Conceptual Change as Change of Inner Perspective

Eric Dietrich, Clay Morrison, and Michiharu Oshima
Program in Philosophy, Computers, and Cognitive Science
Binghamton University, Binghamton, NY 13902-6000
dietrich@binghamton.edu

Abstract

To be a genuinely useful methodology for cognitive psychology, situated action must be extended to explain higher-level human cognition. Yet there is a tension between the requirements for cognitive explanations and the kind of explanations situated action supplies. It is just not clear how to use embodied interaction with an external environment to explain processes that are so internal and that seem to crucially involve representations and concepts. In short, there is nothing for concepts to interact with. Perhaps they interact with each other. This is the idea we explore here. We give a situated action style explanation for conceptual change in the context of analogical reminding. We have two central results: 1) analogical reminding changes concepts in long-term memory, and 2) concepts have implicit as well as explicit structure.

Introduction: Conceptual Change, Creativity, and The Central Problem of Analogy

In this paper, we present our view of analogy, conceptual interaction, and conceptual change from the point of view of situated action. We think that situated action provides a fecund framework for describing what we view as the central problem of analogy: how conceptual interaction produces conceptual change and ultimately, new concepts. We are exploring situated action because our view of analogy and related processes does not sit well with the current cognitivist, non-constructive paradigm in cognitive science.

Explaining analogy, conceptual interaction, and change are not our ultimate goals. These fascinating features of cognition are needed to explain something even more fascinating: creativity. This is our real goal. Of course, a theory of creativity is a long way off, but there is plenty we can say about it now, and indeed research on creativity is enjoying something of a renaissance (e.g., see Finke, Ward, & Smith 1992). At a minimum, situated action gives a vantage point at least to say what creativity is not: creativity is not searching some vast search space (Wolf, Beskin, & Dietrich 1995), and it is not due to an underlying universal architecture. The situated theorist emphasizes that, ultimately, creativity exists because it results in behavioral plasticity, especially in problem solving. A quote from a recent paper by Andrew Wells puts the point nicely:

What is at issue is the... question of whether the behavioral flexibility of the human cognizer derives from an internal architecture which is organized as a universal interpreter [i.e., a universal Turing machine]. Symbol systems theorists claim that it does, situativity theorists, by and large, claim that it does not. (Wells 1996)

Of course what creativity is not is only a start; what explains behavioral flexibility, in general, and creativity, in particular, is still a matter of much debate. Explaining creativity, in our opinion, reduces to the problem of explaining where new concepts come from (at a minimum, explaining creativity certainly includes explaining where new concepts come from). (By “new concepts” we mean new concepts within a given individual. Unlike some situated action theorists, we do not want to eschew the hard-won theoretical entities of more traditional cognitive science. Specifically, we do not want to give up representations and concepts. We think that representations can and must be incorporated into situated action style theories of cognition if we are ever to explain high-level cognitive functions such as analogy and creativity, but we aren’t going to argue for this point here. So for this paper, we assume that concepts are internal representations of an organism’s environment which it interactively engages.)

New concepts come from many different places and arise for many different reasons. Social interaction, learning, and perception, are three obvious places. Even explaining how any of these three result in new concepts is enormously difficult, though cognitive sci-
entists have made in-roads into understanding these processes. We are interested in how new concepts arise within an individual via the interaction of concepts the individual already possesses. If we could successfully explain this process, we would have a good first step towards solving the fundamental problem of analogy, and we would have also a theory that would eventually fit within a larger, more general, theory of creativity. Our task here is to couch our ideas of conceptual change and the genesis of new concepts within the framework of situated action.

**Perspective Shift and Conceptual Change**

It is well-known that changing perspective benefits visual perception. Moving around an object, cocking one’s head, rotating an object in one’s hand—all of these help us see the object better and to better categorize and understand it. We can experience this when we view a two-dimensional representation of some three-dimensional object, say a car chassis, on a computer’s video monitor. The three-dimensionality springs out at us as soon as we start rotating the image on the screen. Such screen rotation is just changing perspective.

That changing perspective helps visual perception (as well as other modes of perception) is something the situation action (SA) community finds agreeable. Perspective shifts are just one form of investigation, after all. The structure (shape, form, function) of an object being looked at is found in the interaction between a seeing system (you and your eyes, for example) and its world (and not just the object, because of context). The world contains crucial information that can’t be got merely by sitting there and passively receiving information. To truly get a grasp of an object, the agent must grasp it (in some sense), turn it over, and examine it from many angles.

But the SA community does more than merely agree that changing perspective helps visual systems see. We think that robust perception is not possible without perspective shifts. That is, the visual information in the world will simply remain there unless the visual system genuinely interacts with it—goes out and gets it. No perception without interaction. Indeed, no information without interaction. And if one believes, as we do, that perception and interaction eventually result in constructed representations of some sort, then one can say: No representation without interaction. (As we discussed above, some in the SA community reject representations almost entirely. So this last principle is not universally agreed to. To reiterate, we think representations are needed for higher cognition.)

But our target is conceptual change. What does perspective change have to do with conceptual change? To answer this, we will present our view of analogy and analogical reminding. But briefly our answer is that the kind of conceptual change we think is involved in analogical reminding is the inner version of perspective change in an interactive agent’s visual system (c.f., Stein 1994). And, just as perspective change results in increased knowledge about an agent’s visual world, so conceptual change results in an agent’s increased understanding of its own concepts which are about its world. In other words, just as perspective change is required for a successful vision system (and ultimately, a successfully seeing agent), so conceptual change is required for a successful, creative problem solving agent. An agent doesn’t fully understand its concepts and what is possible with them without the concepts interacting with one another. Finally, changing perspective is an agent’s way of interacting with its world, its environment. Yet we are claiming that concepts interact with each other. Aren’t these incompatible? No. We are deliberately using the “perspective change” metaphor to flag the fact that the vast array of concepts within an individual functions as the environment for any concept within that array.

The claim that perspective change in perceptual agents is similar to analogical conceptual change in cognitive agents (i.e., agents with a robust mental life) falls directly out of our model of analogy. We now briefly describe this model and show how it leads naturally to a new view of the structure of concepts and to our view of conceptual change as change of inner perspective.

**Analogical Reminding, Conceptual Change, and the Structure of Concepts**

It is well-known that concepts change over time. Learning and forgetting are two obvious kinds of conceptual change. What is less well-known, and much less well understood is the constant, slow, structurally subtle changes that concepts undergo each day. Such changes are not necessarily caused by new input, and do not necessarily represent learning new knowledge or forgetting old. We are interested here in this latter kind of conceptual change.

We believe that the engine of this kind of conceptual change is interacting concepts: concepts change each other merely by interacting (by “conceptual interaction” we mean one concept activating another). We call this the change via interaction hypothesis. The kind of conceptual change it is responsible for we call interactive conceptual change. The species of conceptual change we are most interested in occurs anytime one experiences analogical reminding. We dub this hypothesis the change via analogical reminding hypothesis.
It is a refinement of the change via interaction hypothesis. Explicitly put, it is the claim that analogical reminding alters concepts slightly.

Analogical reminding is very common, and occurs any time some concept in one domain recalls another concept in another domain. For example, imagine that while walking along a sidewalk at night, you see some overturned, haphazard garbage cans and are reminded of Stonehenge on the Salisbury Plain in England. Such occurrences are common.

We need to say what analogy is (according to current theory) before we proceed. There is considerable evidence that analogy is some sort of "mapping" (perhaps a transfer of activation) from the high-level, relational structure of a concept particular to one domain of knowledge to another similar structure from another domain (see Gentner, 1983, for the central statement of this view). The similarity is hypothesized to be quite close, if not exact. This is will be important below. Analogical reminding, therefore, is a species of reminding where one concept successfully maps its high-level structure onto another concept (whether these high-level structures exist ahead of time, and it not where they come from are matters of debate—a debate we are keenly interested in).

Because of Gentner and her colleagues, as well as others, a fair amount is known about analogical reminding. Gentner points out that, broadly speaking, there seem to be three large classes of remindings: 1) sublime analogical remindings (e.g., Rutherford noticing that the alpha particles were like comets), 2) quirky analogical remindings (like the garbage-cans/Stonehenge case above), and 3) mundane remindings (like when garbage cans remind you of other garbage cans or remind you to put out your garbage for tomorrow morning's pickup). There is considerable psychological evidence that types 2 and 3 (quirky and mundane) are far and away the most common. Type 1 is rare. The change-via-analogical-reminding hypothesis predicts that analogical reminding, of both type 1 and type 2, alters concepts. (We suspect that even mundane remindings subtly alter concepts, but are not going to discuss this here.)

In most theories of analogical reminding, the two concepts involved are the concept that retrieves an item from long-term memory, and the concept retrieved. Call the retrieving concept the retriever; call the retrieved concept in LTM just that, "the retrieved concept" (these terms are slightly nonstandard, but more descriptive). Usually, the retriever is some perceptual input item, a percept that has been categorized. And the retrieved concept is an item in long-term memory.

The change-via-analogical-reminding hypothesis predicts (among other things) that the retrieved concept gets changed in both type 1 and type 2 remindings. This prediction is fairly radical. Most theories of analogy predict just the opposite, that only the retriever changes, and it is changed by the retrieved concept. The change-via-analogical-reminding hypothesis is compatible with claim that the retriever changes, but it goes further and claims that the retrieved concept also changes. (From here on out, we will lump type 1 and type 2 analogical remindings together, and leave mundane reminding aside.)

Now, what kind of change are we talking about? Our answer to this question entails a new view about how concepts are represented. We begin with two observations. First, analogical remindings happen very quickly, and second (recall that analogies are close matches of the abstract, high-level, relational structures of two concepts) it is highly unlikely that these relational structures would antecedently match in the usual case. For example, again suppose you see some overturned, jumbled garbage cans by the curb and are reminded of Stonehenge. It is highly unlikely that the jumble of garbage cans matches the jumble of monoliths on the Salisbury Plain (and if they did match, what would be the point of the analogy?). So it is highly unlikely that your initial perception of the cans matches the part of your concept of Stonehenge representing the pattern of the stones seen from a certain perspective. In fact, it is unlikely that your perception of the jumble of the cans antecedently matches even a line drawing (a kind of abstraction) of the stones at Stonehenge.

But how could two concepts which do not have identical or closely similar high-level structure become analogous so quickly? Conceptual information must be represented both explicitly and implicitly. This nicely solves the problem. (Explicit information is the "intended" semantic interpretation of the percept or concept; it is, so to say, the information the concept wears on its sleeve. Implicit information is information that the concept does not wear on its sleeve, and which must be recovered via some process, frequently a process of abstraction, but not always (Kirsh 1990). When a telephone is used as a paper weight, the implicitly represented weight of the telephone becomes explicit. Note, this example also makes the point that implicit information comes in degrees and is relative to the task at hand, since, in terms of grasping and lifting the phone solely, you might very well explicitly represent its weight.)

If concepts are represented in the brain with both explicit and implicit information, then concepts are in some interesting sense ambiguous; concepts have mul-
tiple, related contents some of which are explicit and some of which are implicit. This implicit information is usually some abstraction of the explicit information in the concept. But it is nevertheless implicit because there are myriad ways a given concept might be abstracted; they can’t all be explicitly represented. Which few of these myriad ways become explicit depends on which other thoughts the given concept is interacting with at the time.

We claim that analogical reminding occurs when the retriever successfully renders explicit formerly implicit information in the retrieved concept. This interaction may also make implicit information in the retriever explicit. In this case, both the retriever and the retrieved concept are altered, both by making implicit information explicit. Of course, new implicit information is created, too. (We elide the interesting discussion of why new implicit information is created, and indeed why implicit information must always exist given any physical realization of information.)

So, for example, one last time, suppose you see some overturned, jumbled garbage cans by the curb and are reminded of Stonehenge. As we said, it is improbable that the jumble of garbage cans matches (even partially) the jumble of monoliths on the Salisbury Plain. Since enough of the explicitly represented patterns of each don’t match, being reminded of Stonehenge by the garbage cans isn’t due to any explicitly represented information in either the garbage cans percept or the Stonehenge concept. Rather the reminding occurs because the garbage cans make explicit an abstract structural similarity in your concept of Stonehenge that was formerly implicit. This requisite structural similarity was produced on the fly by the interaction of the two concepts.

In summary, we have argued that one of the fundamental principles of situated action—no representation without interaction—can be fruitfully applied to explaining analogical reminding. In our model, concepts represent information both explicitly and implicitly. The process of conceptual interaction, on our view, renders explicit formerly implicit conceptual information, and the point of doing this is that this is what understanding actually amounts to. Making implicit information explicit just is the internal way of “changing perspective,” and it is this that produces genuine understanding. Since analogical reminding is one kind of conceptual interaction (so we claim), it follows that analogical reminding is one way of making implicit information explicit, and hence one way of producing genuine understanding. Conceptual change, on our view, does not need to have a situated component added to it, rather conceptual change is situated action—only internal.

Dealing with An Objection

There are several objections with which we need to deal. The most important of these, and the only one we will deal with here, concerns the emphasis we place on the low probability that the relational structures of the retriever and the retrieved concept antecedently match. This low probability is crucial for our argument that the retrieved concept changes. The objection is that the matching process in analogical reminding only needs to be a “best-partial-match” algorithm defined over high-level structures. The probability of a partial match seems high enough to guarantee a match quickly. So retrieved concepts don’t need to change, or at least don’t need to change very much. So our model is wrong.

Of course, there probably is some sort of a “best-partial-match” algorithm (in fact, Gentner has psychological evidence for such an algorithm), and it no doubt provides the first filter in an episode of analogical reminding. But this can’t be all there is to the story of analogical reminding because, as we mentioned above, the mapping between the retriever and the retrieved concept is theorized to be very close, if not almost exact. In fact, Gentner has evidence that the mapping process in analogy is very sensitive to detailed structural similarity between the two concepts. It is an easy inference from this (though it still might be wrong) to the claim that the relational structures of the two concepts involved in analogical reminding have very similar relational structure. Gentner herself makes just this inference. So if the two analogous concepts have closely similar relational structure but the structure was not there ahead of time (and it is unlikely that it is), then where did it come from? Answer: it was constructed on the fly via concept interaction. And, how could it be constructed so quickly? Answer: it was implicit in the retrieved concept’s high-level structure.

An Experiment

We close by describing an experiment we intend to run to test our hypothesis (we also have a computer program which implements the central ideas of our model (Oshima 1996)). Suppose subjects memorize five different number strings (e.g. 1 1 5 4 3, 1 2 3 4 5, 1 1 1 2 2, 2 2 2 2 2, and 1 5 6 7 3) and their detailed, verbal descriptions of strings are recorded (e.g., “1 1 5 4 3 is parsed (1 1) (5 4 3) – two one’s followed by five, four, three”). The subjects are then shown a series of number strings one at a time and asked if any string reminds them of one of the five original, memorized
strings. The strings will be designed to either readily remind subjects of one of the “categories” associated with the five original strings or not remind subjects of a string at all (e.g., shown 2 2 9 8 7, subjects will no doubt be reminded of 1 1 5 4 3, but 9 1 9 1 9, will not remind subjects of any of the original five strings). After being shown many strings, the subjects are asked to describe the categories associated with the original five strings (e.g., subjects might describe the category associated with 1 1 5 4 3 as “an identical group followed by an immediate predecessor group”). Once this is established, we return to showing the subjects strings and asking them what they are reminded of, only this time, the strings they are shown contain strings that do not fit well within one of the five memorized “categories” but are nevertheless reminiscent of them (e.g., shown 9 7 5 3 3, subjects might be reminded of 1 1 5 4 3 or with 1 1 1 2 2, etc.). These latter cases are the cases of analogical reminding. We predict that after such analogous cases, the way the subjects describe the original string will have changed slightly by becoming more abstract (e.g., if a subject is reminded of 1 1 5 4 3 by 9 7 5 3 3, then when asked to describe the string 1 1 5 4 3, the subject might described it as a downward sequential string of 3 either preceding or following two identical numbers).

Acknowledgements

Thanks to Art Markman for discussing some of the ideas in this paper with us.

References

Note: This paper is rather under-referenced. Besides the references we mention, we also include here a few of the many works on which our ideas depend.


Hendriks-Jansen, H. 1994. In praise of interactive emergence, or why explanations don’t have to wait for implementations. Proceedings of the 4th international workshop on the synthesis and simulation of living systems.


Indurkhya, B. in press. Metaphor as change of representation. J. of exper. and theor. AI.


