Cognitive Psychology and Cognitive Neuroscience/Situation Models and Inferencing

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Introduction

An important function and property of the human cognitive system is the ability to extract important information out of textually and verbally described situations. This ability plays a vital role in understanding and remembering. But what happens to this information after it is extracted, how do we represent it and how do we use it for inferencing? With this chapter we introduce the concept of a "situation model" (van Dijk&Kintsch, 1983, "mental model": Johnson-Laird, 1983), which is the mental representation of what a text is about. We discuss how these representations might look like and show the various experiments that try to tackle these questions empirically. By assuming situations to be encoded by perceptual symbols (Barsalou, 1999), the theory of Situation Models touches many aspects of Cognitive Philosophy, Linguistics and Artificial Intelligence. In the beginning of this chapter, we will mention why Situation Models are important and what we use them for. Next we will focus on the theory itself by introducing the four primary types of information - the situation model components, its Levels of Representation and finally two other basic types of knowledge used in situation model construction and processing (general world knowledge and referent specific knowledge).

Situation models not only form a central concept in theories of situated cognition that helps us in understanding how situational information is collected and how new information gets integrated, but they can also explain many other phenomena. According to van Dijk & Kintsch, situation models are responsible for processes like domain-expertise, translation, learning from multiple sources or completely understanding situations just by reading about them. These situation models consist, according to most researches in this area, of five dimensions, which we will explain later. When new information concerning one of these dimensions is extracted, the situation model is changed according to the new information. The bigger the change in the situation model is, the more time the reader needs for understanding the situation with the new information. If there are contradictions, e.g. new information which does not fit into the model, the reader fails to understand the text and probably has to reread parts of the text to build up a better model. It was shown in several experiments that it is easier to understand texts that have only small changes in the five dimensions of text understanding. It also has been found that it is easier for readers to understand a text if the important information is more explicitly mentioned. For this reason several researchers wrote about the importance of fore-grounding important information (see Zwaan&Radvansky 1998 for a detailed list). The other important issue about situation models is the multidimensionality. Here the important question is how are the different dimensions related and what is their weight for constructing the model. Some researchers claim that the weight of the dimensions shifts according to the situation which is described. Introducing such claims will be the final part of this chapter and aims to introduce you to current and future research goals.

The VIP: Rolf A. Zwaan

Rolf A. Zwaan, born September 13, 1962 in Rotterdam (the Netherlands), is a very important person for this topic, since he made the most research (92 publications in total), and also because most of our data bases on his work. Zwaan did his MA (1986) and his Ph.D. (1992) at the Ultrecht University (Netherlands), both cum laude. Since then he collected multiple awards like the Developing Scholar Award (Florida state University, 1999) or the Fellow of the Hanse Institute for Advanced Study (Delmenhorst, Germany, 2003) and became member of several Professional Organisations like the Psychonomic Society, the Cognitive Science Society or the American Psychological Society. He works as Chair of the Biology & Cognitive Psychology at the Erasmus University in Rotterdam (Netherlands), since 2007.

Why do we need situation models?

A lot of tasks which are based on language processing can only be explained by the usage of situation models. The so called situation model or mental model consists of five different dimensions, which refer to different sources. To comprehend a text or just a simple sentence, situation models are useful. Furthermore the comprehension and combination of several texts and sentences can be explained by that theory much better. In the following, some examples are listed why we really need situation models.

Integration of information across sentences

Integration of information across sentences is more than just understanding a set of sentences. For example:

"Gerhard Schroeder is in front of some journalists. Looking forward to new ideas is nothing special for the Ex-German chancellor. It is like in the good old days in 1971 when the leader of the Jusos was behind the polls and talked about changes."

This example only makes sense to the reader if he is aware that *"Gerhard Schroeder"*, *"Ex-German chancellor"* and *"the leader of the Jusos in 1971"* is one and the same person. If we build up a situation model, in this example *"Gerhard Schroeder"* is our token. Every bit of information which comes up will be linked to this token, based on grammatical and world knowledge. The definite article in the second sentence refers to the individual in the first sentence. This is based on grammatical knowledge. Every definite article indicates a connection to an individual in a previous sentence. If there would be an indefinite article, we have to build a new token for a new individual. The third sentence is linked by domain knowledge to the token. It has to be known that "Gerhard Schroeder" was the leader of the Jusos in 1971. Otherwise the connection can only be guessed. We can see that an integrated situation model is needed to comprehend the connection between the three sentences.

Explanation of similarities in comprehension performances across modalities

The explanation of similarities in comprehension performances across modalities can only be done by the usage of situation models. If we read a newspaper article, watch a report on television or listen to a report on radio, we come up with a similar understanding of the same information, which is conveyed through different modalities. Thus we create a mental representation of the information or event. This mental representation does not depend on the modalities itself. Furthermore there is empirical evidence for this intuition. Baggett (1979) found out that students who saw a short film and students who heard a spoken version of the events in the short film finally produced a structurally similar recall protocol. There were differences in the protocols of the two groups but the differences were due to content aspects. Like the text version explicitly stated that a boy was on his way to school and in the movie this had to be inferred.

Domain expertise on comprehension

Situation models have a deep influence for effects of domain expertise on comprehension. In detail this means that person A, whose verbal skills are less than from person B, is able to outperform person B, if he has more knowledge of the topic domain. To give evidence for this intuition, there was a study by Schneider and Körkel (1989). They compared the recalls of "experts" and novices of a text about a soccer match. In the study were three different grades: 3rd, 5th and 7th. One important example in that experiment was that the 3rd grade soccer experts outperformed the 7th grade novices. The recall of units in the text was 54% by the 3rd grade experts and 42% by the 7th grade novices. The explanation is quite simple: The 3rd grade experts built up a situation model and used knowledge from their long-term memory (Ericsson & Kintsch, 1995). The 7th grade novices had just the text by which they can come up with a situation model. Some more studies show evidence for the theory that domain expertise may counteract with verbal ability, i.e. Fincher-Kiefer, Post, Greene & Voss, 1988 or Yekovich, Walker, Ogle & Thompson in 1990.

Explanation of translation skills

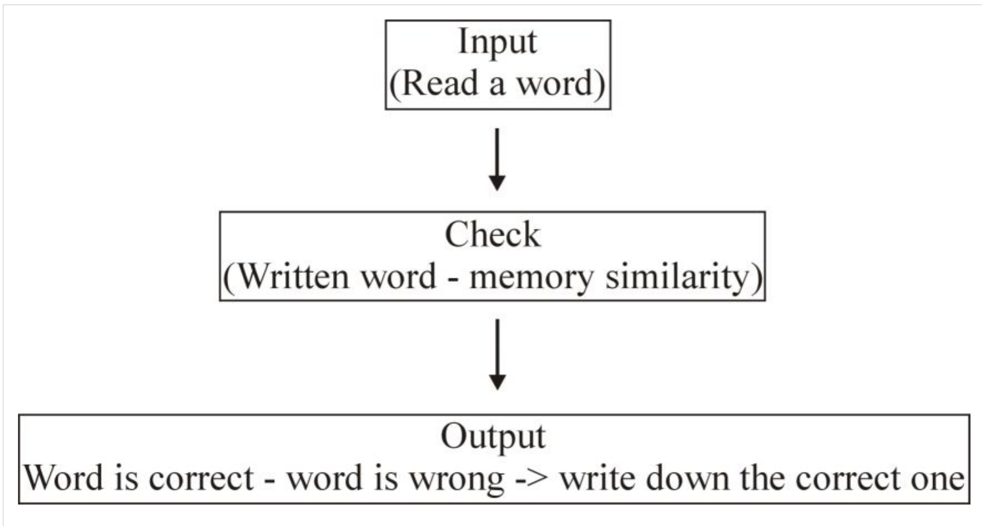
An other example why we need situation models is by trying to explain translation. Translating a sentence or a text from one language to another is not simply done by translating each word and building a new sentence structure until the sentence seems to be sound. If we have a look now at the example of a Dutch sentence:

Now we can conclude that the translation level between Dutch and English is not based on the lexical-semantic level; it is based on the situation level. In this example “don’t do something (action) before you haven’t done something else (another action)”. Other studies came up with findings that the ability to construct situation models during the translation is important for the translation skill (Zwann, Ericsson, Lally and Hill, in 1998).

Multiple source learning

People are able to learn about a domain from multiple documents. This phenomenon can be explained by a situation model, too. For example, we try to learn something about the *“Cold War”* we use different documents with information. The information in one document may be similar to other documents. Referents can be the same or special relationships in the “Cold War” can just be figured out by the usage of different documents. So what we are really doing by learning and reasoning is that we integrate information on the base of different documents into a common situation model, which has got an organized order of the information we’ve learned.

We have seen that we need situation models in different tasks of language processing, but situation models are not needed in all tasks of language processing. An example is proofreading. A proofreader checks every word for its correctness. This ability does not contain the ability to construct situation models. This task uses the resources of the long-term memory in which the correct writing of each word is stored. The procedure is like:



This is done word by word. It is unnecessary to create situation models in this task for language processing.

Multidimensionality of Situation Models

Space

Very often, objects that are spatially close to us are more relevant than more distant objects. Therefore, one would expect the same for situation models. consistent with this idea, comprehenders are slower to recognise words denoting objects distant from a protagonist than those denoting objects close to the protagonist (Glenberg, Meyer & Lindem, 1987).

When comprehenders have extensive knowledge of the spatial layout of the setting of the story (e.g., a building), they update their representations according to the location and goals of the protagonist. They have the fastest mental access to the room that the protagonist is currently in or is heading to. For example, they can more readily say whether or not two objects are in the same room if the room mentioned is one of these rooms than if it is some other room in the building (e.g., Morrow, Greenspan, & Bower, 1987). This makes perfect sense intuitively because these are the rooms that would be relevant to us if we were in the situation.

People's interpretation of the meaning of a verb denoting movement of people or objects in space, such as *to approach*, depends on their situation models. For example, comprehenders interpret the meaning of *approach* differently in *The tractor is just approaching the fence* than in *The mouse is just approaching the fence*. Specifically, they interpret the distance between the figure and the landmark as being longer when the figure is large (tractor) compared with when it is small (mouse). The comprehenders' interpretation also depends on the size of the landmark and the speed of the figure (Morrow & Clark, 1988). Apparently, comprehenders behave as if they are actually standing in the situation, looking at the tractor or mouse approaching a fence.

Time

We assume by default that events are narrated in their chronological order, with nothing left out. Presumably this assumption exists because this is how we experience events in everyday life. Events occur to us in a continuous flow, sometimes in close succession, sometimes in parallel, and often partially overlapping. Language allows us to deviate from chronological order, however. For example, we can say, “Before the psychologist submitted the manuscript, the journal changed its policy.” The psychologist submitting the manuscript is reported first, even though it was the last of the two events to occur. If people construct a situation model, this sentence should be more difficult to process than its chronological counterpart (the same sentence, but beginning with “After”). Recent neuroscientific evidence supports this prediction. Event-related brain potential (ERP) measurements indicate that “before” sentences elicit, within 300 ms, greater negativity than “after” sentences. This difference in potential is primarily located in the left anterior part of the brain and is indicative of greater cognitive effort (Münte, Schiltz, & Kutas, 1998). In real life, events follow each other seamlessly. However, narratives can have temporal discontinuities, when writers omit events not relevant to the plot. Such temporal gaps, typically signalled by phrases such as *a few days later*, are quite common in narratives. Nonetheless, they present a departure from everyday experience. Therefore, time shifts should lead to (minor) disruptions of the comprehension process. And they do. Reading times for sentences that introduce a time shift tend to be longer than those for sentences that do not (Zwaan, 1996).

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All other things being equal, events that happened just recently are
more accessible to us than events that happened a while ago.
Thus, in a situation model, enter should be less accessible after An
hour ago, John entered the building than after A moment ago, John
entered the building.
Recent probe-word recognition experiments support this prediction
(e.g., Zwaan, 1996).
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Causation

As we interact with the environment, we have a strong tendency to interpret event sequences as causal sequences. It is important to note that, just as we infer the goals of a protagonist, we have to infer causality; we cannot perceive it directly. Singer and his colleagues (e.g., Singer, Halldorson, Lear, & Andrusiak, 1992) have investigated how readers use their world knowledge to validate causal connections between narrated events. Subjects read sentence pairs, such as 1a and then 1b or 1a’ and then 1b, and were subsequently presented with a question like 1c:

(1a) Mark poured the bucket of water on the bonfire.

(1a’) Mark placed the bucket of water by the bonfire.

(1b) The bonfire went out.

(1c) Does water extinguish fire?

Subjects were faster in responding to 1c after the sequence 1a-1b than after 1a’-1b. According to Singer, the reason for the speed difference is that the knowledge that water extinguishes fire was activated to validate the events described in 1a-1b. However, because this knowledge cannot be used to validate 1a’-1b, it was not activated when subjects read that sentence pair.

Intentionality

We are often able to predict people’s future actions by inferring their intentionality, i.e. their goals. For example, when we see a man walking over to a chair, we assume that he wants to sit, especially when he has been standing for a long time. Thus, we might generate the inference “He is going to sit.” Keefe and McDaniel (1993) presented subjects with sentences like *After standing through the 3-hr debate, the tired speaker walked over to his chair (and sat down)* and then with probe words (e.g., sat, in this case). Subjects took about the same amount of time to name sat when the clause about the speaker sitting down was omitted and when it was included. Moreover, naming times were significantly faster in both of these conditions than in a control condition in which it was implied that the speaker remained standing.

Protagonists and Objects

Comprehenders are quick to make inferences about protagonists, presumably in an attempt to construct a more complete situation model. Consider, for example, what happens after subjects read the sentence *The electrician examined the light fitting*. If the following sentence is *She took out her screwdriver*, their reading speed is slowed down compared with when the second sentence is *He took out his screwdriver*. This happens because she provides a mismatch with the stereotypical gender of an electrician, which the subjects apparently inferred while reading the first sentence (Carreiras, Garnham, Oakhill, & Cain, 1996).

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Comprehenders also make inferences about the emotional states of
characters.
For example, if we read a story about Paul, who wants his brother Luke
to be good in baseball, the concept of “pride” becomes activated in our
 mind when we read
that Luke receives the Most Valuable Player Award (Gernsbacher,
Goldsmith, & Robertson, 1992).
Thus, just as in real life, we make inferences about people’s emotions
when we comprehend stories.
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Processing Frameworks

Introduction

In the process of language and text comprehension new information has to be integrated into the current situation model. This is achieved by a processing framework. There are various theories and insights on this process. Most of them only model one or some aspects of Situation Models and language comprehension.

A list of theories, insights and developments in language comprehension frameworks:

- an interactive model of comprehension (Kintsch and van Dijk, 1978)
- early Computatinal Model (Miller, Kintsch, 1980)
- Constructing-integration Model (Kintsch, 1988)
- Structure-Building-Framework (Gernsbacher,1990)
- Capacity Constraint Reader Model (Just, Carpenter, 1992)
- Constructivist framework (Graesser, Singer, Trabasso, 1994)
- Event Indexing Model (Zwaan, Langston, Graesser, 1995)
- Landscape Model (van den Brock, Risden, Fletcher, & Thurlow, 1996)
- Capacity-constrained construction-integration Model (Goldman, Varma, Coté, 1996)
- The Immersed Experiencer Framework (Zwaan, 2003)

In this part of the chapter on Situation Models we will talk about several models; we will start with some of the early stuff and then go to the popular later ones. We will start with the work of Kintsch in the 70s and 80s and then go on to later research which is based on this.

An interactive Model of Comprehension

This model was already developed in the 80s; it is the basis for many later models like the CI-Model, or even the Immersed-Experiencer Framework. According to Kintsch and van Dijk (1978), text comprehension proceeds in cycles. In every cycle a few propositions are processed, this number is determined by the capacity of the Short-Term Memory, so 7 plus or minus 2. In every cycle the new propositions are connected to existing ones, they therefore form a connected and hierarchical set.

Early Computational Model

This computational model from Miller and Kintsch tried to model earlier theories of comprehension, to make predictions according to these and compare them to behavioural studies and experiments. It consisted of several modules. One was a chunking program: It's task is to read in one word at the moment, identify if it is a proposition and decide whether to integrate it or not. This part of the model was not done computationally. The next part in the input order was the Microstructure Coherence Program (MCP). The MCP sorted the propositions and stored them in the Working Memory Coherence Graph. The task of the Working Memory Coherence Graph was then to decide which propositions should be kept active during the next processing cycle. All propositions are stored in the Long Term Memory Coherence Graph, this decided which propositions should be transferred back in to the Working Memory or it can construct a whole new Working Memory Graph with a different superordinate node. The problem with this Computational Model was that it show a really low performance. But still it led to further research which tried to overcome it's shortcomings.

Event-Indexing Model

The *Event-Indexing Model* was first proposed by Zwaan, Langston and Graesser (1995). It makes claims about how the incoming information in comprehension is processed and how it is represented in the long-term memory.

According to the *Event-Indexing Model* all incoming actions events are splitted into five indexes. The five indexes are the same as the five situational dimensions, though Zwaan&Radvasnky(1998) claim that there are possibly more dimensions. These might be found in future research. One basic point of this model is the processing time of integrating new events into the current model. It is more easier to integrate a new incoming event if it shares indexes with a previous event. The more contiguous the new event is, the easier it is integrated into the new Situation Model. This prediction made by Zwaan & Radvanksy (1998) is supported by some prior research (Zwaan, Magliano and Graesser, 1995). The other important point of the *Event-Indexing Model* is the representation in long-term memory. Zwaan & Radvasnky (1998) predict that this representation is a network of nodes, these nodes encode the events. The nodes are linked with each other through situational links according to the indexes they share. This connection does not only encode if two nodes share indexes but it also encodes the number of shared indexes through its strength. This second point already hints what the *Event-Indexing Model* lacks. There are several things which it does not include. For example it does not encode the temporal order of the events nor the direction of the causal relationships. The biggest disadvantage of the *Event-Indexing Model* is clearly that it treats the different dimensions as different entities though they probably interact with each other.

Radvansky & Zwaan (1998) updated the *Event-Indexing Model* with some features. This new model splits the processed information into three types. These three types are the situational framework, the situational relations and the situational content. The situational framework grounds the situation in space and time and it's construction is obligatory. If no information is given this framework is probably build up by standard values retrieved from prior world knowledge or some empty variable would be instantiated. he situational relations are based on the five situational dimensions. These are analysed through the *Event-Indexing Model*. This kind of situational information includes not the basic information, which is given in the situational framework, but the relationships between the different entities or nodes in the network. In contrast to the situational framework the situational relations are not obligatory. If there is no information given or there are no possible inferences between entities, then there is simply no relationship there. There is also an index which addresses importance to the different relations. This importance consists of the necessity of the information to understand the situation, the easiness to inference it when it would not be mentioned and how easy the information can later be remembered. Another distinction this theory makes is the one between functional and non-functional relations (Carlson-Radvansky & Radvansky, 1996; Garrod & Sanford, 1989). Functional relations describe the interaction between different entities whereas non-functional relations are the ones between non-interacting entities. The situational content consists of the entities in the situation like protagonists and objects and their properties. These are only integrated explicitly in the Situation Model, like situational relations, if they are necessary for the understanding of the situation. Nonetheless the central and most important entities and their properties are obligatory again. It is proposed that, in order to keep the processing time low, non-essential information is only represented by something like a pointer so that this information can be retrieved if necessary.

The Immersed Experiencer Framework

The Immersed Experiencer Framework (IEF) is based on prior processing framework models (see above for a detailed list) but tries to include several other research findings too. For example it was found that during comprehension brain regions are activated, which are very close or even overlap with brain regions which are active during the perception or the action of the words meaning (Isenberg et al., 2000; Martin & Chao, 2001; Pulvermüller, 1999, 2002). During comprehension there is also a visual representation of shape and orientation of objects (Dahan & Tanenhaus, 2002; Stanfield & Zwaan, 2002; Zwaan et al., 2002; Zwaan & Yaxley, in press a, b). Visual-spatial information primes sentence processing (Boroditsky, 2000). These visual representations can interfer with the comprehension (Fincher-Kiefer, 2001). Findings from (Glenberg, Meyer, & Lindem, 1987; Kaup & Zwaan, in press; Morrow *et al.*, 1987; Horton & Rapp, in press; Trabasso & Suh, 1993; Zwaan et al., 2000) suggest that information which is part of the situation and the text is more active in the reader's mind than information which is not included. The fourth research finding is that people move their eyes and hand during comprehension in a consistent way with the described the situation. (Glenberg & Kaschak, in press; Klatzky et al., 1989; Spivey et al., 2000).

The main point of the Immersed Experiencer Framework is the idea that words active experiences with their referents. For example "an eagle in the sky" activates a visual experience of a eagle with stretched-out wings while "an eagle in the nest" activates a different visual experience. According to Zwaan (2003) the IEF should be seen as an engine to make predictions about language comprehension. These predictions are then suggested for further research.

According to the IEF the process of language comprehension consists of three components, these are activation, construal and integration. Each component works at a different level. Activation works at the world level, construal is responsible for the clause level while integration is active at the discourse level. Though the IEF shares many points with earlier models of language comprehension it differs in some main points. For example it suggests that language comprehension involves action and perceptual representations and not amodal propositions (Zwaan, 2003).

Levels of Representation in Language and Text Comprehension

A lot of theories try to explain the situation model or so called mental model in different representations. Several theories of the representation deal with the comprehension from the text into the situation model itself. How many levels are included or needed and how is the situation model constructed, is it done by once like:

Sentence → Situation Model

Or are there levels in between which have to be passed until the model is constructed? Here are three different representations shown which try to explain the construction of the situation model by a text.

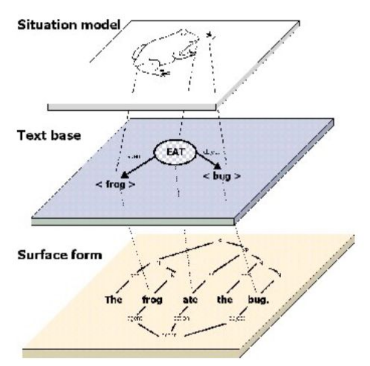
Propositional Representation

The propositional Representation claims that a sentence will be structured in another way and then it is stored. Included information does not get lost. We will have a look at the simple sentence:

"George loves Sally" the propositional representation is [LOVES(GEORGE, SALLY)]

It is easy to see that the propositional representation is easy to create and the information is still available.

Three levels of representation



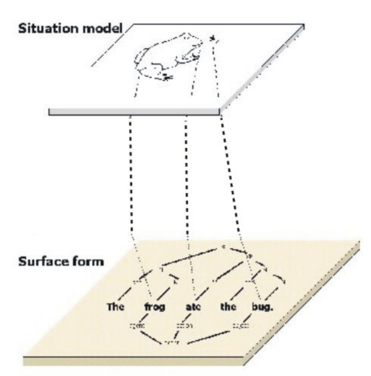
Fletcher(1994); van Dijk & Kintch(1983); Zwaan & Radvansky (1998)

This theory says that there exist three levels of representation the surface form, text base and the situation model. In this example the sentence "The frog ate the bug." Is already the surface form. We naturally create semantically relations to understand the sentence (semantic tree in the figure). The next level is the "Text base". [EAT(FROG, BUG)] is the propositional representation and *Text base* is close to this kind of representation, except that it is rather spatial. Finally the situation model is constructed by the "Text base" representation. We can see that the situation model does not include any kind of text. It is a mental picture of information in the sentence itself.

Two levels of representation

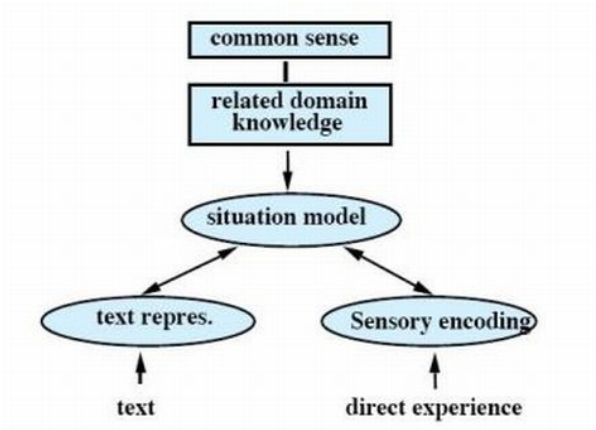
This theory is like the "three levels of representations" theory. But the "Text base" level is left out. The theory itself claims that the situation model is created by the sentence itself and there is no "Text base" level needed.

Further situation model theories directing experiences exist. So not only text comprehension is done by situation models, learning through direct experience is handled by situation models, too.



Frank Koppen, Nordman, Vonk (to appear) Zwaan (2004)

KIWi-Model



A unified model by "Prof. Dr." Schmalhofer

One unified model the so called KIWi-Model tries to explain how text representation and direct experience interact with a situation model. Additionally the domain knowledge is integrated. The domain knowledge is used by forming a situation model in different tasks like simple sentence comprehension (chapter: Why do we need Situation Models). The KIWi-Model shows that a permanent interaction between “text representation → situation model” and between “sensory encoding → situation model” exists. These interactions supports the theory of a permanent updating of the mental model.

Inferencing

Inferencing is used to build up complex situation models with limited information. For example: in 1973 John Bransford and Marcia Johnson made a memory experiment in which they had two groups reading variations of the same sentence.

The first group read the text "*John was trying to fix the bird house. He was* ***pounding*** *the nail when his father came out to watch him do the work*"

The second group read the text "*John was trying to fix the bird house. He was* ***looking for*** *the nail when his father came out to watch him do the work*"

After reading, some test statements were presented to the participants. These statements contained the word *hammer* which did not occur in the original sentences, e.g.: "*John was using a hammer to fix the birdhouse. He was looking for the nail when his father came out to watch him*". Participants of the first group said they had seen 57% of the test statements, while the participants from the second group had seen only 20% of the test statements.

As one can see, in the first group there is a tendency of believing to have seen the word *hammer*. The participants of this group made the inference, that John used a hammer to pound the nail. This memory influence test is good example to get an idea what is meant by making inferences and how they are used to complete situation models.

While reading a text, inferencing creates information which is not explicitly stated in the text; hence it is a creative process. It is very important for text understanding in general, because texts cannot include all information needed to understand the sense of a story. Texts usually leave out what is known as *world knowledge*. World knowledge is knowledge about situations, persons or items that most people share, and therefore don't need to be explicitly stated. Each person should be able to infer this kind of information, as for example that we usually use hammers to pound nails. It would be impossible to write a text, if it had to include all information it deals with; if there was no such thing like inferencing or if it was not automatically done by our brain.

There is a number of different kinds of inferences:

Anaphoric Inference

This kind of Inferencing usually connects objects or persons from one to another sentence. Therefore it is responsible for connecting cross-sentence information. E.g. in "*John hit the nail. He was proud of his stroke*", we directly infer that "he" and "his" relate to "John". We normally make this kind of inference quite easily. But there can be sentences where more persons and other words relating to them are mixed up and people have problems understanding the story at first. This is normally regarded as bad writing style.

Instrumental Inference

This type of Inference is about the tools and the methods used in the text, like the hammer in the example above. Or for example, if you read about somebody flying to New York, you would not infer that this person has built a dragon-flyer and jumped off a cliff but that he or she used a plane, since there is nothing else mentioned in the text and a plane is the most common form of flying to New York. If there is no specific information about tools, instruments and methods, we get this information from our *General World Knowledge*

Causal Inference

Causal Inference is the conclusion that one event caused another in the text, like in "He hit his nail. So his finger ached". The first sentence gives the reason why the situation described in the second sentence came to be. It would be more difficult to draw a causal inference in an example like "He hit his nail. So his father ran away", although one could create an inference on this with some fantasy.

Causal inferences create causal connections between text elements. These connections are separated into *local connections* and *global connections*. Local connections are made within a range of 1 to 3 sentences. This depends on factors like the capacity of the working memory and the concentration due reading. Global connections are drawn between the information in one sentence together with the background information gathered so far about the whole text. Problems can occur with Causal Inferences when a story is *inconsistent.* For example, vegans eating steak would be inconsistent. An interesting fact about Causal Inferences (Goldstein, 2005) is that the kind of Inferences we draw here that are not easily seen at first are easier to remember. This may be due to the fact that they required a higher mental processing capacity while drawing the inference. So this "not-so-easy" inference seems to be marked in a way that it is easier to remember it.

Predictive / Forward Inference

Predictive/Forward Inferences uses the *General World Knowledge* of the reader to build his prediction of the consequences of what is currently happening in the story into the Situation Model.

Integrating Inferences into Situation Models

The question how models enter inferential processes is highly controversial in the two disciplines of cognitive psychology and artificial intelligence. A.I. gave a deep insight in psychological procedures and since the two disciplines crossed their ways and give two main bases of the cognitive science. The arguments in these are largely independent from each other although they have much in common.

Johnson-Laird (1983) makes a distinction between three types of reasoning-theories in which inferencing plays an important role. The first class gears to logical calculi and have been implemented in many formal system. The programming language Prolog arises from this way of dealing with reasoning and in psychology many theories postulate formal rules of inference, a "mental logic." These rules work in a purely syntactic way and so are "context free," blind for the context of its content. A simple example clarifies the problem with this type of theory:

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If patients have cystitis, then they are given penicillin.
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and the logical conclusion:

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If patients have cystitis and are allergic to penicillin, then they are given penicillin
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This is logically correct, but seems to fail our common sense of logic.

The second class of theories postulate content specific rules of inference. Their origin lies in programming languages and production systems. They work with forms like "If x is a, then x is b". If one wants to show that x is b, showing that x is a is a sub-goal of this argumentation. The idea of basing psychological theories of reasoning on content specific rules was discussed by Johnson-Laird and Wason and various sorts of such theories have been proposed. A related idea is that reasoning depends on the accumulation of specific examples within a connectionist framework, where the distinction between inference and recall is blurred.

The third class of theories is based on mental models and does not use any rules of inferencing. The process of building mental models of things heard or read. The models are in an permanent change of updates. A model built, will be equipped with new features of the new information as long as there is no information, which generates a conflict with that model. If this is the case the model is generally re-built, so that the conflict generating information fits into the new model.

Important Topics of current research

Linguistic Cues versus World Knowledge

According to many researchers, language is the set of processing instructions on how to build up the Situation Model of the represented situation (Gernsbacher, 1990; Givon, 1992; Kintsch, 1992; Zwaan & Radvansky, 1998). As mentioned, readers use the lexical cues and information to connect the different situational dimensions and integrate them into the model. Another important point here is prior world knowledge. World knowledge also influences how the different information in a situation model are related. The relation between linguistic cues and world knowledge is therefore an important topic of current and future research in the area of Situation Models.

Multidimensionality

Another important aspect of current research in the area of Situation Models is the Multidimensionality of the Models. The main aspect is here how the different dimensions relate to each other, how they influence and interact. The question here is also if they interact at all and which interact. Most studies in the field were only about one or a few of the situational dimensions.

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