$

    (36) *Some students learn logic*: $\exists x\ (S(x) \wedge L(x,l))$

    (37) *No students learn logic*: $\neg\exists x\ (S(x) \wedge L(x,l))$

    (38) *All students don't learn logic*: $\forall x\ (S(x) \rightarrow \neg L(x,l))$
    logically equivalent to (37)
  - $\forall$ must check each one (so $\rightarrow$)
  - $\exists$ is falsified by one counter example (so $\wedge$)
- All variables must be bound
  If there is an x, y, z it must have a $\forall$ or $\exists$

Why Translate to Predicate Logic

- Explicit representation of scope ambiguity

  (39) *Everyone loves someone*

  a. *Everyone has someone they love*:
  $\forall x\ (P(x) \rightarrow \exists y\ (P(y) \wedge L(x,y))$
  $\forall x \exists y\ (L(x,y))$

  b. *There is some person who is loved by everyone*:
  $\exists y\ (P(y) \wedge \forall x\ (P(x) \rightarrow L(x,y))$
  $\exists y \forall x\ (L(x,y))$

  (40) *Everyone didn't pass the exam*

  a. *Every person failed the exam*: $\forall x\ (P(x) \rightarrow \neg F(x,e))$

  b. *Not all people passed the exam*: $\neg \forall x\ (P(x) \rightarrow F(x,e))$

- You can also use logic to try to reason with the real world
  denotational semantic analysis
  it turns out that this is hard

Restricted Quantifiers

- *Most students read a book*
  - Most(x)(S(x) $\wedge$ R(x))
    most things are students and most things read books
  - Most(x)(S(x) $\rightarrow$ R(x))
    most things are such that, if they are students, they read books

- We need to restrict the quantification
  - (Most x: S(x)) R(x)

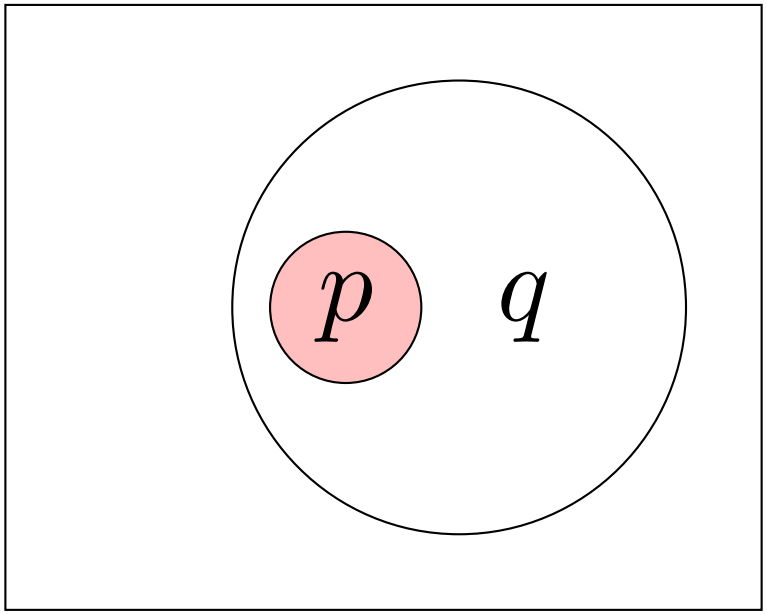
- Sometimes we need to decompose
  - *everybody* ($\forall$x: P(x))
  - *something* ($\exists$x: T(x))

Generalized Quantifiers

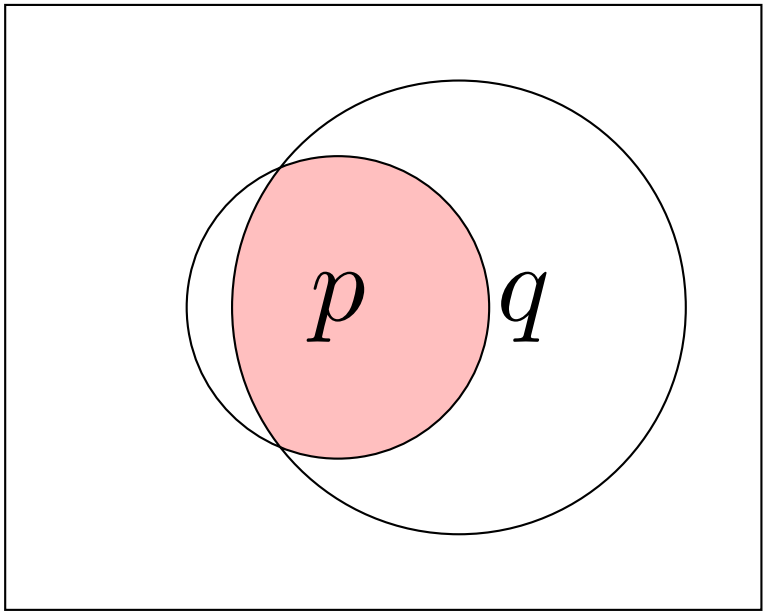
- Q(A,B): *Q A are B*
- `most(A,B)` = 1 iff $|A \cap B| > |A - B|$
- `all(A,B)` = 1 iff $A \subseteq B$
- `some(A,B)` = 1 iff $A \cap B \neq \emptyset$
- `no(A,B)` = 1 iff $A \cap B = \emptyset$
- `fewer than x(A,B,X)` =1 iff $|A \cap B| < |X|$

Generalized Quantifiers: `all`, `most`

all p are q

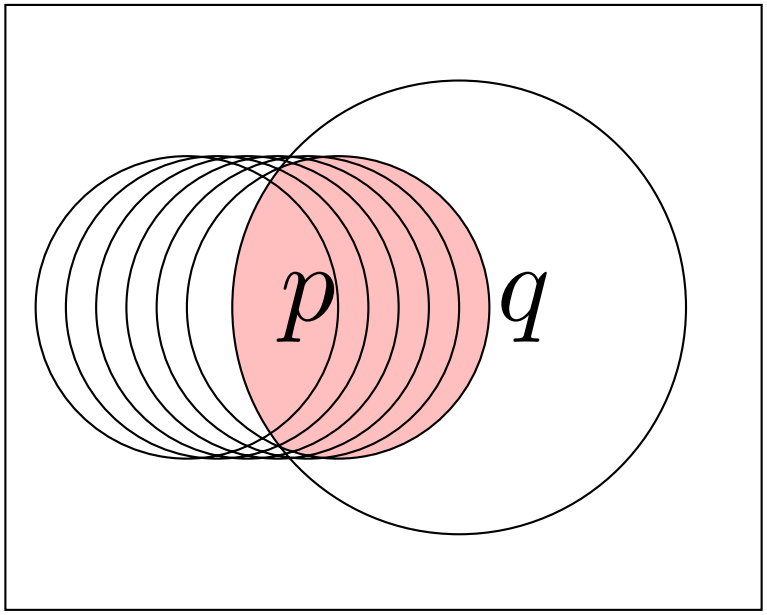


most p are q

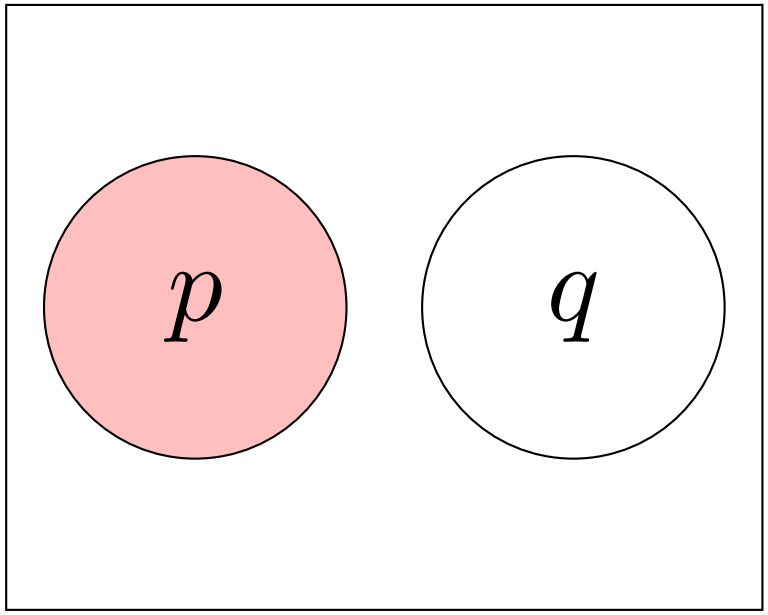


Generalized Quantifiers: `some`, `no`

some p are q



no p are q



Strong/Weak Quantifiers

(41) only **weak** quantifiers can occur in existential *there* sentences

a. *There is a fox in the henhouse*

b. *There are two foxes in the henhouse*

c. **There is every fox in the henhouse*

d. **There are both foxes in the henhouse*

➢ **symmetrical** (cardinal) quantifiers are **weak**
det(A,B) = det(B,A)

(42) *three lecturers are Australian* = *three Australians are lecturers*

➢ **asymmetrical** (proportional) quantifiers are **strong**
det(A,B) $\neq$ det(B,A)

(43) *most lecturers are Australian* $\neq$ *most Australians are lecturers*

? Come up with some more strong and weak quantifiers

Negative Polarity Items (NPI)

➢ Some words in English mainly appear in negative environments

(44) a. *Kim doesn't ever eat dessert*
b. **Kim does ever eat dessert*

(45) a. *Kim hasn't eaten dessert yet*
b. **Kim has eaten dessert yet*

(46) a. *Few people have eaten dessert yet*
b. **Many people have eaten dessert yet*

(47) a. *Rarely does Kim ever eat dessert*
b. **Often does Kim ever eat dessert*

➢ Not just negation, but also some quantifiers

? Come up with some NPIs and environments

Monotonicity

- Some quantifiers control entailment between sets and subsets
  - **Upward entailment** goes from a subset to a set
  - **Downward entailment** goes from a set to a subset

(48) a. *Kim doesn't eat dessert* $\Rightarrow$ *Kim doesn't eat hot dessert*

b. *Kim doesn't eat hot dessert* $\not\Rightarrow$ *Kim doesn't eat dessert*

Downward entailment

(49) a. *Kim eats some desserts* $\not\Rightarrow$ *Kim eats hot desserts*

b. *Kim eats some hot desserts* $\Rightarrow$ *Kim eats some desserts*

Upward entailment

- Negative Polarity Items are licensed by downward entailing expressions

- Formal models of quantification can be used to make predictions about seemingly unrelated phenomena

In other languages too!

(50) 我 没有 任何 朋友
wo mei-you renhe pengyou
I NEG-have any friend
"I don't have any friends."

(51) * 我 有 任何 朋友
wo you renhe pengyou
I have any friend
*"I have any friends."

Negation Scope

Negation can be triggered by many things, and the elements can be far away.

(52) *The German was sent for but professed to know nothing of the matter …* (HOUN)

(53) *I trust that there is nothing of consequence which I have overlooked?*”

(54) “*A dabbler in science, Mr. Holmes, a picker up of shells on the shores of the great unknown ocean.*

(55) *Our client looked down with a rueful face at his own unconventional appearance.*

Sentiment and Connotation

Connotation

Many words carry more meaning than just identifying their referent.

(56) a. *Kim is slender*
b. *Kim is thin*
c. *Kim is haggard*

(57) a. *The young lout is here.*
b. *The young boy is here.*
c. *The young gentlemen is here.*

(58) a. *The young lout is arrogant.*
b. *The young boy is proud.*
c. *The young gentlemen is confident.*

(59) a. *That bitch is cheap.*
b. *That woman is economical.*
c. *That lady is frugal.*

Sentiment in the Holmes corpus

- Doyle often gives us not-so subtle cues as to whether characters are good or bad.

- Some of them are very nationalist (and borderline racist, but not always)

(60) *A large face, seared with a thousand wrinkles, burned yellow with the sun, and marked with every evil passion, was turned from one to the other of us, while his deep-set, bile-shot eyes, and the high thin fleshless nose, gave him somewhat the resemblance to a fierce old bird of prey.* (SPEC)

(61) *He was a fine creature, this man of the old English soil, simple, straight and gentle, with his great, earnest, blue eyes and broad, comely face.* (DANC)

(62) *"The aborigines of the Andaman Islands may perhaps claim the distinction of being the smallest race upon this earth, …They are naturally hideous, having large, misshapen heads, small, fierce eyes, and distorted features."* (SIGN)

(63) *There was a portrait within of a man, strikingly handsome and intelligent, but bearing unmistakable signs upon his features of his African descent.* (YELL)

? Can you find some examples of clearly positive or negative descriptions?

Sentiment and Composition

- Sentiment can be built up.

  (64) *good*
  (65) *very good*
  (66) *less than very good*
  (67) *I have never found it to be less than very good*

- It can be complex

  (68) *The new story is good, especially the characterization, although the dialogue is a little stiff.*

- Polarity can depend on the target

  (69) *The screen is very wide.*
  (70) *Their nostrils are very wide.*

- It can come from other things than lexical cues: ⋆⋆⋆⋆⋆

Annotating Sentiment

Score	*Example*	*Example*	*Example*	*Corpus Examples*
95	*fantastic*	*very good*		*perfect, splendidly*
64	*good*	*good*		*soothing, pleasure*
34	*ok*	*sort of good*	*not bad*	*easy, interesting*
0	*beige*	*neutral*		*puff*
-34	*poorly*	*a bit bad*		*rumour, cripple*
-64	*bad*	*bad*	*not good*	*hideous, death*
-95	*awful*	*very bad*		*deadly, horror-stricken*

We annotate **senses**: words given their meaning, before they are transformed by the syntax. So ***good*** in *That is very very good* and ***good*** in *That is no good* get the same score.

➢ Note that most words carry no sentiment.

High and Low Examples in multiple languages

Concept	freq	score	*English*	score	Chinese	score	Japanese	Score
i40833	24	50	*marriage*	39	婚事	34	結婚	58
			wedding	34				
i11080	5	40	*rich*	33	有钱	34	裕福	66
i72643	4	33	*smile*	32	微笑	34	笑み	34
i23529	40	−68	*die*	−80	去世	−60	亡くなる	−63
					死亡	−64	死ぬ	−62
i36562	5	−83	*murder*	−95	谋杀	−95	殺し	−64
							殺害	−63

By generalizing to the concept, we can share sentiment values across languages (Bond et al., 2016, 2019).

Conclusions

- Language can be used to reason
- We reason unconsciously when we decide which words to use
- Language can be used to convey impressions and opinions
  - You will try to do this as part of projects 1 and 2

*

References

Francis Bond, Arkadiusz Janz, and Maciej Piasecki. 2019. A comparison of sense-level sentiment scores. In *Proceedings of the 11th Global Wordnet Conference (GWC 2019)*.

Francis Bond, Tomoko Ohkuma, Luís Morgado da Costa, Yasuhide Miura, Rachel Chen, Takayuki Kuribayashi, and Wenjie Wang. 2016. A multilingual sentiment corpus for Chinese, English and Japanese. In *6th Emotion and Sentiment Analysis Workshop (at LREC 2016)*. Portorož.