Simulation, Communication and Identity

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Barsalou's Understanding by Simulation

A bridge between truth-conditional and conceptual semantics?

understanding by simulation is not even conceptual semantics, but cognitive science

This paper

a stronger interpretation of understanding by simulation

instead of the purely bayesian one (a natural model of likelihood)

"Conceptual structure is what defines proper simulations and action concepts can be seen as methods for simulating the actions in their extension."

Overview

Simulation
Simulation of actions
Simulation of Communication Verbs
Event identity

Simulation

In a mental simulation of an action or event the subject lives through the various steps in which the action or event unfolds from the perspective of agent, of the undergoer or the experiencer, without performing the action or experiencing the event.

Such simulations in various modes (visual, auditory, motoric) can be interpreted as part of the enhancement of the signal interpretation in perception since it makes available modal information that can be matched against the signal.

From the perspective of Bayesian interpretation, simulation is a model of likelihood: it shows you what may have caused the signal as something with exactly the same kind of appearance as the signal. This is why one can match with the signal.

The product of the prior (the degree to which the action or event is expected) and likelihood selects the best hypothesis from the ones arising from perceptual cues.

Put more qualitatively, if one can simulate a full match with the signal for a cued hypothesis, that is the correct hypothesis unless there are other more probable hypotheses for which a fully matching hypothesis is also possible.

Such simulations are independently useful in planning: they make it modally accessible what will happen if we do so and so and thereby help in making decisions.

The mirror neuron system can be seen as the implementation (or part of the implementation, or as a simple model of a more complex polyneuronic implementation) of how simulation may work in the brain. It is the planning component that runs the simulation in mirror mode, replacing the self by the agent of the action in observing actions by others.

The above gives the weak version of understanding-by-simulation

The stronger version of understanding-by-simulation:

a. understanding an action or event concept is to be able to simulate it

b. understanding an action or event falling under a concept is to be able to simulate it as an instance of the concept

c. the structure of the concept guides the simulation

to understand an utterance is to simulate making it

to simulate an utterance is to reconstruct its planning and running through its execution as if you were the speaker

For simulated sentence production in utterance understanding there is wealth of psychological evidence. (experimental results in Pickering and Garrod) but also joint turn finishing and grammaticality judgments.

Grice in Meaning:

to understand an utterance is to recognise the speaker intention in making it

Simulation checks the syntactic, morphological and semantic correctness of the intention recognition. But it does more: the intention must fit into the linguistic and non-linguistic context, and must deal with the goals of the conversation.

An example from Grice to illustrate conversational implicature

A: I am out of petrol.

from situation infer:

the person is traveling with his car
the car does not run anymore because of lack of fuel
the utterance is an appeal for help with his problem

further reasoning:

I know where this man can get petrol, nl.
In the garage around around the corner

The Gricean intention: A wants B to help him with his problem.

B: There is a garage around the corner.

B helped A.
B told A where he could get new fuel.
A asked B to tell him where he could get new fuel.
A explained B his problem.
B gave A the information that there was a garage around the corner
B implied that the garage around the corner is open and sells petrol.

Gricean intention: B wants A to believe that he can get petrol just around the corner at the garage.

But with understanding by simulation there is more than just pragmatics. The speaker has simulated being in a car without gazoline when traveling in an unknown place. He has been able to reconstruct A's utterance from that perspective and seen that help was needed. This simulation must be partially identified with the semantic and pragmatic processing, inference and reasoning in the example.

Arbib's mirror neuron theory of action concepts: the function of mirror neurons is to assimilate the self and others in carrying out a particular action. An action concept is the brain classifying the action of another agent by its own action states in which the self is replaced by the other.

The same assimilation of self and other can be the basis for assimilation of undergoers in action or for experiencers. But not directly by mirror neurons.

(the archetype of major syntactic functions can be understood from this classification. An almost direct construction of Dowty's proto agent and proto-patient features is also possible by this route. But not today.)

Understanding-by-simulation can be constructed as Bayesian interpretation in this sense: a partial simulation is incrementally constructed, checked and selected in a perception or in the understanding of a meaningful linguistic unit like an utterance.

Simulation shows up in iconicity (e.g. the order of the events follows the order in which they occur in a story or in a conjunction), but also in the structure of event concepts.

Moens and Steedman on accomplishments.

preparatory phase $<$ start $<$ activity $<$ culmination $<$ result

Process: without culmination and consequent state

Points: no activity, start

State: result, ongoing activity or preparatory state

Planning: forming an intention to achieve the culmination and the consequent state through realising the preparation and the activities

Later stages presuppose the earlier stages: they create the situation in which the next stage is possible. (affordance, Hobbs' occasion or enablement)

Other event and state concepts by removing structure.

In a frame theory, one can see this is as a set of slots for action concepts that need to be filled for the particular concept, and that are constrained by causal relations such as occasion (enablement) and proper causality.

goal
intention
preparation
start
activity
culmination
result

causal constraints

goal causes intention
intention causes preparation+start+activity+culmination
preparation enables activity
activity causes culmination
culmination causes result

(in frames the relations can be represented by having causal attributes)

Simulation would be following the causal predictions to go from the simulation of the agents goal to the intention formation and then onwards to the execution of the action until the result is reached.

Example climb the Szrenica

goal: visit workshop
intention: to reach the mountain hut on foot
preparatory actions: get proper shoes and clothing, go to start of the path up
activity: follow the path upwards
culmination: the top is reached
result: one finds oneself at the top

further planning is needed is for following the path:

many steps upwards adapted to terrain
orient oneself by reading available signposts
rest to regain breath when needed

a. Planning bottoms out in motor plans for muscle movements constituting forming letters or making steps. The actual bottom level is not accessible to consciousness.

b. A representation of the whole process should be a hierarchical structure where the subactions used to execute the higher action are daughters of the higher action.

Full simulation

simulate everything that belongs to the event according to its concept, including simulating the subevents in the event concept

e.g. a full memory of a past event

(very similar to Livia Polanyi's discourse trees)

Partial simulation

allow gaps and underspecification in a full simulation (needed for normal NL interpretation and for normal perception)

1. the intention of the higher level action causes the intentions of the lower level actions by planning

2. the combined lower level actions are the way in which the higher level action was carried out.

3. From the planning perspective, the lower level actions are but one way in which the higher level action can be carried out

4. In perception, the lower levels can indicate the higher levels of the hierarchical structure, given the context.

observation: Henk struggling upwards on the path leading to the top.

Hypothesize his intention to want to go to the end of the path.

other explanations can be excluded and this one makes sense: so the upwards struggle indicates that:

Henk is climbing the Szrenica.

Perhaps -using context and perceivable further detail- adopt further hypotheses about why, preparation, signposts, etc. The hierarchical tree could partly be discovered by further investigation, but cannot be infered in its full specificity.

Henk's behaviour indicates his intention given the context.

observation: Mary calls John a Republican
context: John abhors anything Republican
context: Mary knows this
ergo
Mary insulted John intentionally.

In the context, the observation indicates the conclusion

Peirce's examples of indicating:

the weather vane indicates the direction and the force of the wind
the clock indicates the time
John's utterance "I am hungry" indicates that he is hungry

Typical property: additional facts are needed for this to be so

the weather vane needs to be in the right position
the clock must be adjusted to the right time
John must be sincere

Lewis, Schiffer: candle on table with A and B on both sides of the table

indicates to A and B that there is a candle.
indicates to A that B sees the candle.
indicates to B that A sees the candle

etc.

indicates to A and B that it is common ground between them that there is a candle on the table.

E indicates F iff knowing that E is sufficient reason for assuming that F in the context

indication is a reason for assuming a causal process that leads from the realisation of E to the realisation of F (hallucination, hologram)

A full simulation of the higher event will contain a simulation of the lower level events

congratulate Mary
writing a letter
write characters, words and lines
draw forms on a piece of paper
move fingers holding pen while pressing pen against the paper surface

More formally(?)

F is a subframe of another frame G

G has all the information in F and more

(extra attributes and/or more specific sorts)

Borrowed from HPSG:

full simulation of C maximally specific frame for C

Communication verbs

class: involve the intended formation of attitudes in the recipient on the basis of recognising the intention behind the action

simulation: they involve motor action but much is mental action

Three causal relations

effects: a mental process leading to another mental process or to an basic action

E indicates F: E normally causes the realisation that F exists

causes: other types of causation

First example: Tomasello/Clark style "giving" A joint action

give

agent
recipient
theme
goal = result
preparation agent holds theme
intention1 preparation+activity+culmination
activity agent presents theme to recipient
recipient recognises intention1
recipient forms intention2 to take theme from recipient
culmination recipient takes theme
result recipient has theme

causal relations

goal effects intention1
intention1 effects hold
intention1 effects present
present indicates intention1
present effects recognition
recognition effects intention2
intention2 effects take
take causes possession

Second example

John and Mary agreed to study the roots of pragmasemantics.

It has become a joint goal of John and Mary to study the roots of pragmasemantics.

It is common ground between John and Mary that they share the goal of studying the roots of pragmasemantics.

John: Let's study the roots of pragmasemantics.
Mary: Great idea. Let's.

One level up.

John formulates a proposal to study the roots of pragmasemantics.
Mary assents to a contextually given proposal to do something.

One level up.

John makes a proposal.
Mary accepts it.

propose
convey
agree
assent
accept

assent

speaker
hearer
proposal
goal: make it CG that speaker accepts proposal
intention: produce signal+hearer realises that speaker accepts proposal
activity: produce signal
culmination: hearer realises that it is CG that speaker accepts proposal
result: it is CG that speaker accepts proposal

causal relations:

goal effects intention
intention effects produce signal
signal indicates that speaker accepts proposal
signal effects hearer realisation that speaker accepts proposal
realisation effects it being CG that speaker accepts proposal

convey

speaker
hearer
goal: make it CG that speaker makes proposal
intention: produce signal+hearer realises that speaker makes proposal
activity: produce signal
culmination: hearer realises that it is CG that speaker makes proposal
result: it is CG that speaker makes proposal

causal relations:

goal effects intention
intention effects produce signal
signal indicates that speaker makes proposal
signal effects hearer realisation that it is CG that speaker makes proposal
realisation effects it being CG that speaker makes proposal

propose

speaker
hearer
goal: make a proposal CG
intention: convey proposal +hearer realises that speaker makes proposal+hearer accepts proposal
activity: convey proposal
culmination: hearer realises that it is CG that speaker makes proposal and intends hearer to accept it
result: it is CG that speaker makes proposal and intends hearer to accept it

causal relations:

goal effects intention
intention effects produce signal
signal indicates that speaker makes proposal and intends hearer to accept it
signal effects hearer realising that it is CG that speaker makes proposal
and intends hearer to accept it
realising effects it being CG that speaker makes proposal and intends hearer to accept it

accept

proposal
speaker
hearer
goal: make proposal CG
intention: assent +hearer realises that proposal is CG
activity: assent
culmination: hearer realises that proposal is CG
result: proposal is CG

causal relations:

goal effects intention
intention effects assent
assent indicates that proposal is CG
assent effects hearer realising that proposal is CG
realising effects that proposal is CG

agree (not an action concept)

participants X+Y
theme
activity: X proposes theme
culmination: Y accepts theme
result: CG theme

causal relations:

propose enables accept

Event Identity

Events must always be taken to be events falling under a concept

Two events instantiating different action concepts are identical iff their full simulations are identical

Example

John proposed to study the roots of pragmasemantics and Mary accepted. (add causal relation, make theme of accept John's proposal)

John and Mary agreed to study the roots of pragmasemantics.

(identical if the constituents are identical)

Two events are entangled iff they have a shared subevent in their simulation

Two events are distinct iff they are not entangled

Additivity: two distinct answers to the same question

(Jasinskaja) Aliena broke her skis. She lost her only means of transport

ski into a tree
lose is unspecific about the method of losing, but it must be specified in the concept that there is a losing event

John felled an apple tree. He destroyed grandfather's favourite fruit tree.

destroy is open for method and cutting it down is one option for the method.

Angelica Kratzer

(a) John painted a portrait of Mary.
(b) John painted an apple.

a complete simulation of (a) is a simulation of (b) but not inversely

Level generation (Alvin Goldman)

causal

John pulled the trigger.
John killed Bill.

The pulling of the trigger was part of killing Bill. (the other part being the bullit hitting Bill and Bill dying)

conventional

John put the queen to E6.
John checkmated Bill.

A full simulation of the actual checkmating includes John's putting the queen on E6.

Mary called John a Republican.
Mary insulted John.

A full simulation of Mary insulting John includes her application of Republican to John.

simple

John killed Bill.
John committed a crime.

John did x and x is a crime.
A full simulation of the event of John committing a crime includes John's killing of Bill

John ran the mile in time t.
He broke the world record.

augmentation

John met Mary.
John met Mary in the garden.

A full simulation of the higher level concept -which must include a slot for the lower level concept- will also simulate the lower level but not inversely

Other events can be simulated too, but from undergoer and experiencer perspectives

Accomplishment is the richest: other cases can be obtained by omission of parts

remove intentions and goals
remove culmination
remove activity
remove result

States

results (washed)
ongoing processes (growing)
preparatory states (know, belief, want)

Nouns

quite different

attribute based (father, director, sister)
sortal nouns (man, cat, coffee)

characterising smell, size, shape, skin, sound etc.

NL semantics

There is no conflict. The model of action simulation comes from NL semantics using indication and causality. The same truth conditions -or rather their strengthened version- are predicted. Whether frames are used or not. My contention would be that one gets more reasoning for free.

Summary

Simulation can be understanding for action concepts

In perception and interpretation this is partial simulation

Full simulation can be compared with completely instantiated signs in HPSG

Conceptual structure of action verbs determines which constituent events need to be simulated in a full simulation

Event identity can be explained by full simulation

Two events are identical if and only if their full simulations are

Communication can be understood by simulation in a faithful picture of Grice/Clark/Tomasello perspective

Conclusion

Indeed, the simulation concept provides a bridge between formal semantics and conceptual semantics.

The simulation concept helps in adding more detail to the semantics of verbs:
indication, effecting, causality, intention

They could have been added on the basis of normal semantic argument: semantic intuitions

There was never much point in not doing truth conditions for conceptual semantics.

If one accepts that the models are models of reality as perceived by humans and not reality as such from various scientific angles

Credits

Sebastian Loebner's work on cascades (he does not agree)
Remko Scha's views on functional nouns and Bayesian interpretation
Reinhard Blutner for his making understanding-by-simulation an issue
Wiebke Petersen and Sebastian Loebner for convincing me that Barsalou is great