Notes on cognitive ontologies

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1 Introduction

I have been trying to think about how to develop an ontology for cognitive psychology and it has lead me to some difficult terrain. So here are some ideas, in no particular order.

1. A major motivator for me to develop my brain model was my need to be able to talk clearly about psychology. So my brain model does actually provide an ontology, or the beginnings of one. I did write a brief note a few months ago indicating one connection between my model and cognitive phenomics. I will expand this in another note, but the main concepts are cortical modules, descriptions, rules, competition, weights, storage, associative access, transmission of data, and confirmation, and you define other cognitive concepts in terms of these. This approach is thus to first devise an ontology for neuropsychology.

2. Instead, of course, as Russell Poldrack remarked, an ontology of cognitive psychology should be derived from how a society of cognitive psychologists think and describe cognition to each other. This leads to a quite small number of concepts, and a pretty well flat ontology, i.e. very few is-a or part-of relations, as given in the Darpa ontology of cognition.

3. However, it seems to me that if we take an ontology to be a set of concepts that is agreed by a social group, then in the case of a living science, this set of concepts will be constantly changing, so there is a real conflict between the idea of standardizing concepts and their terminology so that findings and theories can be compared, and also entered into computer databases, on the one hand, and the actual use of concepts and language in practice on the other.

4. I emailed a friend of mine, Fiona Cowie, who is professor of philosophy at Caltech and she said she had been thinking about related ideas and she sent me a draft of a paper she

is working on. She is interested in, among other things, the idea of innateness in science.

5. The use of language by scientists has to be a difficult subject. My impression is that:

The continuous introduction of new concepts
New concepts and terms are introduced fairly readily so that every year there are new ideas and terminology.

Dynamic change in the meanings of terms
Existing terms are constantly changing in their meaning.

Multiple overlapping descriptions
There are usually multiple overlapping ways of describing a given situation and scientists use all of them. They try to find the one that best fits their current purpose.

Multiple construals in exact sciences
Even in established, worked out, sciences such as physics, there are multiple ways of construing a given physical system.

The concept of innate
In Fiona's paper she shows all the different ways in which the term "innate" is used, and showing that these are all used in various different situations, even though they all have different meanings.

A historical example
Fiona also recounts a historical case where the theory of organic chemistry was being developed in the late eighteenth century, but at the same time, several alternative ontologies continued to be used, for designing experiments and for discussions, even though the scientists involved accepted that they were incorrect and that the new theory was taking over.

The use of primitives in science
She also refers to the work of Richard Samuels on a new concept of primitive in science, which means a term which the scientists work with but agree not to explain, or better, for which there is no explanation. I have myself observed this in action in the use of the term "control process" in cognitive psychology. It was introduced by Atkinson and Shiffrin in 1965 or so and has been much used, but no analysis or explication has ever been attempted. It is however very useful since it gives a way of referring to all the mechanisms that make data storage and transmission happen without having to explain how any of it actually works. Thus one could talk about a system of memory components

and only describe the data and operations but not the control. In this way, psychologists could avoid having to talk to those nasty boys in computer science.

Language as a game

Fiona and other philosophers can perhaps explain current philosophies of language. I myself have always regarded language as a kind of poetry, that is the idea that any word actually exactly means anything has always seemed to me to be asking for trouble. The transition from having words refer to actual things and the meanings of sentences being derived from the component words, to language being more of a game, is the transition made by Wittgenstein from his first [Ludwig Wittgenstein, 1922] to his second [Ludwig Wittgenstein, 1953] book.

Diversity in neuroanatomy

When I started looking for a more detailed justication of my model in neuroanatomy, at first I thought there would be a summary of the anatomy of the cortex in some book. There is not, and as I probed further I was surprised to find that different parts of the brain were treated differently with different parcellations, notations and concepts, and there was no attempt to reconcile these. Indeed different neuroanatomists had different ways of thinking. I took this to be the hallmark of a living science, that individual scientists develop their own ways of describing the systems they are studying and the field not only tolerates but gains from this diversity.

Diversity in psychology

I have found that there is a considerable literature on this point, some arguing that diversity of explanation in psychology is good and others that it is not so good. For example, Arthur Staats [Arthur W. Staats and Leendert P. Mos, 1987] has argued for a unified ontology in psychology.

Dynamic variation in beliefs

After all, we have a situation where new findings are constantly changing the way we think, however this is done by many steps where some things are clearer than others, then some findings are found to differ from others, and so on. So we need to have a way of thinking that accomodates and facilitates this situation. So words should not be carved in stone, but should be changeable in meaning. However they should not be like wet lettuce leaves, they have work to do, they should be as strong as we need them to be at each moment, and should be strengthened and weakened as we need them to be at each moment.

Social constructionism

There is of course the idea that science is a social process and that scientific language is constructed by interactive and cooperative activity. One pace setting book is "Science in action" by Bruno Latour [Bruno Latour, 1987]. There are a few writers in the social sciences, such as Kenneth Gergen and also J. Potter and John Shotter, who have been developing these ideas. There are also books by Vivien Burr [Vivien Burr, 2003] and Fiona Hibberd [Fiona J. Hibberd, 2005]. Gergen has a nice summary concerning psychological science in what he calls the *postmodern context* [Kenneth J. Gergen, 2001]. He summarises the change in three dimensions: 1. From individual reason to communal rhetoric

2. From the world as objectively given to a socially constructed world

3. Language as truth bearing to pragmatic practice.

He also mentions Richard Rorty, a leading philosopher in this area, for example in his book "Philosophy and the mirror of nature" [Richard Rorty, 1979]. All of this work provides an intellectual context but does not help us much in developing an actual ontology for cognition.

Ontologies for social psychology

I did however find some analyses of terms in social psychology [David Weissman, 2000].

Particular words

Jay Garfield [Jay L. Garfield, 1988] has studied the concept of belief in psychology.

Distributed knowledge

In our book on distributed artificial intelligence [Bond and Gasser, 1988], Les Gasser and I develop a social approach to multiagent systems. One main axiom is that there is *no global perspective*. That is, knowledge is distributed. By this we meant that each database and each program are designed and constructed by some individual or group at a particular time, and incorporate their assumptions, ideas and terminology. Each particular group then has its own perspective and there is no group that can understand directly what every group is doing. Instead, individuals or groups interact by *negotiation* to use each others' data and ideas. Thus, in the current context, it is a mistake to try to reconcile different ontologies in a clear cut way.

Communication between groups

In order to connect say neuroanatomy and neuropsychology we would need some words that both groups understand in order for them to communicate. However, if you make a

standardized version of a word, like "activation", "connection", "area", "neuron", etc., which both groups are supposed to use, this will lead to misunderstandings. It will be difficult to come up with a definition of the meanings of words that both groups can work with. Instead, an alternative approach would be to have some way for the groups to negotiate, dynamically in each case, the information that they want to communicate.

Related work on computer ontologies

I have noticed in a book called "The Handbook of Ontologies" [Staab and Studer, 2004], a paper on automatic reconciliation of ontologies [Hameed et al., 2004], another on the verification of ontologies [Gomez-Perez, 2004], and one on Ontoclean which is a methodology for validating the otnological adequacy of taxonomic relationships [Guarino and Welty, 2004].

Some initial conclusions

Thus, I am lead to believe that the use of language in psychology is very much a game. That it is constantly shifting and developing, and that we should take this into account in any development of computer ontologies for psychology. At the very least, we need:

1. ontologies to change with time, rapidly and
2. there need to be coexisting multiple ontologies, and
3. there needs to be a way for different groups to negotiate the meanings of terms that are used to communicate between them.

In order to support this kind of regime, there would need to be ways of automatically updating; as ontologies are changed, items in databases that have been previouslt classified might need to be adjusted.

So we need a "deeper" ontological language so that transitions and their consequences can be described. This deeper language would contain words which could be used to construct definitions of the meanings of words in cognitive science. Then when the society agrees that a given word's meaning has changed, a new definition of its meaning would be agreed and a formal definition constructed in this language. Definitions would be used to update classifications, and also for negotiation with other groups ontologies.

Or we could assign a numerical degree of flexibility to each word, or we could order all the words from more and less fundamental and less and more changeable.

Forming a consortium

One idea is for us to take the initiative and to organize a workshop and to form a consortium on cognitive ontologies. We could put together a discussion document and

invite speakers and discussants.

Deeper ontologies

There is I have discovered quite a lot of work on deeper ontologies. There is work arising from philosophy, usually called *Foundational ontologies* or *formal ontologies*, a term which dates back to Husserl [Edmund Husserl, 1900]. There is related work in linguistic ontologies, by semanticists of natural language. There is also work originating in AI.

Active philosophy groups include:
1. IFOMIS, The Institute for Formal Ontology and Medical Information Science and European Centre for Ontological Research, Saarland University at Saarbrucken, directed by Barry Smith, with software system BFO(Basic formal ontology).
2. Onto-Med, Ontologies in Medicine group, Leipzig University, directed until recently by Barbara Helle, and with software GFO(General formal ontology) and Onto-builder.
3. V.U.B. Starlab in Brussels, with the DOGMA system.
4. The Laboratory for Applied Ontology in Trento, with their WonderWeb Foundational Ontologies library, and also DOLCE (Descriptive ontology for linguistics and cognitive engineering), with Nicola Guarino and Claudio Masolo. 5. Luc Schneider, originally at Leipzig has now started a group on foundational ontologies in Geneva.

Semanticists are developing ontologies for what meanings are expressed in natural language sentences. See [Dahlgren, 1995] who bases her work on formal semantic types in the DRP framework [Kamp, 1981], [N. Asher, 1987]. These types inclde individual, event, state, property and proposition.

AI groups are concerned knowledge representation, and in particular how to develop standard methods that can be used for web content. They include:
1. Stanford University and the KIF representational system.
2. The CYC system of Douglas Lenat [Douglas B. Lenat and R. V. Guha, 1900] which has a public domain core representational system and then a proprietary knowledge base.

Three main issues

1. The existing cognitive ontologies, from Darpa and from Brede, are isa hierarchies. However there are a lot of other connections among cognitive concepts. We need to develop other relations, for example, memory can be subcategorized into modality, and also time duration, so this will mean multiple parents, but also memory is related to the use of memory in problem solving, and also to the learning of memories. So these

would be other relations such as spatial memory "used in" navigation problem solving, and learning spatial maps "causes" spatial memory.

2. To manage the temporal change in ontologies:
(i) have a standing committee and conference every five years.
(ii) they would update the ontology, introducing new terms and modifying the meanings of existing terms and relations among terms.
(iii) they should be able to express these changes formally and precisely, e.g. memory(2005) = memory(2000) and new memory type
memory(2000) = memory(2005) - new memory type.
(iv) for this we need a more general ontology language.

3. For interactions among different ontologies, for example those on different abstraction levels, such as the cognitive level, the neuropsychological level and the neural systems level, we need to develop precise methods of interaction.
For example, there is a word synapse at the neural level and the word synapse at the molecular level. These are however not the same word as they have different meanings. Each side of the interaction could have a definition of the meaning of the word, and in exchanging information, a process of negotiation would occur using these definitions, which would use common deeper ontological concepts.

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