Chapter 17

Mending or abandoning cognitivism?

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17.1 Introduction

The representational–computational theory of the mind, the core of cognitivism, has been the foundation of the cognitive sciences, despite continuing doubts about some, or all, of its postulates, mental symbols being just one of them. The current interest in embodiment makes times ripe, though, for some rethinking of the basics. In this chapter I will explore whether current interest in an embodied, embedded approach to cognition should be carried out as an alternative only to abstract symbols, while keeping most of cognitivism, or rather as a proper alternative to cognitivism. To this purpose, I will highlight the shortcomings and risks of a cognitivist version of the embodied meaning approach, and will finally favour a more radical, interactivist, and dynamical approach to cognition.

17.2 Cognitivism and the problem of understanding

Cognitivism is meant to refer to the set of basic postulates which inform most of the cognitive sciences (Searle 1990; Haugeland 1995, 1998). It is a version of the representational–computational theory of the mind, according to which the mind is an information processor which plays by the formality condition (Fodor 1975; Newell 1980). That is, mental processes are conceived as manipulations of mental symbols in virtue of their form – their syntax – while also respecting the semantic relations that hold between these states in virtue of their content. Thus, the brain is viewed as a syntactic engine driving a semantic engine (Block 1990).

The building blocks of cognition, according to this general approach, are these mental symbols, which are conceived as abstract, digital, discrete, amodal, explicit representations. Consequently, cognitivism implies a representational, translational view of language understanding. Understanding is thought to consist in the rule-guided transformation of a set of natural language sentences into a mental representation (a macroproposition, a situation model, etc., according to the particular theory one favours) composed of mental symbols, which supposedly captures the linguistic meaning of the sentences. This transformation is conceived of as a formal, syntactical, inferential process which ends up with a mental representation expressing the linguistic meaning, or proposition. Hence, the problem arises as to what confers meaning to these internal states and how they gain their semantic contents in the first place, equivalent in expressive power to that of language. This has been called ‘the symbol grounding problem’ (Harnad 1990).
Since Searle’s Chinese room argument, a main part of the discomfort with cognitivism is due to this view of (language) understanding as translation into a mental code; simply substituting one sign (public) for another (mental) through a formal process comes short of providing understanding just by itself. It is not only that algorithmic accounts of this process are still lacking, but rather, as noticed already by Winograd in the 1970s and in the philosophical arena by Wittgenstein in his private language argument, that the mere tokening of a ‘mental formula’ in one’s ‘belief box’ comes short of amounting to understanding.

However, it should be also kept in mind that many other related problems present insurmountable difficulties for cognitivism. Specifically, in the area of language understanding, the frame problem, or as Fodor has called it, the problem of relevance or of nondemostrative inference, is still as challenging as ever. Moreover, it is the reason why no algorithmic account of understanding has been achieved (given the high context-dependency of the process, which is something that formal processes are not good at). The combinatorial explosion of alternatives, plus the lack of algorithmic procedures to reduce the search to just the ‘relevant’ ones, suggests (for Fodor himself) that cognitive science is limited to modular processes and is not going to be able to account for ‘nonmodular’ ones (Fodor 1983, 2001). Notice that it is the very allegiance to cognitivism that makes such a problem unsolvable. Therefore, the recent ‘massive modularity’ program that attempts to avoid the frame problem by claiming that all cognitive processes are modular (Cosmides and Tooby 1992; Sperber 1996; Pinker 1997) may be misguided. If the real problem is cognitivism itself, then the debate on the scope of modularity turns out to be misplaced.

There are many other problems that vex cognitivism, understood as symbolic processing: lack of flexibility (Clark 1989), the problem of common coding of inputs and outputs (Prinz 1990; Turvey 1977), the problem of how to account for double activation of the same symbol in a single sentence (Jackendoff 2002), etc. While we do not need to discuss these other problems in any detail here, it is important to keep in mind that symbol grounding is not the only problem, so that were we to find a solution for it within cognitivism that would not amount to its final success. On the contrary, cognitivism is plagued by these different, related problems — they all have something to do with processing — because of its central commitment to a strict distinction between data structures and operations on them, imported from classical artificial intelligence (AI) teachings. In the last section, I will argue for a different conception of mental representation, which has to be accompanied by a change in the conception of mental processing as symbol crunching to have any chance of overcoming all these problems.

17.3 Peirce on symbol grounding

I was happily surprised by the reference to Peirce in the convenors’ position paper (Glenberg et al., Chapter 1, this volume), because I think that Peirce’s theory of signs is well suited to clarify the questions involved in symbol grounding and to appreciate the difficulties of cognitivism. To begin with, it seems to me important to realize that while
notions of both symbol and grounding can be found in Peirce, they are used in quite a
different sense than has become standard usage in cognitive science. For Peirce, symbols
are just one kind of sign, the grounding relation of which depends upon public rules of
usage. Let’s see this in some more detail.

Remember that Peirce was interested in external, public signs in general. His definition of
sign states that a sign ‘is something that stands for something else in some respect or other
for somebody.’ His technical term for this something that signifies is ‘representamen,’ and for
what is signified, ‘object.’ The next technical notion, most relevant in this context, is ‘ground’,
which refers to the sort of relation in virtue of which the ‘representamen’ stands for the
‘object.’ He distinguishes three kinds of grounding relations: iconic, indexical, and symbolic.
As is well known, iconic signs are signs in virtue of resemblance between representamen and
objects in some respect for somebody; indexical ones, in virtue of covariation; and symbolic
ones in virtue of an arbitrary, conventional agreement (for an introduction to Peirce’s theory
in terms of its relevance to cognitive science, see Gomila 1996).

It follows from this that, for Peirce, mental states clearly could not be symbols; moreover,
it is doubtful whether they could be signs. There is no way in which mental states
could be arbitrarily or conventionally viewed as symbols (let’s say, that the firing of a cell
assembly is taken to mean that the Pope lives in Rome). \(^1\) As a matter of fact, nobody
has seriously claimed that the content of mental states is grounded in conventions;
however, the practice in AI and in cognitive modelling of hypothesizing states with some
determined content by stipulation, which so closely reminds of conventions, is one of the
sources of discomfort with symbolic cognitivism that our convenors make explicit
(Glenberg et al., Chapter 1). Anyway, what’s clear is that cognitivist mental symbols do
not correspond to Peircean symbols because they are not grounded conventionally. But
do they fare better as Peircean indexes or icons? Mental images would seem to fare better
as icons, but, as many will still remember, images were banned from cognitivism in
the so-called ‘image proposition’ debate, in the early 1980s, and were finally accepted
only when they were revised as nonanalogical, nonresemblance-based representations,
though nonreducible to (cognitivist) symbols (Kosslyn 1994). Current neuroscientific
practice speaks openly of brain codes, and the methods used (e.g., event-related poten-
tials [ERP], functional magnetic resonance imaging [fMRI]) look for nomic covariations
between external stimuli and neural electrophysiological or hemodynamic patterns,
which would look more like indices (DeCharms and Zador 2000).

But remember that Peircean signs require a subject to grasp the grounding relation,
and there is nobody inside the head in charge of ‘reading’ or interpreting the states.
This is a second reason why mental states cannot be viewed as Peircean signs: no internal
interpreter can be assumed, on pain of falling into the homuncular fallacy. There is
a third reason: we have not been able yet to individuate mental states in virtue of their
‘form’; in Peircean terms, we cannot yet individuate mental states as ‘representamen’,

\(^1\) As I was preparing the final version of this paper, I came across the recent paper by Held et al. (2006),
where Vosgerau makes the same claim (Vosgerau 2006, p.270).
so as to apply the type/token distinction characteristic of signs and recognize a mental state token as of the same kind as another. It is not just that such a notion requires a type/token distinction which, *prima facie*, is not clearly applicable to mental signs. As a minimum requirement, a clear sense of what Peirce called 'representamen', the material, iterable form of the sign would require repeatable mental states identifiable as such – as of the same type – quite apart of their meaning relation. However, this is something that we have not yet achieved: our identification of mental state types is through their referent, or their external relata, not their intrinsic form, or internal 'syntax'. The closest we get to such a goal is through work such as Pulvermüller’s (Chapter 6, this volume), which in any case proceeds through standard covariational procedures to individuate his neural networks correlated with linguistic signs in standard situations.

Is there any sense in which we could think of mental states as representations? The answer is 'yes', but as natural signs, as informational states, not as signs dependent upon a subject of interpretation, signs that have to be read or understood; hence, not as Peircean signs, but as Gricean natural signs (Grice 1957). And when we turn to natural signs, 'grounding' amounts to carrying information (Dretske 1981), which is spelled out as a nomic correlation, plus some sort of functional relevance of this information for the system. No internal ‘interpreter’ is needed, and hence there is no lurking regress.

As a matter of fact, the different proposals discussed in this book could be seen from this vantage point as variations on this idea. The disagreement regarding grounding was on the correlated term purported to ‘ground’ the content of mental or brain states. In *latent semantic analysis* (LSA), covariation with patterns of linguistic use is what ‘grounds’ the linguistic meaning (Landauer and Dumais 1997; Kintsch 1998); Shapiro’s discussion (see Chapter 4, this volume) made reference to Fodor’s asymmetric dependency, an attempt to ‘ground’ meaning in the nomic covariation between mental states and world properties (Fodor 1991); Steels’ work (see Chapter 12) could suggest that ‘grounding’ is achieved by correlation with social practices; and embodied meaning could be viewed as suggesting that linguistic meaning is grounded in the perceptual and motor states coactivated in language processing.

So, at this point, we can get a more precise characterization of what we need to overcome the problems that vex cognitivism, a better view of how the internal states postulated to account for understanding are to be conceived (individuated), how they are supposed to provide understanding, and how they get their representational grip.

### 17.4 Embodied meaning as a version of cognitivism?

Given these preliminaries, it seems to me that the embodied meaning approach we are considering in this debate offers an alternative only to the classical view of mental symbols as abstract, amodal types, rather than as an alternative to cognitivism overall; in other words, it takes for granted the general idea of cognition as symbol crunching, while proposing a different view of the nature of such symbols – not as abstract, symbolic, etc., but as sensorimotor schemas or bodily patterns of activation, or as built up of such basic elements (a significant ambiguity, see later). In so doing, it comes short of what is needed to
overcome the difficulties of cognitivism. Just as the imagery debate—a debate which can be seen as a relevant precedent to the current debate—made clear, an account of mental representation has to be connected to an account of mental processing; a view of mental representation has to go hand in hand with a view of mental processing. In this way, an alternative to abstract symbolic cognitive science has to include an alternative to symbolic processing as syntactic transformation of data structures. Currently, such a processing account is missing, or implicitly cognitivist. In addition, there are even difficulties with the very formulation of the embodied meaning program. In this section, I will try to outline some difficulties that it seems to me affect this approach in this regard, and in the next section I’ll suggest what an alternative to the cognitivist processing framework might look like.

The intuition behind the embodied meaning program consists in the idea that the best way to ‘ground’ the macropropositions that are assumed to express meaning is to exploit their connection to sensory and motor brain states, which ‘ground’ their content (Barsalou 1999; de Vega 2001; Glenberg and Kaschak 2002; Pulvermüller, Chapter 6, this volume). But the grounding cannot consist exclusively of the simple coactivation in language processing of the same states involved in perceptual or behavioural interaction. There are plenty of such associations in the working brain, most of which do not ground semantic relationships.

To address this stricter requirement, a common, more or less explicit assumption behind this approach is what could be called a simulationist view of mental representation. According to simulationism, the very same states involved in perception and action are also involved in ‘off-line’ cognitive processes, where thinking or memory or imagination involve the same contents as the on-line corresponding processes (i.e., perception, action). In language comprehension, this idea amounts to viewing meaning as reactivation of the brain structures involved in the perceptual or motor interaction with the extralinguistic reality referred to. Therefore, no intermediate state (abstract, amodal) is needed to account for understanding. The ‘language of thought’ expression is substituted by the activation of those sensorimotor cortices which are supposed to be involved in the perceptual and motor interaction with what the linguistic expression means.

Simulationist approaches have proliferated in different areas: visual imagination (Kosslyn 1994); reasoning (Johnson-Laird 1998, 1983); motor imagination (Jeannerod 2001); emotional decision-making (Damasio 1994) or theory of mind (Gordon 1986, Goldman 2005). Synergistic effects among them contribute to its gathering momentum, and I’m not in a position to discuss simulationism as such. With regard to language comprehension however, it seems unsatisfactory to me. To put it provocatively, the way the embodied meaning program claims to solve the symbol grounding problem seems to me a case of throwing the baby out with the bathwater. In caricature, it could be said that, for symbolism, the grounding problem is to explain how the postulated abstract, amodal, arbitrary representational states get their meaning. But since for embodied meaning there are no such abstract, amodal symbols, there is nothing to ground. End of the problem—of the grounding problem, not of the problem of meaning, of course.

Maybe I’m attacking a straw man for (some version of) embodied cognition. Surely this is not what they want to say; what they want to claim is that the symbolic view of understanding, that of translating linguistic symbols into a ‘language of thought’ made of
abstract symbols, falls short of being a satisfactory account of understanding. Their point, as I understand the drive behind it, is to think of understanding as grounded in the interactions of the organism with its environment, an idea I approve of. However, it is not clear that what they put in place of mental symbols has the proper features to play the role that constitutes understanding. As a matter of fact, they seem to play on an ambiguity, according to which ‘grounded’ meanings oscillate between symbols supported by sensorimotor schemas and the sensorimotor schemas themselves. In the first case, no different view of understanding is really offered (it is just translation into a language of thought, now grounded – this is, in fact, the view advocated by Harnad in his 1990 paper); in the second interpretation, no account of understanding is really offered because, as in the caricature, the explanandum disappears.

The problem in this case is indeed abstraction. Language expresses abstract meanings and we definitely grasp them. If what we postulate in order to account for how we are able to grasp such abstract meanings is not abstract enough, our account cannot be satisfactory, given the translational view of understanding as background. As a matter of fact, this was the problem of empiricism for years: in trying to ground concepts in images or sensory impressions, abstraction was ‘the’ problem. To use an example from de Vega et al. (2004), in reading a sentence about digging it seems that activity in the motor cortices appears (as if actually digging). However, a straight identification of mental meaning with such a brain pattern would be too simple a proposal: this correlational activity cannot be taken to constitute the content of the word, because contents are abstract but brain activity as such is not. Conversely, if such motor activation amounted to the meaning of the word, then an apraxic person should be unable to understand such a word. Something more sophisticated is needed, even for ‘concrete’ words, which are, in this sense, also abstract. Thus, there are many different ways to ‘dig’, or to use the example of my presentation, to ‘open’ (a door, a box, a theatre, a call for papers,…). Some contributors to the volume (most notably, Pulvermüller, see Chapter 6), try to identify a common brain pattern to all those different cases of ‘opening’, but even if progress is possible in this direction it is still inappropriate to call such an internal state ‘the meaning’ – the meaning is the action itself.

For me, the real problem here has to do with the implicit alliance to the translational view of language understanding. Mental symbols are substituted by sensorimotor patterns in the same role as ‘internal’ translation of the linguistic content, and that move is not big enough to avoid the constitutive problems of cognitivism. The classical objection to such ‘imagistic’ accounts of meaning is due also to Peirce; it’s his comment that there cannot be an iconic sign for negation (while the modern debate started in the 17th Century regarding the nature and necessity of mathematical knowledge). Since there is not a single experience that corresponds to a proposition such as ‘not-p’ (given that so many may be true in such a situation), negation was thought by Peirce to be symbolic. Barsalou (1999) was also aware of this problem, though he considered it a side problem.²

² Johnson-Laird, on his part, changed his initial view of these ‘mental models’ as perceptual representations into an abstract view to accommodate negation (Johnson-Laird 2002). I will turn to the notion of ‘mental model’ in the last section.
But when we consider this tradition, the Peircean notion of ‘grounding’ doesn’t really fit; grounding seems to be understood more like ‘constitution’ or ‘derivation.’ Glenberg et al. (Chapter 1, this volume) seem, at some points, to be thinking of this notion in their chapter. The embodied meaning program would consist in the project of deriving or explaining conceptual thought in terms of sensorimotor experience. According to this version of the program, symbols would not be eliminated but ‘discharged’. Although they do not mention it, an important resource in this way of understanding the programme would look for multimodal representations as an intermediate step between abstract thought and concrete sensorimotor experience. We can think of very different properties and relations that are clearly multimodal even at the sensory level (examples: rhythm, synchrony, form, and above all, space and time), and it could be claimed that this redundancy gives rise to multi-sensory, or intersensory, representation which ‘abstracts’ the particulars of any modality (Bahrick et al. 2004). Spatial imagery can be amodal in this sense (Schwartz 1999). Again, this is in the empiricist tradition, but its point is not so much to ‘ground’ the mental representations in the sense of Peirce, Harnad, or Searle, but to construct abstract representations out of less abstract ones, and so on. However, as Fodor has argued insistently (most outstandingly in Fodor 1980), a good account of this process of abstraction is still missing – although a non-Fodorian might believe that statistical approaches have recently been offering new insights in this regard (for an account of the origin of the abstract concept of space out of sensorimotor dependencies, see Philipona et al. 2003).

But, while this program is very interesting and important, this is not what we need to ground meaning. For were we to take this seriously as a solution to the symbol grounding problem, we would get the wrong meaning ascriptions: we would have to ascribe sensorimotor experiences or motor programs as meanings, not (truth-valuation) propositions as the content of our mental states. The meaning of ‘I drink a beer’ is the state of affairs that makes the sentence true, not the movements of my hands and lips, or a representation of those movements either. As another example, would we be willing to say that the laugh a joke provokes is part of its meaning?

There are also a couple of objections having to do with the brain as a grounder of meaning. First, although from the neural point of view it is clearly possible to distinguish sensorimotor primary areas in virtue of their neural connections to effectors and effectors, respectively, from other associative or executive areas, it seems strange that all meaning must rely on sensorimotor foundations. If everything is sensorimotor, from the meaning point of view, and since linguistic processing involves the whole brain, then it follows that ‘sensorimotor’ would have different extensions in both cases, or otherwise we could not honour the aforementioned distinction between primary and nonprimary cortical areas.

Second, off-line, simulationist processing seems not to involve the primary sensorimotor cortical areas (which would make it possible to distinguish veridical perception from imagination), while the embodied meaning program puts all the weight into the primary brain areas. But I’m not competent enough to press these points.

In conclusion, it seems to me that the embodied cognition program is more concerned with neurological implementation than symbolic cognitivism was, which I think is correct.
As a matter of fact, the implementation of symbolism (in AI) has shown meagre success (as cognitive explanation, not in technological terms), to put it mildly. The development of cognitive robotics as a program to model intelligence has been a consequence of such a stalemate, and has taken the converse approach (starting from the bottom up, where implementation matters a lot, to try to get cognitive abilities out of sensorimotor patterns of interaction). But meaning, I contend, is not neural implementation: it depends upon and is made possible by implementation. Accordingly, I prefer the expression ‘embodiment of mental states’ rather than ‘embodiment of meaning’. It also has the virtue of bringing the problem of mental processing (see Section 17.3) into the open.

17.5 A more radical, non-cognitivist alternative

Up until now, I’ve been arguing that symbol grounding is not the only problem that affects cognitivism; I’ve suggested that it is in terms of informational states that it has to be addressed (to avoid regress or circularity), and that the embodied meaning program faces the problem of abstraction. Now, I would like to suggest a possible direction language comprehension research might take, which seems to me to offer a way to overcome the problems of cognitivism while suggesting how abstract cognition is possible. It is the option of dynamicism.

For starters, it may be convenient to remind you that representations are introduced as mediator states between meaning and brain: we can understand or think a thought in virtue of a mental state, neurologically implemented, that represents its content. Thus, mental representations are theoretical entities introduced to naturalistically account for certain psychological abilities, those that exhibit intentionality (Markman and Dietrich 2000). It is a fact that we can think abstract, propositional thoughts and understand abstract linguistic expressions, but this does not impose an explanation in terms of corresponding abstract mental symbols (as discrete entities, whose causal powers depend on their ‘form’, their syntactical properties), or not so abstract sensorimotor patterns. Other options may be available, which may have the added value of a better view of cognitive processing (instead of as symbol crunching). Two other stipulations are relevant, though I cannot discuss them here: language is arguably the canonical way to ‘measure’, to describe, propositional thought. A practical, implicit, not translational, conception of understanding is in order for many reasons (according to which understanding is not having a mental inscription but practical abilities of how to proceed, in a Wittgensteinian fashion; see Gomila 2002a). Finally, I want to make clear that I agree with the embodied meaning program that questions of implementation and embodiment matter a lot, and this is what makes embodied cognition congenial to dynamicism.

Recall the basics of dynamicism: it proposes a change of metaphors for cognition, from information processing to control; it focuses on sensorimotor and social coordination in real-time, as the outcome of basic processes, from which higher cognitive abilities are thought to emerge; adaptive behaviour is seen as the outcome of the interaction between body and environment, without an internal center of control where the ‘instructions’ are read and executed; knowledge acquisition is accounted for in terms of self-regulatory and
self-organizational processes, not postulation of explicit representations (for an introductory presentation see Beer 2000; Port and van Gelder 1995 was its manifesto). Interesting cognitive properties that dynamic models nicely capture include: dependency upon the details of previous history, upon context, sensitivity to initial conditions, priming, modulation of expectancies, perseverative behaviours in terms of previous motor activation, etc. (Erlangen and Schöner 2002).

Dynamicism has rightly been criticized for its grand antirepresentationalist contentions about cognition on the grounds of modest, meaning-impoverished sensorimotor coordination tasks (Clark and Toribio, 1995), and that, in more complex tasks, some notion of representation will still apply (Clark and Grush 1999). Some of the leading dynamicists agree (van Gelder 1998; Spencer and Schöner 2003); however, it is clearly a noncognitivist kind of representation since it cannot play the formalist role cognitivism attributes to mental symbols (mental processes as syntactic ones, as symbol crunching). This renewed notion of representation is not that of a discrete, stable, static, syntactical entity as in classical cognitivism, but a timed, continuous flux of states in a dynamical system. A way to make clear the appeal of this approach is in the context of motor control, through the notion of forward models (Wolpert 1997).

Forward models of control were developed in the early 1960s to overcome the limitations of classical feedback models in cybernetics (Kalman 1960), and were applied in neuroscience in the early 1970s (Ito 1970; Evart 1971). In simple sensorimotor tasks, control is achieved through (sensory, proprioceptive) feedback. Within these models, continuous comparison between the current state (as measured by the proprioceptive feedback) and goal state (specified in a ‘vocabulary’ compatible with the proprioceptive one), suffices to reduce their difference and eventually reach the goal state.

However, in some cases, where the movement is quick and the context may change fast, the feedback could not be available fast enough to help control the movement in time, or effectively. For such cases, forward models offer a better option: in addition to the motor centres that issue a motor sequence or plan, and the sensory or proprioceptive feedback provided from the effectors, an efference copy is sent to a ‘model’ of the motor system, called the emulator because it implements the same input–output function as the body–environmental interaction. While in principle this emulator could consist of a look-up table (a specification of a classical machine-table, of production rules, saying what to do for each input), its interest in control arises when it implements a ‘dynamic model’ of the subject–world system, an implicit model, the outcome of a previous story of engagement and interaction between system and environment. Thus, the emulator offers to the system an anticipation of the expected feedback given such a motor plan, thereby making possible the adjustment of the motor execution before the effective feedback comes. In a forward model, motor control is made efficient through the combination of the information from the sensors, together with the estimation of position offered by the emulator, in order to anticipate the actual state of the system and environment in which the interaction takes place.

An example of such a system may help. Think of long-distance navigation, where every route decision is plotted onto a chart where a scale model of the system (ship’s position,
target position, accumulated knowledge of the geography – rocks, currents – and information of current state – winds, weather) is represented. In such a way, an expectation of ‘where we should be already’, given direction and time, can be contrasted with ‘where we seem to be’, given measures of position – mostly done by global positioning systems nowadays. Of course, here the change of positions in the ‘internal’ model are executed by the officers in charge, while an internal emulator runs automatically.

The interesting point is that forward models such as this have been useful in accounting for the performance of several motor phenomena: orientation (with the cerebellum as space emulation [Ito 1980; Miall et al. 1993]), sensory integration (Wolpert et al. 2001), control of saccades (where ocular movements of adjustment to keep visual stability continuously take place [Tweed 2003]), response monitoring (Rodriguez-Fornells et al. 2002) and neuropsychological syndromes derived from their partial failure (Frith et al. 2000; Blakemore et al. 2002).

This has led Grush (Grush 2004) to suggest that this cybernetic notion, developed in the area of motor control, could help unify a whole set of areas of research, basically in that it can provide a general model of how both on-line (visual perception, motor control) and off-line processes (motor imagery, visual imagery, and even reasoning, language, and theory of mind phenomena) could be understood in a unified way. His idea is that:

… the brain constructs neural circuits that act as models of the body and the environment. During overt sensorimotor engagement, these models are driven by efference copies, in parallel with the body and environment, in order to provide expectations of the sensory feedback, and to enhance and process sensory information. These models can also be run off-line in order to produce imagery, estimate outcomes of different actions, and evaluate and develop motor plans (Grush 2004, p.377).

An important remark is that an emulator system need not ‘run’ on the same circuits that take charge of the direct interaction with the environment (in motor control at least, the evidence suggest that the cerebellum plays this emulation role), as the simulationist approach contends. This goes against the popular idea of simulation as off-line functioning: that visual imagery takes advantage of the same neural circuits involved in visual perception, except from the primary cortices (Kosslyn 1994), which is echoed with regard to motor imagery and motor control by Jeannerod (1997), and which can also be found in some of the chapters in this book with regard to language comprehension: linguistic understanding of action verbs would exploit the same circuits that the actions themselves to which they refer involve (for example, Pulvermüller, Chapter 6). Barsalou (1999) even introduces the term ‘simulators’ to express a parallel idea with regard to cognition as imagistic simulation capacities derived from perceptual experience, which would also provide the sense of linguistic expressions.

The difference consists in that emulation theory claims that imagery is produced not just by the activation of the visual or efferent areas, but by the fact that this activation feeds an emulator, which does not need to be restricted to the very same areas. It could be claimed that the difference between simulationism and emulationism is not so important: there might be different brain regions involved in off-line processes, instead of the
same, but this does not amount to a different conception of semantic grounding. However, keep in mind that the emulation theory is proposed in the context of dynamic models. In this regard, the interesting question here is how to conceive of the ‘forward models’ implemented by the emulators. From the technical point of view, they could just consist of a look-up table, i.e., a pairing of classical, symbolic, representations (like ‘if … then …’) productions. However, since an emulator’s function is to mimic the input–output function of some other system, it is clear that an optimal emulator should work on the same state variables as the real system, or at least on an approximation, a scale model.

Grush is not explicit about how to conceive of this articulated model of the body–environmental interaction. Spencer and Schöner’s notion of ‘dynamic field’ (Spencer and Schöner 2003) is promising to me, but developments in computational neuroscience such as those as presented by Knoblauch (Chapter 7, this volume), which formalize how the cortex could implement these models as complex neural networks, open a new field of possibilities to figure out how the brain might implement such emulator models.

What is crucial, though, is that such emulators, given their time constraints, cannot work as symbol crunchers but as dynamical systems that mimic the relevant variables of the interaction. In other words, from this perspective we are not going to expect specific neural activity correlated with each word; as mentioned before, a strength of dynamicism is that it captures nicely the context-dependency of meaning whereas cognitivism assumes context-independent symbolic types, whose causal interaction was determined precisely by its form.

17.6 Analogue representation of models

The question remains how to conceive of the states of emulators as mental representations, as contentful states, and consequently how language comprehension is to be conceived if not as translation into a mental symbolic code. In this regard, I take it that the representational value of such dynamical models that make emulation possible accords best with what has been called a ‘model’ analogue versus ‘sense’ analogue representation. The former is best illustrated by a map, while the latter is typically a mental image (or an off-line simulation of a perceptual or motor experience).

What is meant by analogue representation is a state that carries information in virtue of the resemblance with what it represents. It has generally been understood as perceptual resemblance, and contraposed to propositional, language-like representations. As a matter of fact, it was mental images that drove the general notion, which were thought of as a kind of continuous representation, in opposition to the discreteness and abstractness of propositions (mental symbol composites). It can be claimed, however, that analogue representation (and computation) need not be continuous, but also discrete and abstract. Think, for instance, of a map which marks the size of a population using concentric circles along a scale (less than 10,000 people, one circle; 10,000–100,000 people, two circles; and so on). The map represents the territory by keeping distance relations, and represents population size by ‘discretizing’ this magnitude
along a scale. This suggests the ‘map’ or ‘model’ interpretation of analogue representation, even though the term ‘model’ is already too ambiguous since it’s also been used for the perceptual understanding of mental models advocated by Johnson-Laird and his followers (as re-enactment of a perceptual experience, and hence as a kind of ‘sense’ analogue, and of simulationism). However, he has also lately accepted that symbolic elements may also appear in them, given the outstanding role of negation and quantification in their theory, and its abstractness (Johnson-Laird 2002). It is clear that we would never see such concentric circles in reaching a city, just as the perceptual content of an experience cannot be negative; however, it is still true that the representational relation between city size and number of circles is analogue, in a sense that cuts across the contraposition between continuity and discreteness.

This notion of analogue representation extends naturally into a notion of analogue computation (remember that it is useless to solve the problem of representation without solving the problem of computation). Instead of conceiving of computation as rule-based manipulation of explicit symbols, analogue computation involves the instantiation of the relations in focus in another medium, which is designed so as to reproduce their values and their interaction. This is the case of scaled-down models, such as a wind tunnel, where the aerodynamical effects are played out on a small-scale model of the aircraft, which allows one to compute the effects without any explicit algorithm execution. It would also be the case of, say, an electric circuit designed to model the flux of commercial distribution in a country, where wires might be taken to represent routes because of the general, abstract isomorphy between representation and represented. The intrinsic interactions between voltages, resistances, etc., in the model are exploited to compute the interaction of the represented values, while some of the parameters may depend on threshold crossing, for instance (thus introducing discontinuity and discreteness). What makes the representation possible is the (partial) isomorphy between the representing and the represented states and values, not their sensorial or motor resemblance.

To sum up, discrete is not the same thing as digital: the first allows for a unique representation of a set of values; the latter involves disjoint variables (Blachowicz 1997). Embodied representation, I want to suggest, should be conceived under this ‘model’ analogue representation where it is the relational identity between ‘object’ and ‘representamen’, rather than their resemblance, that grounds the representationality and the computational effects rather than its sensible content. In this way, abstraction is allowed and harmless. I take it that Grush’s emulation theory of representation can be viewed as an updated version of this notion, in that it grounds representation in the internal ‘model’ of the interaction between the system and environment that mediates this very interaction, and ultimately grounds its representational stance. Just as in an airplane, where control is based both on the values of the relevant variables (wind force, altitude, etc.) and on an on-line emulation of the effects of those variables on the machine, given previous values in a continuous calculation, human cognition is to be seen as relying on these internal models of the interaction. So while these internal models are to be conceived as ‘schematic’ or ‘diagrammatic’, they are also temporal and dynamical rather
than sensorial, conscious, or imagistic.³ (Luc Steels commented at some point in the Garachico workshop debate that he uses whatever parameter and magnitude he finds useful, not just continuous variables but discrete as well; it may be alright to represent a magnitude by several intervals rather than a rational number; in any case, relational isomorphy may also play a role).

It is not obvious, however, how this approach could be applied in detail to language comprehension. Some considerations can be advanced. First, this approach makes context matter right from the start: language comprehension will proceed according to practical concerns (a point already underlined by Glenberg (1997) as regards ‘memory for action’), which may account for the differences in ‘level of processing’ (underlined mostly by Sanford, Chapter 10, this volume). Second, understanding is not to be conceived as building an explicit symbolic representation of linguistic content, but rather as the outcome of feeding this linguistic information into an active model of the interactive state (which could account for the difficulties in isolating meaning from other effects of language processing, e.g., emotional, nonverbal, facial, and gestural, as pointed out by Nathan, Chapter 18); in this way, it opens a path to try to deal with the problem of relevance (or frame problem). Third, this continually updated internal ‘model’ is not to be conceived as either a ‘sentence in the language of thought’ or the imagistic simulation of a perceptual content; the sensoryimotor cortical activations involved in language processing, as demonstrated by Glenberg, de Vega, Pulvermüller, and others, may be reinterpretable as part of the running of the emulator in the control of one’s own activity, given current goals. Fourth, a correlational approach to mental functioning (looking for the neuronal correlates of cognitive functions) should yield to a more interactionist view of neural activity: instead of interpreting neural activation as the coding of meaning, it should be viewed as the activity elicited by the linguistic stimulus in an effort to anticipate what’s next and how to behave in such particular situation. The idea here is to carry home at the brain level the well established dictum that ‘meanings are not in the head,’ but in these patterns of interaction, which allows human experience to make sense in providing continuous anticipation and expectancy of what’s next. Finally, it seems to me that computational neuroscience work, such as that discussed by Knoblauch (Chapter 7, this volume), coheres well with the current view of the cortex’s main function as anticipation and expectancy generation based on internal models (promising a grand-scale model of the interaction, instead of the egocentric model implemented by the cerebellum in motor control).

There is a further implication as regards the psychological role of linguistic items as material symbols. As Clark (2006) has suggested, an alternative view of understanding (instead of as translation) may focus on its stabilizing and anchoring role of otherwise fluid and context-sensitive modes of thought and reason. I would put it this way: that the

³ In cognitive psychology, it has been the work on mental models by Gentner and Stevens (1983) that has been closer to this interpretation of internal models. Shepard’s notion of ‘second-order isomorphisms’ (Shepard 1975) may be also seen as a precursor to this approach. It was within this program that dynamical aspects of representation were first emphasized (cf. Freyd 1987).
order of explanation should be reversed. Instead of explaining language comprehension in terms of translation into a language of thought (be it abstract or built out of sensorimotor primitives), we should conceive of propositional thought and explicit representation in terms of our linguistic competence, of our practical use of external social symbols (Gomila 2002b). It is the acquisition of this competence that gives our thinking its expressive scope, not the other way around.

**Debate**

**Luc Steels:** I just wanted to say, you know, that this kind of emulationism obviously can be very useful. In fact, there’s been some people, particularly in Berkeley, looking at embodied language understanding using this simulationist approach. But it is also obvious that it is extremely limited, because we cannot expect to simulate every aspect of our world, you know, to learn to do that. I mean, to do it in a realistic way is just not possible. So, it can play a role, but it cannot substitute for all the rest, I think.

**Arthur Glenberg:** And what’s all the rest?

**Steels:** Well, for example, if you say there is an airplane flying over here, are you emulating flying and everything? It cannot be; you cannot experience yourself flying. So there are lots of aspects that we could emulate, but it is a small amount of what’s actually needed in order to understand, to predict the future, or infer.

**Glenberg:** The point of contraposing emulation to simulation has to do with this. Simulation, as it has been conceived, relies very much on imagination, as a sort of imagistic construction based on previous perception and active elicitation. Emulation, on the contrary, was introduced as a sort of nonexplicit, unconscious process that mediates fast and efficient action–perception integration, involving a kind of nonsymbolic model of the body–world interactive system. It is thus conceived as the nonrepresentational background that makes one’s experience in the world make sense; or, to put it in another terms, to feel at home in the world. From this point of view, this is what understanding amounts to, not to write an explicit proposition in a sort of belief box, but in that the experience makes sense, that we know how to proceed in such a situation, that we feel at home in the world. It is a distinct idea of understanding, not like the translational one of symbolic cognitivism.

**Lawrence Barsalou:** I’m interested in asking whether you take a reductionist approach, if the higher-order phenomena different people are talking about can be reduced to these low level dynamic systems. I think the history and philosophy of science show that reductionism doesn’t often work; higher-level concepts are needed to explain, or can be ideal for explaining, various phenomena. So I was wondering what your thoughts are on this. Maybe the higher-level concepts will have to be implemented in a different way as was classically conceived, but will still be useful.

**Antoni Gomila:** I agree. This is not to be understood as a reductionist proposal but as a reinterpretationist one. There is so much interesting work done from the standpoint
of cognitivism. I’m not suggesting that it is useless or makes no sense. My reasoning is the following: we have, on the one hand, nice software programs (like AutoTutor) or hardware machines, and are told by cognitivism that the brain works just as these programs and machines. But, on the other hand, neuroscience textbooks do not provide a glimpse as to how this could be so. In the last 50 years, the dominant approach to study cognition has been the top-down one you refer to, hoping that in the end we will be able to find out how this can take place in the brain. However, the flourishing of neuroscience (during the ‘brain decade’) has not provided such an answer. On the contrary, neuroscience seems to have assumed the cognitivist jargon (of codes, symbols, and so on), without making it coherent at its level. Thus, cognitivism expected neuroscience to make clear how the brain instantiates a Turing machine, but what we’ve got is a queer situation in which neuroscience doesn’t provide such an answer but accepts the idea of the brain as a kind of computational device. This is what seems to me wrong. Dynamicism is appealing to me because it has an offer of bypass such a strange situation. It is more congenial to what we know about how the brain works, and answers the question of how the brain computes: in terms of its dynamic patterns. Dynamic models have been put forward in interactionist terms (by Thelen and Schöner), but also of the brain as a system with no need, for instance, for an executive system.

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