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A pre-semantics for counterfactual conditionals and similar logics

Karl Schlechta *†

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Abstract

The elegant Stalnaker/Lewis semantics for counterfactual conditonals works with distances between models. But human beings certainly have no tables of models and distances in their head.

We begin here an investigation using a more realistic idea, based on findings in neuroscience. We call it a pre-semantics, as its meaning is not a description of the world, but of the corresponding structure in the brain, which is (partly) determined by the world it reasons about.

Our basic concept is that of a "picture" or "scenario" on the meaning level, a group of connected neurons on the neural level.

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1 Introduction

1.1 The Stalnaker/Lewis semantics for counterfactual conditionals

Stalnaker and Lewis, see e.g. [Sta68], [Lew73], gave a very elegant semantics to counterfactual conditionals, based on minimal change. To give meaning to the sentence "if it were to rain, I would take an umbrella", we look at all situations (models) where it rains, and which are minimally different from the present situation. If I take an umbrella in all those situations, then the sentence is true. E.g., situations where there is hurricane - and I will therefore not take an umbrella - will, usually, be very different from the present situation.

This idea is very nice, but we do not think this way. First, we have no catalogue of all possible worlds in out head. Thus, we will have to compose the situations to consider from various fragments. Second, classical reasoning, taken for granted in usual semantics, has an "inference cost". E.g., when reasoning about birds, we might know that penguins are birds, but they might be too "far fetched", and forgotten.

It seems that human beings reason in pictures, scenes, perhaps prototypes, but in relatively vague terms. We try to use a more plausible model of this reasoning, based on neural systems, to explain counterfactual conditionals. But the basic Stalnaker/Lewis idea is upheld.

First, we develop in the next section our ideas how we think. We will see that the main problems on our level are conceptual in nature. It seems difficult to find elementary, atomic, pictures and corresponding connected groups of neurons, so we postulate that there are none. We can always analyse, look inside, and, conversely, combine. The right level of abstraction depends on the structure examined. In addition, there is no surface as opposed to an inside, as cells have, all inter-group connections seem to go from inside to inside.

At the end, we come back to our initial problem, the meaning of counterfactual conditionals.

Our ideas are very rudimentary, all details are left open. Still, we think that it is a reasonable start. We might be overly flexible in our concepts, but it is probably easier to become more rigid later, than inversely.

(Note that the case of update is somewhat different. In update, the question is how the actual world changes, and not how we believe the world (and we) behave, as is the case here.)

2 Background

2.1 Introduction

We discuss here our ideas how human beings think: not in propositions and logical operators, or in models, but in pictures, scenarios, prototypes, etc. On the neural level, such pictures correspond to groups of neurons.

We will be vague, on the meaning level, as well as the neural level. This vagueness results in flexibility, the price to pay are conceptual difficulties.

We have three types of objects:

(1) pictures or groups (of neurons),

(2) connections,

(3) attention.

Groups will be connected areas of the brain, corresponding to some picture, groups may connect to other groups with different types of connectors, which may be positive or negative. Finally, attention focusses on groups or parts of groups, and their connections, or part thereof.

Groups do not necessarily correspond to nodes of graphs, as they are not atomic, and they can combine to new groups. Attention may hide contradictions, so the whole picture may contain contradictions.

We use the word "group" to designate

- on the physiological level a (perhaps only momentarily) somehow connected area of the brain, they may be formed and dissolved dynamically,

- on the meaning level a picture, scene (in the sense of conscious scene), a prototype (without all the connotations the word "prototype" might have), any fragment of information. It need not be complete with all important properties, birds which fly, etc., it might be a robin sitting on a branch in sunshine, just any bit of information, abstract, concrete, mixture of both, whatever.

2.2 Some (Simplified) Facts About Neurons

Neurons have (often many) dendrites, one core (soma), and one axon. Dendrites have often many branches, so do axons. Basically, signals arrive at the dendrites, travel through the core, and are emitted through the axon. The connection between two neurons is called a synapse, the axon of neuron 1 leads to a synapse, where it connects to a dendrite of neuron 2. The synapse can be excitatory (positive), or inhibitory (negative). Thus, a neuron may send a positive signal (+1) to another neuron via a positive synapse, -1 via a negative synapse, or no signal at all, 0, when there is no connection, or the neuron does not fire. So, it is +1, -1, or 0.

Remark: A negative synapse does not correspond (directly) to negation. When group N_1 codes "black", N_2 codes "white", then a negative connection between N_1 and N_2 in both ways blocks activity of the other group, when one is active. E.g., N_2 does not code "not black", as "yellow" is not black either, but not coded by N_2. Negative links rather work for coherence.

If, within a certain time interval, the sum of positive signals Σ^+, i.e. from positive synapses, arriving at the dendrites of a neuron is sufficiently bigger than the sum of negative signals Σ^-, i.e. from negative synapses, arriving at the dendrites of the same neuron, the neuron will fire, i.e. send a signal via its axon to other neurons. This is a 0/1 reaction, it will fire or not, and always with the same strength. (If Σ^+ is much bigger than Σ^-, the neuron may fire with a higher frequency. We neglect this here.)

2.3 Comparison to Defeasible Inheritance Networks

For an overview of defeasible inheritance, see e.g. [Sch97-2].

Note that several neurons may act together as an amplifier for a neuron: Say N_1 connects positively to N_2 and N_3, and N_2 and N_3 each connect positively to N_4, and N_1 is the only one to connect to N_2 and N_3, then any signal from N_1 will be doubled in strength when arriving at N_4, in comparison to a direct signal from N_1 to N_4.

(1) Consequently, direct links do not necessarily win over indirect paths. If, in addition, N_1 is connected negatively to N_4, then the signal from N_1 to N_4 is 2 for positive value (indirect via N_2 and N_3) and -1 for negative value (direct to N_4), so the indirect paths win.

(2) By the same argument, longer paths may be better.

On the other hand, a longer path has more possibilities of interference by other signals of opposite polarity.

So length of path is no general criterion, contrary to inheritance systems, where connections correspond to "soft" inclusions.

(3) The number of paths of the same polarity is important, in inheritance systems, it is only the existence.

(4) There is no specificity criterion, and no preclusion.

(5) In inheritance systems, a negative arrow may only be at the end of a path, it cannot continue through a negative arrow. Systems of neurons are similar: If a negative signal has any effect, it prevents the receiving neuron from firing, so this signal path is interrupted.

(6) Neurons act directly sceptically - there is no branching into different extensions.

2.4 The Elements of Human Reasoning

It seems that humans (and probably other animals) think in scenarios, prototypes, pictures, etc., which are connected by association, reasoning, developments, etc. We do not seem to think in propositions, models,

properties, with the help of logical operators, etc. This will be secondary, by people who are educated in logic, children who learnt to speak a language, etc.

We have to look at above scenarios or pictures. For simplicity, we call them all "pictures". Pictures can be complex, represent developments over time, can be combined, analysed, etc., they need not be precise, may be inconsistent, etc. We try to explain this, looking simultanously at the thoughts, "meanings" of the pictures, and the underlying neural structures and processes.

We imagine these scenarios etc. to be realised on the neural level by neurons or groups of neurons, and the connections between pictures also by neurons, or bundles of neurons.

To summarize, we have

(1) Pictures,

on the

- meaning level, they correspond to thoughts, scenarios, pictures, etc.
- neural level, they correspond to neurons, clusters of connected neurons, etc.

(2) Connections or paths,

on the

- meaning level, they correspond to associations, deductions, developments, etc.
- neural level, they correspond to neurons, bundles of more or less parallel neurons, connecting groups of neurons, etc.

All that follows is relative to this assumption about human reasoning.

2.4.1 Pre-semantics and Semantics

In logic, a sentence like "it rains", or "if it were to rain, I would take an umbrella" has a semantics, which describes a corresponding state in the world.

We describe here what happens in our brain - according to our hypothesis - and what corresponds to this "brain state" in the real world. Thus, what we do is to describe an intermediate step between an expression in the language, and the semantics in the world.

For this reason, we call this intermediate step a pre-semantics.

In other words, real semantics interpret language and logic in (an abstraction of) the world. Pre-semantics is an abstraction of (the functioning of) the brain. Of course, the brain is "somehow" connected to the world, but this would then be a semantics of (the functioning of) the brain. Thus, this pre-semantics is an intermediate step between language and the world.

2.5 Pictures: the Language and the Right Level of Abstraction

2.5.1 The Level of Meaning

A picture can be complex, we can see it as composed of sub-pictures. A raven eats a piece of cheese, so there are a raven, a piece of cheese, perhaps some other objects in this picture. The raven has a beak, etc.

It is not clear where the "atomic" components are. On the neural level, we have single neurons, but they might not have meaning any more.

To solve this, we postulate that there are no atomic pictures, we can always decompose and analyse. For our purposes, this seems the best way out of the dilemma.

In one context, the raven eating the cheese is the right level of abstraction, we might be interested in the behaviour of the raven. In a different context, it might be the feathers, the beak of the animal, or the taste of the cheese. Thus, there is no uniform adequate level of abstraction, it depends on the context.

Relation to Models Pictures will usually not be any models in the logical sense. There need not be any language defined, some parts may be complex and elaborate, some parts may be vague or uncertain, or only rough sketches, different qualities like visual, tactile, may be combined. Pictures may also be inconsistent.

2.5.2 The Neural Level

On the neural level, pictures will usually be realised by groups of neurons, consisting perhaps of several thousands neurons. Those groups will have an internal coherence, e.g. by strong internal positive links among their neurons. But they will not necessarily have a "surface" like a cell wall to which other cells or viruses may attach. The links between groups go (basically) from all neurons of group 1 to all neurons of group 2. There is no exterior vs. interior, things are more flexible.

If group 1 "sees" (i.e. is positively connected to) all neurons of group 2, then group 2 is the right level of abstraction relative to group 1 (and its meaning). (In our example, group 1 looks at the behaviour of the raven.) If group 1a "sees" only a subgroup of group 2 (e.g. the feathers of the raven), either by having particularly strong connections to this subgroup, or by having negative connections to the rest of group 2, then this subgroup is the right level of abstraction relative to group 1a. Thus, the "right" level of abstraction is nothing mysterious, and does not depend on our speaking about the pictures, but is given by the activities of the neuron groups themselves.

(We neglect that changing groups of neurons may represent the same pictures.)

2.5.3 The Conceptual Difficulties of this Idea

This description has certain conceptual difficulties.

(1) In logic, we have atoms (like propositional variables), from which we construct complex propositions with the use of operators like $\wedge$, $\vee$, etc. Here, our description is "bottomless", we have no atoms, and can always look inside.

(2) There is no unique adequate level of abstraction to think about pictures. The right granularity depends on the context, it is dynamic.

(3) The right level of abstraction on the neural level is not given by our thoughts about pictures, but by the neural system itself. Other groups determine the right granularity.

(4) Groups of neurons have no surface like a cell or a virus do, there is no surface from which connections arise. Connections go from everywhere.

2.5.4 Summary

- "Pictures" on the meaning level correspond to (coherent) groups of neurons.
- There are no minimal or atomic pictures and groups, they can always be decomposed (for our purposes). Single neurons might not have any meaning any more.
- Conversely, they can be composed to more complex pictures and groups.
- Groups of neurons have no surface, connections to other groups are from the interior.

2.6 Connections or Paths

One neuron can connect to another neuron via axon, synapse, dendrite. This is the simplest connection.

Connections may also be indirect, N_1 via N_2 to N_3, etc. Groups of neurons may connect to other groups of neurons in various ways, some direct, some indirect, etc., by single neurons and synapses, or by bundles of neurons and synapses.

We sometimes call all such connections paths.

Connections may correspond to many different things on the meaning level. They may be:

(1) arbitrary associations, e.g. of things which happened at the same moment,

(2) inferences, classical or others,

(3) connections between related objects or properties, like between people and their ancestors, animals of the same kind, etc.,

(4) developments over time, etc.

Again, there are some conceptual problems involved.

(1) As for pictures, it seems often (but perhaps less dramatically) difficult to find atomic connections. If group N_1 is connected via path P to group N_2, but N_1' is a sub-group of N_1, connected via a subset P' of P to sub-group N_2' of N_2, then it may be reasonable to consider P' as a proper path itself.

(2) If, e.g., the picture describes a development over time, with single pictures at time t, t', etc. linked via paths expressing developments, then we have paths inside the picture, and the picture itself may be considered a path from beginning to end.

    Thus, paths may be between pictures, or internal to pictures, and there is no fundamental distinction between paths and pictures. It depends on the context. More abstractly, the whole path is a picture, in more detail, we have paths between single pictures, "frames", as in a movie.

Remember: Everything is just suitably connected neurons!

2.6.1 Comments on Groups and Connections

(1) The use of a group of neurons makes this group easier accessible, and strengthens its internal coherence.

    Thus, the normal case becomes stronger.

(2) The use of a neural connection strengthens this connection. Again, the normal connections become stronger. Both properties favour learning, but may also lead to overly rigid thinking and prejudice.

    Note that this is the opposite of basic linear logic, where the use of an argument consumes it.

(3) When two groups of neurons, N_1 and N_2 are activated together, this strengthens the connection between N_1 and N_2. We call this the Δ-rule. See e.g. [Pul13].

    This property establishes associations. When I hear a roar in the jungle, and see an attacking tiger, next time, I will think "tiger" when I hear a roar, even without seeing the tiger.

(4) A longer connection may be weaker. For instance, penguins are an abnormal subclass of birds. Going from birds to penguins will not be via a strong connection (though *penguin* $\rightarrow$ *bird* is a classical inference). If Tweety is a penguin, we might access Tweety only by detour through penguin. Thus, Tweety is "less" bird than the raven which I saw in my garden. Consequently, the subset relation involved in the properties of many nonclassical logics has a certain "cost", and the resulting properties (e.g. $X \subseteq Y \rightarrow \mu(Y) \cap X \subseteq \mu(X)$ for basic preferential logic, similar properties for theory revision, update, counterfactual conditionals) cannot always be expected.

2.6.2 Summary

- Connections are made of single axon-synapse-dendrite tripels, connecting one neuron to another, or many such tripels, bundels, or composed bundels. Again, it seems useful to say that connections can usually be decomposed into sub-connections.

- Connections can be via excitatory or inhibitory synapses, the former activate the downstream neuron, the latter de-activate the downstream neuron.
- Connections can have very different meanings.
- Connections can be interior to groups, or between groups.
- There usually is no clear distinction between groups and connections.

2.7 Operations on Pictures and Connections

To simplify, we will pretend that operations are composed of cutting and composing. We are aware that this is probably artificial, and, more generally, an operation takes one or more pictures (on the meaning level) or groups (on the neural level), and constructs one or more new pictures or groups.

Before we describe our ideas, we discuss attention.

2.7.1 Attention

An additional ingredient is "attention". We picture attention as a light which shines on some areas of the brain, groups of neurons, perhaps only on parts of those areas, and their connections, or only parts of the connections.

Attention allows, among other things, to construct a seemingly coherent picture by focussing only on parts of the picture, which are coherent. In particular, we might focus our attention on coherences, e.g., when we want to consolidate a theory, or incoherences, when we want to attack a theory. Focussing on coherences might hide serious flaws in a theory, or our thinking in general. In context A, we might focus on α, in context B, on β, etc.

As we leave attention deliberately unregulated, changes in attention may have very "wild" consequences.

Activation means that the paths leading to the picture become more active, as well as the internal paths of the picture.

Thus, whereas memory (recent use) automatically increases activity, attention is an active process.

Conversely, pictures which are easily accessible (active paths going there), are more in the focus of our attention. E.g., we are hungry, think of a steak (associative memory), and focus our attention on the fridge where the steak is.

Attention originates in the "I" and its aims and desires. Likewise, "accessibility" is relative to the "I" - whatever that means. (This is probably a very simplistic picture, but suffices here. We conjecture that the "I" is an artifact, a dynamic construction, with no clear definition and boundary. The "I" might be just as elusive as atomic pictures.) Attention is related to our aims (find food, avoid dangers, etc.) and allows to focus on certain pictures (or parts of pictures) and paths.

2.7.2 Operations

Consider the picture of a raven eating a piece of cheese.

We might focus our attention on the raven, and neglect the cheese. It is just a raven, eating something, or not. So the connection to the raven part will be stronger (positive), to the cheese part weaker positive and/or stronger negative.

Conversely, we might never have seen a raven eat a piece of cheese. But we can imagine a raven, also a raven eating something, and a piece of cheese, and can put these pictures together. This may be more or less refined, adjusting the way the cheese lies on the ground, the raven pecks at it, etc. It is not guaranteed that the picture is consistent, and we might also adjust the picture "on the fly" to make it consistent or plausible.

(When composing "raven" with "cheese" and "pecking", the order might be important: Composing "raven" first with "pecking" and the result "raven + pecking" with "cheese", or "raven" with "pecking + cheese" might a priori give different results.)

It is easy to compose a picture of an elefant with the picture of wings, and to imagine an elefant with small wings which hovers above the ground. Of course, we know that this is impossible under normal circumstances. There is no reality check in dreams, and a flying elefant is quite plausible.

This is all quite simple (in abstract terms), and everyone has done it. Details need to be filled in by experimental psychologists and neuroscientists.

Obviously, these problems are related to planning.

Identification vs Description We may address a (part of a) picture without having a description of it, an identification suffices.

Suppose we see an animal, and hear some strange frightening noise. We can address the noise by the label "that scary noise" without being able to describe the noise more precisely. We can isolate, compose, etc. this part of the picture, the identification is enough. In above scenario, we used descriptions of elefants, wings, etc., but this is not always necessary.

3 Analysis of Counterfactual Conditionals

We apply our ideas to counterfactuals.

Note that the Stalnaker/Lewis semantics hides all problems in the adequate notion of distance, so we should not expect miracles from our approach.

3.1 The Umbrella Scenario

"If it were to rain, I would take an umbrella."

We have the following present situations, where the sentence is uttered.

(1) Case 1: The "normal" case. No strong wind, I have at least one hand free to hold an umbrella, I do not want to get wet, etc.

(2) Case 2: As case 1, but strong wind.

(3) Case 3: As case 1, but I carry things, and cannot hold an umbrella.

We have the following pictures in our memory:

(1) Picture 1: Normal weather, it rains, we have our hands free, but forgot the umbrella, and get soaked.

(2) Picture 2: As picture 1, but have umbrella, stay dry.

(3) Picture 3: Rain, strong wind, use umbrella, umbrella is torn.

(4) Picture 4: As picture 1, but carry things, cannot hold umbrella, get soaked.

(5) Picture 5: The raven eating a piece of cheese.

Much background knowledge goes into our treatment of counterfactuals. For instance, that a strong wind might destroy an umbrella (and that the destruction of an umbrella in picture 3 is not due to some irrelevant aspect), that we need at least one hand free to hold an umbrella, that we want to stay dry, that we cannot change the weather, etc.

First, we actively (using attention) look for pictures which have something to do with umbrellas. Thus, in all cases, picture 5 is excluded.

Next, we look at pictures which support using an umbrella, and those which argue against this. This seems an enormous amount of work, but our experience tells us that a small number of scenarios usually give the answer. There are already strong links to those scenarios.

Case 1: Pictures 3 and 4 do not apply - they are too distant in the Stalnaker/Lewis terminology. So we are left with pictures 1 and 2. As we want to stay dry, we choose picture 2. Now, we combine case 1 with picture 2 by suitable connections, and "see" the imagined picture where we use an umbrella and stay dry.

Case 2: Pictures 1 and 4 do not apply. I would prefer to stay dry, but a torn umbrella does not help. In addition, I do not want my umbrella to be torn. Combining case 2 with picture 3 shows that the umbrella is useless, so I do not take the umbrella.

Case 3: Only picture 4 fits, I combine and see that I will get wet, but there is nothing I can do.

3.2 A Tree Felling Scenario

Consider the sentence:

"If I were to fell that tree, I would hammer a pole into the ground, and tie a rope between tree and pole, so the tree cannot fall on the house."

We have the present situation where the tree stands close to the house, there are neither rope nor pole, nor another solid tree where we could anchor the rope, and we do not want to fell the tree.

We have

- Picture 1 of a pole being hammered into the ground - for instance, we remember this from camping holidays.
- Picture 2 of a rope tied to a tree and its effect - for instance, we once fastened a hammock between two young trees and saw the effect, bending the trees over.
- Picture 3 of someone pulling with a rope on a big tree - it did not move.

We understand that we need a sufficiently strong force to prevent the tree from falling on the house.

Pictures 2 and 3 tell us that a person pulling on the tree, or a rope tied to a small tree will not be sufficient.

As there is no other sturdy tree around, we have to build a complex picture. We have to cut up the hammock Picture 2 and the tent Picture 1, using the rope part from Picture 2, the pole part from Picture 1. It is important that the pictures are not atomic. Note that we can first compose the situation with the pole part, and the result with the rope part, or first the situation with rope part, and the result with the pole part, or first combine the pole part with the rope part, and then with the situation. It is NOT guaranteed that the outcome of the different ways will be the same. When there are more pictures to consider, even the choice of the pictures might depend on the sequence.

4 Comments

There are many aspects we did not treat. We established a framework only.

(1) Usually, there are many pictures to choose. How do we make the choice?

(2) How do we cut pictures?

(3) How do we determine if a combined picture is useful?

(4) Attention can hide inconsistencies, or focus on inconsistencies, how do we decide?

(5) Are all these processes on one level, or is it an interplay between different levels (execution and control)?

(6) These processes seem arbitrary, but we are quite successful, so there must be a robust procedure to find answers.

Some of the answers will lie in the interplay between (active) attention and more passive memory (more recent and more frequently used pictures and processes are easier accessible). Recall here Edelman's insight, see e.g. [Ede89], [Ede04], to see the parallels between the brain and the immune system, both working with selection from many possibilities. We assume that we have many candidates of the same type, so we have a population from which to chose. We chose the best, and consider this set for the properties of those combined areas.

It is natural to combine the ideas of the hierarchy in [GS16], chapter 11 there, with our present ideas. Exceptional classes, like penguins, are only loosely bound to regular classes, like birds; surprise cases even more loosely.

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