When Coffee Cups Are Like Old Elephants, or Why Representation Modules Don’t Make Sense

Robert M. French
Department of Psychology (B32)
University of Liège, 4000 Liège, Belgium
Email: rfrench@ulg.ac.be

Abstract • I argue against a widespread assumption of many current models of cognition—namely, that the process of creating representations of reality can be separated from the process of manipulating these representations. I hope to show that any attempt to isolate these two processes will inevitably lead to programs that are either basically guaranteed to succeed ahead of time due to the (usually carefully hand-crafted) representations given to the program or that would experience combinatorial explosion if they were scaled up. I suggest that the way out of this dilemma is a process of incremental representational refinement achieved by means of a continual interaction between the representation of the situation at hand and the processing that will make use of that representation.

Introduction

The tradition of separating representation and processing dates from the earliest attempts to model cognition on a computer. The notion that the world could be represented by means of a vast set of symbols designating the objects of which the world is composed and rules with which to manipulate those symbols goes back even further, at least to the work of Frege and Russell (see Frege 1952 and Russell 1924). This view has been called Objectivism by George Lakoff (Lakoff 1987) who characterized it as follows: “On the objectivist view, reality comes complete with a unique correct, complete structure in terms of entities, properties, and relations.” The application of this principle to the modeling of cognition bears a name: the Physical Symbol System Hypothesis (hereafter, PSSH; Newell & Simon 1976). This view, one that served as the cornerstone of artificial intelligence for over two decades, posits that thinking occurs through the manipulation of representations composed of atomic symbolic primitives. Implicit in this view, in practice if not necessarily in theory, is that the creation of these representations is separate from their subsequent manipulation.

Especially since Rumelhart & McClelland (1986), the PSSH view of cognition has come under attack by connectionists as being inadequate to produce the full range of cognitive phenomena. However, in many connectionist models the input vectors presented to the network consist of a set of present—or-absent features (i.e., a 1 or 0 for each input node representing a particular feature) for the patterns to be processed. The network then processes a particular set of inputs corresponding to the set of features describing each pattern. But where does this choice of input features come from in the first place? The tacit assumption is that they can be created elsewhere and then processed by the network. Again, initial representation and processing are separate.

Context-independent Representations and the Myth of an Independent Representation Module

From the start it was, of course, realized that, although computers were fast, they were not infinitely fast and, as a result, the problems they could solve had to be tractable. And, while it was clear that the way in which a problem was represented could significantly affect processing time (Amarel 1968), tractability was largely perceived as being about processing, not representation. In other words, many early modelers in artificial intelligence implicitly shared the logician’s faith in the existence of universal representational languages and techniques for representing any situation in a context independent manner. This belief in context-independent representation was necessary to justify sep-
rating representation from processing. If any object or situation could, at least potentially, be represented in a context-independent manner by a set of necessary and sufficient properties, the separation of representation and processing was appropriate and it made sense to develop techniques for processing representations without being concerned with the actual production of the representations. The research strategies that evolved respected this representation-processing division of labor. Considerable resources were devoted to developing heuristic techniques to reduce search times during processing, while a comparable (but non-overlapping) effort was spent attempting improving representation languages. If nothing else, the one thing that almost everyone agreed on was that representation had to precede processing. I hope to show that this view is fundamentally flawed. I will argue for the necessary simultaneity and interactivity of the two processes.

In this article I will use the area of analogy-making to argue for this interactive, simultaneous view of processing and representation.

Representation and the Recognition of “Sameness”

Successful models of human cognition must be able to see one object (or situation or relation) as being “the same as” some other (Hofstadter 1979; Mitchell 1993; French 1995). For example, whenever the thought “That’s like...” occurs to us, we are perceiving one thing in terms of something else. New situations are understood in terms of previously encountered ones, emphasis is placed on particular aspects of one situation by likening it to another, and so on. This is, without question, one of humans’ most fundamental means of making sense of the world. Central to this ability to perceive the “sameness” in two different objects or situations is the problem of representation. We will consider the problem of representation via the mechanism of analogy-making. The goal of the exercise that follows is to attempt to demonstrate the extraordinarily malleable nature of representations that allows us to understand even the most straightforward of utterances.

Consider any ordinary object—for example, a credit card. Whenever we make an analogy between the credit card and something else, we focus on certain features of the card and not others. So, for example, when we say, “A credit card is like money,” we are focusing on its pecuniary aspect; in other words, the card, like money, can be used to purchase things. It is crucially important to observe how the representation of “credit card” must change with each statement in order to accommodate the analogy. The point is the context-dependent nature of representations. As I hope you will realize, no a priori property list for “credit card,” short of all of our life experience, could accommodate all possible utterances of the form, “A credit card is like an X.” Consider this short list of examples:

- “A credit card is a like a doorkey.” In this case, we are no longer focusing on it’s money-providing features—which, in fact, become completely irrelevant—but rather on its very thin shape, size, relative rigidity, and thickness.
- “A credit card is like a Braille book.” Here, we are focusing on the raised letters on the front of the card.
- “A credit card is like a ruler.” Because you can draw a straight line with it.
- “A credit card is like an autumn leaf.” The focus here is on wind resistance. If you dropped both from the Empire State Building, they would have similar falling patterns (although the card would no doubt fall faster).
- “A credit card is like a breeze.” Because you can cool yourself off with it if you use it as a little fan.
- “A credit card is like a soup-can label.” Both contain encoded information that can be automatically read by a machine (in one case, from a magnetic strip; in the other, from a bar code).
- “A credit card is like fingernails.” Both produce goosebumps in listeners who hear them scraped across a blackboard.
- “A credit card is like a bat.” Because you’ll never know what it’s like to be either of them...

Perhaps it is becoming apparent that you can, with a little imagination, explain why a credit card is like absolutely anything. Even though your explanation (i.e., the context you create) may be stretched, it will be understood. Try it: A credit card is like a rose. A credit card is like a doormat. A credit card is like a horse race. A credit card is like a switch-blade knife. A credit card is like the Spanish Inquisition. The list is endless, but you will always be able to transfer some facet of your long-term memory representation of “credit card”—