Routledge
Taylor & Francis Group

Check for updates

ARTICLE

# The psychological reality of practical representation

## Carlotta Pavese

Philosophy, Duke University, Durham, NC, USA

**ABSTRACT**

We represent the world in a variety of ways: through percepts, concepts, propositional attitudes, words, numerals, recordings, musical scores, photographs, diagrams, mimetic paintings, etc. Some of these representations are mental. It is customary for philosophers to distinguish two main kinds of mental representations: perceptual representation (e.g., vision, auditory, tactile) and conceptual representation. This essay presupposes a version of this dichotomy and explores the way in which a further kind of representation – procedural representation – represents. It is argued that, in some important respects, procedural representations represent differently from both purely conceptual representations and purely perceptual representations. Although procedural representations, just like conceptual and perceptual representations, involve modes of presentation, their modes of presentation are distinctively practical, in a sense which I will clarify. It is argued that an understanding of this sort of practical representation has important consequences for the debate on the nature of know-how.

## 1. Introduction

We represent the world in a variety of ways: through percepts, concepts, propositional attitudes, words, numerals, recordings, musical scores, photographs, diagrams, mimetic paintings, and so forth. Some of these representations are *mental*. It is customary for philosophers to distinguish between two main kinds of mental representations: *perceptual representation* (e.g., vision, auditory, tactile) and *conceptual representation*. This essay presupposes a version of this dichotomy but explores the ways in which another kind of representation – *procedural representation* – represents. Procedural representation is a sort of representation posited by psychologists studying procedural systems and skillful behavior. It is argued that, in some important respects, procedural representations represent in a different way than both purely conceptual representations and purely perceptual representations. In particular, procedural representations involve modes of presentation just like conceptual representation and

**CONTACT** Carlotta Pavese ✉ carlotta.pavese@duke.edu 🌐 Philosophy, Duke University, Durham, NC, USA

perceptual representations do, but their modes of presentation are, as I will clarify, distinctively practical. An understanding of this sort of practical representation has important consequences for the debate on the nature of know-how.

In Section 2, I discuss, in general terms, the ways in which conceptual and perceptual representation represent by looking at some prominent work on conceptual and perceptual modes of presentation. Then, I introduce the theoretical possibility of *a distinctively practical form of representation* – a form of representation involving distinctively practical modes of presentation which are, as I will clarify, neither (or not entirely) conceptual, nor (or not entirely) perceptual. In Section 3, I argue that the procedural representations posited in current psychological and neuroscientific theories of motor behavior – particularly those in control theories of motor behavior – are an example of practical representation. In Section 4, I build off of certain assumptions about the nature of the representations on which procedural memory systems are based, in order to show that the same argument generalizes to every psychological theory that assigns to procedural memory systems a role in explaining skillful behavior. In Section 5, I distinguish the notion of practical representation from Nanay's (2013) notion of "pragmatic" representation, and I compare it to other recent discussions of motor representation. In Section 6, I discuss the import of my discussion for the recent debate on the nature of know-how. In particular, I argue that the notion of practical representation developed in this essay helps defuse a very common but wrongheaded argument against intellectualist theories of know-how (Fridland, 2017; Levy, 2017), according to which intellectualist theories about know-how cannot account for the role of motor representation in skillful motor behavior. I conclude in Section 7.

## 2. Preliminaries

Mental representation is perspectival. That means that we never represent things neatly. We always represent the world and its parts in some particular way, and the way we represent the world constitutes the "perspective" from which we represent it.

It is very common for philosophers to speak of conceptual and perceptual representation as perspectival in this way. A variety of authors characterize beliefs as maps from which we steer, suggesting that beliefs constitute points of view or perspectives (Ramsey, 2001:146; Armstrong, 1973; Lewis, 1994: 310–311; Braddon-Mitchell & Jackson, 1996, p. 177–184). Dretske (1988:79) utilizes the same metaphor in a more general sense for propositional attitudes. Burge generalizes it to both perceptual and conceptual representation: "All representation is representation-*as*" (Burge, 2010, p. 51), and all "representation is necessarily from some perspective or standpoint" (Burge, 2009, p. 247).

The perspectival character of conceptual representation is reflected in the *intensionality* of representation attributions that exploit the locution "represent Y as X" (Burge, : 35; Neander, 2017: ch. 2). For example, consider Mark's conceptual representation of Venus. Mark might think of Venus as the morning star but might be unaware that it also appears in the evening. Then, Mark represents Venus as the morning star (1.a. is true) but not as the evening star (1.b. is not true):

> 1.a. Mark represents Venus as the morning star.
> 1.b. Mark represents Venus as the evening star.

Mark represents Venus under one mode of presentation but not under the other, and this is reflected by the representation attribution "Mark represents Venus as…" being *intensional*.

It is well-known that conceptual representations can create intensional (or opaque) contexts. What about *non-conceptual* perceptual representation? (Bermúdez), 1995; Burge, , ; Evans, 1982; Neander, 2017; Peacocke, As Peacocke, 2001, p. 244) points out, there certainly is some intuitive notion of "mode of presentation" that applies non-controversially at the level of non-conceptual perceptual content: In perception, like in thought, we perceive things as being thus and so. Moreover, Peacocke (2001:73–75) observes that perceptual representations stand in many-to-one relations to their content, as, for example, when we perceive a square as a square or as a diamond, like in the Mach diamond's case (Rock, 2001; Humphreys & Quinlan, 1988; Humphreys, 1983; Neander, 2017:172–4; Figure 1).

Along the same lines, Burge (2010: 36–46) distinguishes conceptual representation from non-conceptual perceptual representation and points out that also in perception we perceive things through modes of presentation (Burge, , p. 41), although the modes of presentation are quite different between the two cases. For one thing, in perception the notion of perspective is more "concrete, commonly spatial-directional, sometimes phenomenological."[1]
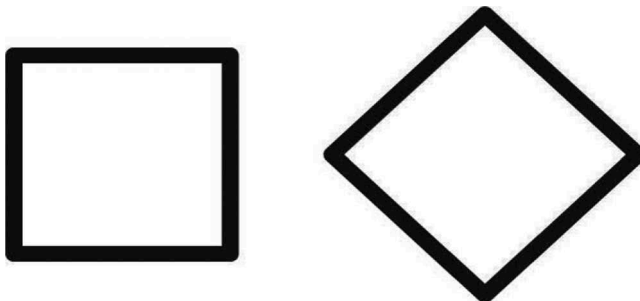


**Figure 1.** An ordinary square and a Mach diamond.

Why think that these non-conceptual ways of perceptually representing are *bona fide* modes of presentation? As noted, one indication of the presence of modes of presentation is the intensionality of the corresponding representation ascription. As Neander (2017, p. 34–8) points out, ascriptions of non-conceptual perceptual representations can create intensional contexts. In order to make this point, Neander notes that visual scientists routinely take visual representations to be structured along imaginary Cartesian grids (McCloskey, 2009; Palmer, 1999) :(see Figure 2)

Now, consider the following perceptual representation of a star and the following ascriptions:

> 2.a. Mary's visual system represents the top of the star as located at (4, 2.8).
> 2.b. Mary's visual system represents the top of the star as located at the place mentioned above for illustrative purposes.
> 2.c. Mary's visual system represents the top of the star as located at the place to which the arrow points in Figure 4.

Ascription 2.a might be true of Mary's visual system, but, as Neander observes, we can, of course, refer to the same point in space (4, 2.8) in a different way, for example, as the place mentioned in the sentence above for illustrative purposes (Neander, 2017, p. 37). Alternatively, we could refer to it as the place to which the arrow points in Figure 6. Although the descriptions "4, 2.8," "the place mentioned in the sentence above for illustrative purposes," and "the place to which the arrow points in Figure 6" co-refer, ascriptions 2.b and 2.c are not true of Mary's visual system, as Mary's visual system does not represent the moon as located at the place mentioned in the sentence above for illustrative purposes.[2]
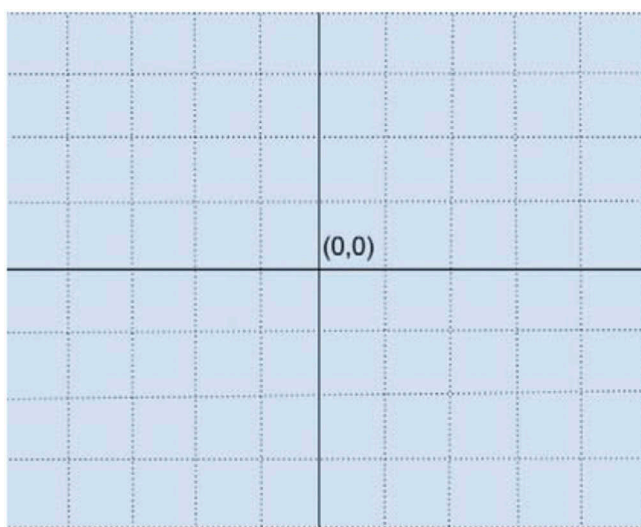


**Figure 2.** The visual field as a Cartesian grid.
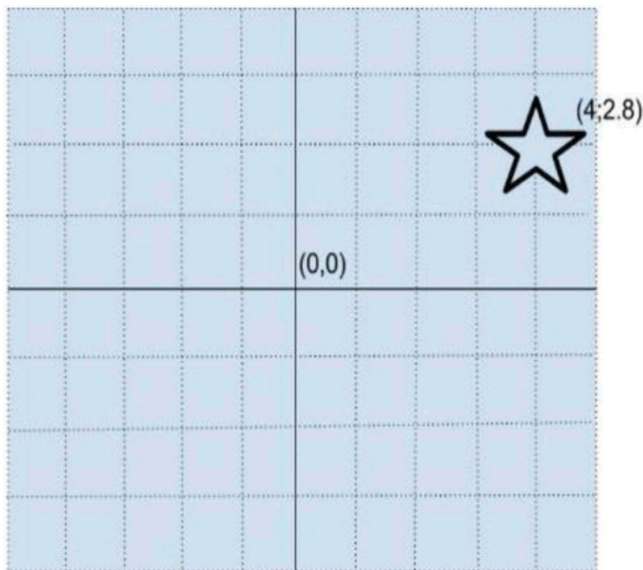
**Figure 3.** Star on a Cartesian grid.
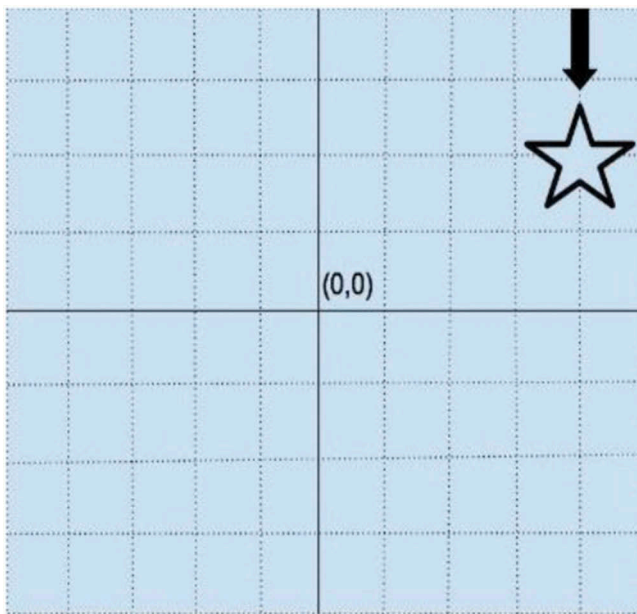


**Figure 4.** Star and arrow on a Cartesian grid.

As Neander (2017, p. 37) points out and as this example shows, because of the intensionality of their reports, it makes sense to also talk of modes of presentation for the visual system's representations, regardless of whether those representations are introspectively accessible to the subject and regardless of whether those representations are conceptual.

Hence, both conceptual representation and non-conceptual perceptual representation can involve modes of presentation. They can both be *representations-as*. Such modes of presentation constitute, as Burge (2010:37) puts it, the *perspective* from which an animal or a person's representation steers: Representing in a perspectival way is equivalent to the representation having a mode of presentation (also. Burge, , p. 249–50).

The relevant perspective differs, of course, in the case of conceptual or perceptual representation: In one case, modes of presentation are conceptual, and in the other, they are not. There is, however, a commonality. In both kinds of representations, the nature of the relevant perspective is tied to the relevant *representational abilities*: As Burge (2009:250) puts it, in perception, like in thought, we represent "through abilities that provide partial, incomplete, usually fallible perspectives on actual or purported subject matter." In other words, what we can represent and how we represent it depends on the representational abilities and capacities of the representing subject. Perceptual representations represent the world in accordance with one's *perceptual abilities*. Conceptual representations represent the world in accordance with one's *conceptual abilities*.

What are perceptual abilities or capacities? I will refer to perceptual abilities in general as I do to particular kinds of representational abilities – abilities to *track* features of the environment. By "ability to track features of the environment," I mean, quite standardly, the ability to change states in a lawlike fashion in accordance with the variations in one's environment. A long tradition in the philosophy of mind takes the perceptual system to be the paradigm case of a system well-suited for tracking features of the environment (e.g., Dretske, 1988; Stalnaker, 1998:347; Neander, 2017, p. -152–3).[3] For example, in Neander's (2017) previous example, the visual system tracks the environment by locating objects in two-dimensional space. This ability is a special kind of tracking ability, for it is an ability to vary states which are two-dimensionally structured in accordance with the variations of objects and their features in three-dimensional space. Alternatively, consider the Mach diamond. Noting this phenomenon, Humphreys and Quinlan (1988) argued that perceptual representations of squares are structurally distinct from perceptual representations of diamonds and that this structural difference depended on how one represented the orientation of the figure (see also Humphreys, 1983). The different ways in which one might represent the orientation of a figure correspond to different visual modes of presentation which are, in turn, indebted to the structural characteristics of our visual tracking abilities. Finally, the auditory system and the touch system also track features of the environment (Coombs, Fay, & Elepfandt, 2010; Dau, Püschel, & Kohlrausch, 1996; Porter et al., 2001), although their ways of tracking features in the environment do not need to be of the same kind as the

visual ability to locate objects in two-dimensional space, nor do they need to share the same structural characteristics. Their modes of presentation are correspondingly different. Hence, although perceptual abilities can vary a lot across sensory modalities, they are all essentially *tracking abilities* – abilities to carry information about the environment.

Conceptual representations too represent in accordance with the abilities that representing subjects possess. In this case, however, the relevant abilities are conceptual. What a conceptual ability is depends on what concepts are, and this is, notoriously, a thorny question in philosophy and psychology. Some take a concept to be any mental representation that is combinatorial – that can combine into more complex representations in accordance with systematic, structural rules (Camp, 2009; Fodor, 1975, 1994, 1998; Gallistel, 1990). Following Camp (2009), I will call this the *minimalist conception of concepts*. A more widely held view of concepts takes a concept to be a representation that is combinatorial and, in addition, underlies higher-order cognitive capacities of predication and thinking.[4] On this *robust conception* of concepts, as I will call it, many combinatorial representations that underlie lower-level cognitive abilities, such as perceptual or motor abilities, do not count as concepts if those abilities are not abilities to predicate or to think. For the purpose of the main argument in this essay, I will assume a robust conception of concepts, as it seems to prevail both in psychology and in philosophy (Burge, ; Laurence & Margolis, 1999; Machery, 2009; Margolis & Laurence, 2014; Peacocke, 2001; Prinz, 2001; Rosch, 1978; Rosch & Mervis, 1975).[5]

Thus far, I have been arguing for a couple of theses. The first thesis, already rather popular in the philosophy of mind, is that both conceptual representations and (non-conceptual) perceptual representations can involve modes of presentation. In this sense, they are *perspectival*. As Neander's (2017) argument shows, just because a representation involves modes of presentation does not necessitate that the representation be introspectively accessible to the subject or even that it is part of the subject's experiential state. The second thesis is that the nature of the perspectives of conceptual representation and of nonconceptual perceptual representation. The perceptual abilities that we possess constitute the perspective from which we can perceive the world, and the conceptual abilities that we possess constitute the perspective from which we can conceptually represent the world. In the case of perceptual representation, the relevant abilities are tracking abilities. In the case of conceptual representation, they are the ability to predicate and to think.

This discussion puts us in a position to introduce the theoretical possibility of a distinctively practical kind of representation. The thesis that practical representation is psychologically real is the thesis that there is a third way of representing the world, alongside perceptual representation and

conceptual representation – that is, a practical way of representing the world. To practically represent the world is to represent it in accordance with abilities that are neither necessarily perceptual nor necessarily conceptual, in that they are not necessarily abilities to track, nor are they necessarily abilities to predicate or to think. These abilities differ from tracking abilities as well as from predicative and thinking abilities in their direction of fit (Platts, 2001:257; Anscombe, 1957, p. 56): Instead of having a world-to-mind direction of fit like tracking and thinking abilities do, they have a mind-to-world direction of fit. In this sense, they are practical abilities.[6]

The claim of this essay, then, is that practical abilities can also constitute the perspective from which we represent the world, in the same way that perceptual abilities can constitute the perspective from which we perceptually represent the world and conceptual abilities can constitute the perspective from which we conceptually represent the world. When we represent the world from the perspective provided to us by our practical abilities, we represent it *practically*.

The next section argues that practical representation enters center stage in current psychological theories of motor control that appeal to motor instructions and motor commands.

## 3. Practical representation in control theories of motor behavior

According to so-called "control theories" of motor behavior, a motor task such as, for example, the task of pouring wine in a glass involves a series of sensorimotor transformations that map the intentions of the agent together with visual and other sensory information about the location of the targeted objects (bottle and glass) and the location of the limbs into a series of motor commands. The idea behind these models is that the agent's intentions are mapped into motor representation bit by bit – the bits being the smallest parts of the complex intentions. For example, consider the complex task of pouring wine in a glass. Suppose we break it into parts. For example, one part might consist in moving the hand to the glass, another part in lifting the bottle of wine, yet another in bending it, and so on. According to these models, each of these parts is mapped onto a motor command that is executed by the motor system; its execution gives rise to visual feedback which is then fed into the motor system and, given the possibly updated intention of the agent, is mapped into a new motor command, and so on (e.g., Bernstein, 1967; Schmidt, 1975, 2003; Jeannerod, 1997:11–55; 2006; Arbib, 1981, 1985; Wolpert, 1997; Wolpert & Ghahramani, 2000; Wolpert & Flanagan, 2001; Wolpert & Kawato, 1998; Kawato 1999; Wolpert & Diedrichsen & Flanagan 2011; Wolpert & Ghahramani & Jordan 1995; Wolpert & Miall & Kawato 1998; Trappenberg 2009).

In these computational models (see Figure 5), the role of motor commands can then be characterized as twofold. Firstly, motor commands translate desires and intentions that the agent might have into a representation that can then be interpreted and executed by the motor system; secondly, motor commands instruct the motor system how to execute a given motor task.

*Qua* outputs of the motor planning and *qua* inputs to the motor system's computations, it is plausible to take motor commands to be representations *of some sort*. Of course, they are not representations in the sense that they have truth- or accuracy-conditions. They are, nonetheless, as Tulving (1985, p. 387–8) puts it, "prescriptive" representations or, as Anderson, 2005 , p. 165) puts it, "procedural" representations – like imperatives in natural languages.[7] *Qua* representations, it makes sense to ask what motor commands represent and how.

On the denotational model, as I will label it, motor commands represent what they prescribe – tasks which are to be performed by the motor system. The denotational model dovetails nicely with a particular approach to the semantics of imperatives that has been put forward in recent years (Lascarides & Asher, 2004; Barker, 2012), according to which the meaning (or denotation) of an imperative such as (1) is an *action outcome*[8]:

(1) Dance!

According to this denotational model, (1) denotes the outcome of dancing. Extending the denotational approach to motor commands, we see that a motor command denotes, or represents, an action outcome, such as the result of moving one's hand to a target location or the result of lifting a wine bottle. More generally, on a broadly teleo-semantic approach to the content of mental states, a conative state has as its content the effect that the conative state has the function of bringing about (Millikan 1984; Papineau 2001; Schulte Pavese, 2001). Extending this approach to the content of motor commands, we see that a task is the content of motor commands since a task is that which a motor command has the function to bring about.

However, motor commands do not just denote, or represent, action outcomes (or task outcomes). They do so from a certain perspective, through a certain mode of presentation. The first step of the argument is the claim that a motor command does not just represent a task neatly, but it represents in a particular way and in accordance with a particular method. Consider again the example of a motor task that consists in moving one's hand to a target location. There are a number of possible paths that the hand could move along, and for each of these paths, there is a number of velocity-profiles (trajectories) that the hand could follow.

Even after having specified the hand-path and the velocity, each of the hand's locations along the path can be achieved by multiple combinations of joint angles, and each arm configuration can be achieved by many different muscle activations (Wolpert, 1997, p. 2). In this sense, the same motor task can be performed by a variety of different methods.

Now, in these computational models, so-called "motor-planning" is the process through which a task intended by the agent is translated into a motor command and the particular method by which a task is to be performed by the motor system is selected across a variety of different options. As Wolpert (1997, p. 2) puts it:

> Motor planning can be considered as the computational process that consists in selecting a single solution or pattern of behavior at the levels in the motor hierarchy, from the many alternatives which are consistent with the task.

Figure 4 (from Wolpert, 1997, p. 3) shows the motor hierarchy. In it, the same task outcome – reaching for a glass on a table – corresponds to different paths the hand could take which, in turn, correspond to different possible trajectories that could be executed by different movements of the joints, and these movements, in turn, correspond to different muscle activations that could be prescribed by still different neural commands.

Motor commands are supposed to be the outputs of this process of motor planning. If so, they must bear record of the method by which the task they represent is to be performed. Hence, they must prescribe the task as to be performed in accordance with a certain method.

Therefore, the denotational model is incomplete. Motor commands do not just represent tasks. They represent them in a particular way – as to be performed in accordance with a certain method. These different methods can be ascribed to the modes of presentation, whereby motor commands represent the task to be performed. In fact, it is quite natural to think of these methods as modes of presentation of tasks. As we have just seen, methods stand to tasks in a many-to-one relation, for the same task can be performed by more than one method. Moreover, a method is always a method to perform a specifiable task (Girard 1989; Pavese, 2001, p. 2–5); finally, the execution of a method $M$ would, in favorable conditions, result in an output of the task that $M$ is a method to perform. In this sense, a method fixes, or determines, that task.

For example, consider Method 1, Method 2, and Method 3, given in Figure 7.[9]

As this example illustrates, different methods to perform a task can be thought of as different ways of breaking down a task into subtasks (Pavese, 2001, 2001). Method 1 breaks the task $\tau_1$ into two parts: $\tau_{1a}$ and $\tau_{1b}$. Method 2 differs from Method 1 in that it breaks $\tau_{1a}$ and $\tau_{1b}$ into further
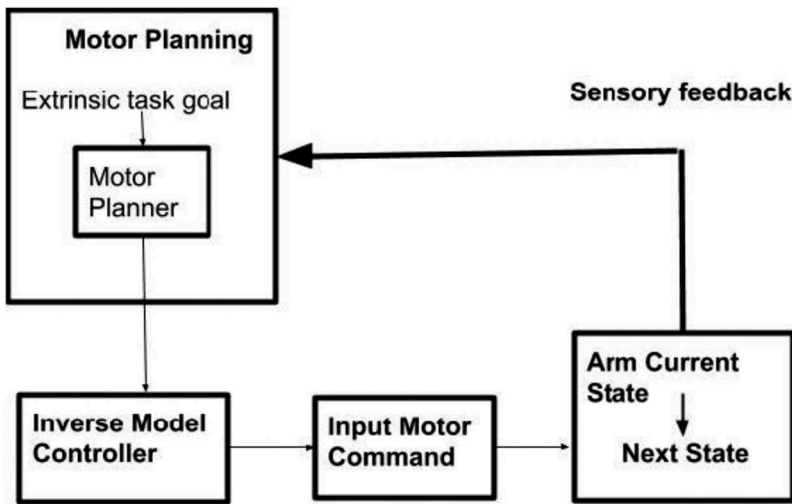
Figure 5. The motor system (Wolpert, 1997, pp. 209–210; Trappenberg, 2009, p. 271; Kawato, 1999, p. 719).

parts. Method 3 differs from Method 2 and Method 1 because it breaks $\tau_1$ down into three altogether different parts ($\tau_{1x}$, $\tau_{1Y}$ and $\tau_{1Z}$) and $\tau_{1Y}$ into two further parts ($\tau_{1Ya}$, $\tau_{1Yb}$). Because each of these three methods are methods to perform the same task ($\tau_1$), they all denote or represent $\tau_1$. However, they represent it in different ways, that is, through different decompositions of the task into parts. In this sense, different methods can be different modes of presentation of the same task. They present the same task differently, as they represent it through a different breakdown of the task into parts, that is, through a different structure.

Why think of these modes of presentation as distinctively practical? As the example above illustrates, different methods can be thought of as different ways of breaking down a task into subtasks (Pavese, 2001, 2001). *Qua* ways of breaking down a task into subtasks, they must come to an end at some point. They cannot divide into subtasks indefinitely because a method for a system *s* to perform the task $\tau$ must answer the question "How can *s* perform $\tau$?" that is, it must provide an explanation of how *s* can execute $\tau$. A satisfactory explanation of how *s* can execute $\tau$ must come to an end at some point – it cannot go on *ad infinitum*. If methods for performing a task cannot divide it into subtasks indefinitely, then their division of tasks into parts must reach a set of "elementary" subtasks – ones that have no further proper parts.[10]

Now, either the set of elementary subtasks is relative to a system, or the set is not relative to a system, in other words, it is absolute. The problem with the latter option supposition is that it is not clear that the notion of an absolute elementary subtask even makes sense. An elementary task is, by

definition, one that a given system at a given time (or a given set of systems with certain commonalities at a given time [. Fodor 1968:629]) can perform directly, but of which it cannot perform a proper part. Hence, the very same operation may be elementary for a system at a particular time and not elementary for another system at that time or, even, for that very same system at another time. Because of this, it is not clear that we are speaking intelligibly when we say that there are ways of breaking down a task into a set of elementary operations that could be common to every system.

The relativity of elementary operations can be seen starting from the phenomenon of "chunking." Chunking is a process by which a sequence of elementary operations gets "chunked" into parts that can then be executed as unified wholes (Verwey, 1996, 2001; Sakai, Kitaguchi, & Hikosaka, 2003). For example, through chunking, a sequence of elementary operations [A], [B], [C], [D], [E], and [F] can get chunked into two big parts [A, B, C] and [D, E, F]. Through chunking, the sequence [A, B, C] loses, so to say, theoretically interesting structure: The system has now come to execute it directly, for it has at its disposal a "specialized" instruction for executing, at once, a task that, before, it had to execute through three different instructions. In psychological theories of motor behavior, it is widely thought that practice makes improvements in performance possible precisely through chunking, for chunking makes the processing of a motor sequence more efficient (Verwey, 2010; Verwey, Abrahamse, Ruitenberg, Jiménez, & de Kleine, 2011, p. 407).

Now, if a chunked sequence is a specialized instruction that, from the point of view of its computational structure, is without parts, it makes sense to think of it as a new elementary operation for the system. If chunking is possible, as it seems to be, then the set of elementary operations of a system must change over time; in virtue of their lack of computational structure, the new chunks qualify for inclusion in the list of newly acquired elementary operations. Moreover, different systems may have different elementary operations at the same time, for they might have undergone different chunking processes.

If what counts as an elementary operation is relative to systems and times and if a method is a way of breaking down a task into operations that are elementary for a system, then methods must be relative to systems and times too. In other words, whether a way of breaking down a task into subtasks constitutes a method for that system to perform that task will depend on the system's stock of elementary operations.[11] Hence, methods are not just modes of presentation of tasks: They are practical modes of presentation, as they represent a task in terms of operations that the system can elementarily perform. These most basic abilities do not need to be conceptual abilities nor do they need to be perceptual abilities, for they do

not need to sort things into categories or predicate of things, nor do they need to track features of the environment. Their direction of fit (Platts, 2001: 257; Anscombe, 1957, p. 56) is mind-to-world rather than world-to-mind. In this sense, the perspective of motor representation is neither (entirely) conceptual nor (entirely) perceptual but, rather, distinctively practical.[12]

Now, we have all the ingredients for an argument to the effect that motor commands are practical representations and that, through them, motor systems represent practically. Consider a motor system with the following elementary operations: $\tau_{1a1}$, $\tau_{1a2}$, $\tau_{1b1}$ and $\tau_{1b2}$ but not $\tau_{1Z}$, $\tau_{1X}$ or $\tau_{1Y}$. We can further suppose that $\tau_{1a}$ and $\tau_{1b}$ are not elementary for the system. Consider a motor task $\tau_1$ and the three methods in Figure 3. Although Method 1, Method 2, and Method 3 are all ways to perform $\tau 1$, only 3.b is true:

   3.a. Motor system 1 represents $\tau_1$ as to be performed in accordance with Method 1.
   3.b. Motor system 1 represents $\tau_1$ as to be performed in accordance with Method 2.
   3.c. Motor system 1 represents $\tau_1$ as to be performed in accordance with Method 3.

Moreover, although Method 1 and Method 2 partially overlap, only Method 2 represents $\tau_1$ from the point of view of the elementary abilities of Motor System 1. By contrast, Method 1 does not tell the system how to further decompose $\tau_{1a}$ and $\tau_{1b}$. Since $\tau_{1a}$ and $\tau_{1b}$ are not elementary for Motor System 1, Method 1 is not a method for the system to perform $\tau 1$. Hence, it is not a practical mode of presentation of $\tau 1$ for Motor System 1.

In this sense, ascriptions of motor representations are intensional (or opaque) in a similar way to how ascriptions of perceptual representations are intensional (or opaque) and in a similar way to how ascriptions of conceptual representations are usually taken to be intensional (or opaque): Although these methods all determine the same task, not all of them are ways in which Motor System 1 can represent.

Hence, motor representations involve modes of presentation, but the relevant modes of presentation are practical, for they represent a task in accordance with the system's most basic practical abilities. Thus, a motor system might represent a task differently across time with the variations of its practical abilities across time, and two motor systems with different practical abilities might represent a task differently at the same time. Because the motor representation of the same task varies with a system's stock of practical abilities at a given time, motor representations qualify as practical.

## 4. The scope of practical representation

My argument in the last section consisted in pointing out that motor commands qualify as practical representations, in the sense that I introduced in Section 2: They represent a task as needing to be performed in accordance with a method, where a method breaks down the task in different ways depending on the system's practical abilities.

In order to forestall a potential objection, it is important to emphasize that the claim here is not that any representing state with a mind-to-world direction of fit thereby represents practically. For example, desires have a mind-to-world direction of fit, but they do not thereby represent practically in the sense that is relevant here, for they do not thereby represent what is desired differently depending on the practical abilities of the desiring subject. Here, it is helpful to recall the *force–content* distinction for mental states. Beliefs and desires have different forces but the same kind of content. Though the force of desire has a mind-to-world direction of fit, desires do not thereby represent practically, for they do not thereby represent the world differently depending on the practical abilities of the subject. Alternatively, consider commands that are issued with imperatives in public languages, such as "Dance!" If the denotational semantics for imperatives is correct, such a command represents the task of dancing. However, it does not represent the task of dancing practically, for it does not represent it differently depending on the speaker's or hearer's practical abilities. What is distinctive of practical representation is that the abilities which are relevant to how it represents have a mind-to-world direction of fit. Like any sort of commands, motor commands have a mind-to-world direction of fit, but that in itself is not what makes them practical representations. What makes them practical representations is the way in which they represent the task to be executed – the fact that they represent it differently as a function of the practical abilities of the representing system.

Thus far, I only argued that motor representations are practical. Does practical representation extend beyond the realm of motor tasks? Note that my characterization of practical representation in Section 2 is not restricted to motor tasks: Practically representing *any* task is a matter of representing it in terms of a system's elementary abilities. Given this characterization, we should expect practical representation to take center stage in explanations of skills other than motor skills. This section documents certain widespread assumptions in psychology and neuroscience on the type of representations on which procedural memory systems are based. The goal is to show that if those assumptions are not wrongheaded, then the argument given in the last section generalizes to every skill, for it generalizes to every procedural memory system.

The distinction between declarative and procedural systems is foundational in cognitive science and goes back to Milner's pioneering experiments in the late 1950s. Her work with the patient known as H.M. has been taken as revealing a dissociation between different kinds of knowledge. After bilateral removal of the hippocampus, parahippocampal gyrus, entorhinal cortex, and most of the amygdala, done to relieve debilitating symptoms of epilepsy, H.M. was unable to form new memories of facts or events, and he could no longer access memories he acquired in the few years leading up to his surgery. Nevertheless, Milner (1962) found that over 10 trials, H.M. acquired the motor-skills necessary to trace the outline of a five-pointed star in a condition of only being able to see the reflection of the star, his hand, and the pencil in a mirror. This learning indicated a dissociation between the function of forming memories of facts and events, on the one hand, and the function of improving motor-skills, on the other.

Cohen and Squire (1980) subsequently demonstrated that the skill-learning preserved in amnesia is not limited to motor-skill-learning but also includes cognitive-skill-learning. Cohen and Squire (1980) concluded that the storage and reinstitution of "procedures" for action (procedural memory) is entirely distinct from the storage and retrieval of previously learned facts or previously experienced events (declarative memory). While "procedures" for actions are retained by amnesiacs from trial to trial and indeed are perfected from trial to trial, the relevant declarative knowledge has to be reacquired by amnesiacs at each trial.

Since Milner (1965) and Cohen and Squire (1980), the distinction between procedural knowledge and declarative knowledge has been foundational in psychology and neuroscience (. Bayley, Franscino, & Squire, 2005; Cohen & Eichenbaum, 1993; DeBrigard, forthcoming; Roy & Park, 2010; Squire, 1992, 2009; Squire & Kandel, 2003; Squire & Wixted, 2011, 2016; Squire & Zola-Morgan, 1988). Although there is no shortage of detractors, even those challenging the distinction end up relying on some version of it (Dew & Cabeza, 2011; Henke, 2010).

How are we to think of this procedural component? It is not unusual for cognitive scientists to talk of procedural memory systems as *representation-based* and to describe the representations as "prescriptive." For example, Tulving (1985, p. 387–388) points out that "the representation of acquired information in the procedural system is prescriptive rather than descriptive." Here Tulving is not just talking about the motor system but, more generally, about procedural memory systems which may be involved in the generation of actions that are not necessarily motor. Along the same lines, Anderson (1982) studies cognitive skills such as learning to program a computer or solving a differential equation. For the acquisition of skills of this sort, Anderson (1982, p. 369–371) distinguishes two stages: (1)

a declarative stage in which facts are learned about the skill domain and (2) a procedural state in which the domain knowledge is "directly embodied in procedures for performing the task." Procedures are characterized as "primitive rules," and such primitive rules are represented as instructions. For example, a primitive rule for performing addition would have the form of a conditional instruction or an imperative, conditional on the goal of the task:

> If the goal is X, then do Y!

Since Anderson (1982), it has been very common for psychologists and neuroscientists to think of procedural representation in such prescriptive terms. For example, in their study of cognitive skills such as solving a differential equation, (Singley and Anderson, 1982, p. 165) talk of "procedural representations" for algebraic operations such as 'restate' and 'evaluate.' By "procedural representations," they mean a "production rule," and they model production rules after computer program instructions (Singley & Anderson, 1989, p. 190–1).

(Knowlton & Foerde, 2008, p. 107) inquire over the "neural representations supporting different forms of nondeclarative learning" across various domains of skills, including both visuo-motor skills, such as dancing and mirror-inversion drawing tasks, and cognitive skills, such as picture-naming, word-completion, and probabilistic classification-tasks (Foerde, Knowlton, & Poldrack, 2006; Knowlton, Mangels, & Squire, 1996). As they acknowledge (2011:109), cognitive skills too are "not purely declarative or procedural, with performance influenced by both types of knowledge depending on the circumstances." They claim that a procedural component supports different forms of non-declarative learning in the case of cognitive skills too, and they conceive of that procedural component as involving a "procedural" representation. An account of the procedural component of cognitive skills in terms of instructions is also explicitly defended by Taatgen (2013). On Taatgen's model, a cognitive skill such as counting involves the proceduralization of certain declarative knowledge into production-rules, also represented along the lines of computer programs as instructions.

To summarize, current psychological theories of skillful behavior assign to procedural components an important role to play not only in a theory of motor skills but also in a theory of non-motor, cognitive skills. When modeling procedural systems, psychologists also routinely posit "procedural" representations, and those representations are generally thought of as prescriptive.[13] On the assumption that this practice of positing procedural representations is legitimate, the argument in the last section generalizes to cover a variety of different sorts of tasks: Any such task that can be represented procedurally is thereby represented practically, in the sense

that it can be represented in terms of the elementary operations of the relevant procedural system (whether it is a motor system or not). If so, far from being confined to an explanation of motor skills, practical representation enters center stage in any psychological explanation of skills, whether motor or not, that assigns an explanatory role to procedural systems.

## 5. Comparisons

A number of authors (Rizzolatti, Fogassi, & Gallese, 2001; Rossetti, 2001; Gallese & Metzinger, 2003; Stevens, 2005; Rizzolatti & Sinigaglia, 2001; Pacherie, 2011; Nanay, 2013; Butterfill & Sinigaglia, 2014; Sinigaglia & Butterfill, 2015; Lex, Schütz, Knoblauch, & Schack, 2015; Mylopoulos & Pacherie, 2016; Levy ; Brozzo, 2017; Fridland, 2017) have discussed and emphasized the central role that motor representation plays in the production of intentional motor actions. Nanay (2013) has even coined a new expression – "pragmatic representation" – to characterize the intervention of a special sort of unconscious representation in the guiding of action. The notion of practical representation introduced in this essay differs, however, in some crucial respects, both from Nanay's (2013) pragmatic representation as well as from the above authors' discussions of motor representation. This section highlights some crucial differences.

For Nanay (2013), pragmatic representations are not at all prescriptive. In fact, Nanay (2013, p. 16–17) distinguishes between a cognitive or representational component (which he calls "the immediate antecedent of actions") and a "conative" component, and he explicitly identifies pragmatic representation with the cognitive component:

> The cognitive component represents the world, whereas the conative one moves us to act. As long as we make a distinction between these two components of the immediate mental antecedents of action, there is no reason why the representational component (what Brand calls the "cognitive" component) would need to have a "world to mind" direction of fit. The "conative" component moves us to act, and the representational component tells us how the world is in such a way that would help us to perform this movement.

I doubt that Nanay would count motor commands or motor schemas among his pragmatic representations because, for him, both motor commands and motor schemas are prescriptive and have a mind-to-world direction of fit. The same is true of most of the recent philosophical and psychological discussions of motor representation: They do not necessarily take motor representation to be prescriptive (or, at least, not explicitly). By contrast, practical representations in the sense discussed here *are* prescriptive: They represent a task as to be performed in a certain way. In this

sense, my practical representations resemble more the "conative component" of Nanay's (2013) immediate antecedents of actions than Nanay's pragmatic representations proper.

Secondly, my proposal differs from both Nanay's (2013) concept of pragmatic representation as well as from other discussions of motor representations in that my notion of practical representation is more general than that of pragmatic or motor representation. Current discussions of the role of motor representation in intentional action, such as Butterfill and Sinigaglia (2014, 2015), and Mylopolous and Pacherie (2017), are explicitly restricting their attention to motor actions.[14] These authors are not interested in providing a more general functional characterization of procedural representation. Nanay (2013, p. 18) is also very explicit in restricting his notion of pragmatic representation to the domain of non-mental actions:

> I don't think we have any reason to believe that the representational components of the immediate mental antecedents of mental actions are perceptual states (although some may be quasi-perceptual states, such as mental imagery, see Shepard and Metzler 1971). The argument I will present for the claim that pragmatic representations are perceptual states only applies to non-mental actions.

Because Nanay (2013, p. 3–4) focuses on motor actions, for which perception is essential, he identifies pragmatic representation with a sort of perceptual representation:

> Pragmatic representations are, at first approximation, the representational components of the immediate mental antecedents of action. They are also genuine perceptual states. [..] Pragmatic representations are *bona fide* perceptual states.[15]

Nanay (2013) goes on to characterize pragmatic representations as perceptual representations that are unconscious – not typically accessible through introspection.

In contrast, practical representations as conceived in this essay do not need to be perceptual representations (or, at least, not entirely). In Sections 2–3, we have seen that, whereas perceptual representation represents the world through one's perceptual abilities, which are essentially tracking abilities, practical representation represents the world through primitive abilities that are not necessarily perceptual. In particular, as I understand it, although a practical perspective might involve perceptual abilities – as, for example, in the case of sensory-motor representation, where the perceptual component is essential – the perspective is not limited to those abilities, for, by definition, a practical perspective includes abilities that do not need to be perceptual abilities. While perceptual representation represents the world in terms of our perceptual abilities, which are essentially discriminatory and tracking abilities, practical representation represents

the world in terms of abilities that are not necessarily and not entirely perceptual. They differ from perceptual abilities in that they have a different direction of fit.

Moreover, whereas Nanay's pragmatic representation is sensory-motor, practical representation is not exhausted by sensory-motor representation. Recall that a practical way of representing a task is a way of representing a task in terms of a system's most basic practical abilities. In the last section, I tried to emphasize that motor representation as posited by control theories of motor behavior is just one example of practical representation. Practical representation, in my sense, plays a role in explanations of skillful non-motor behavior: In particular, it plays a role in explanations of skillful mental and cognitive behavior, such as skills in performing mathematical tasks, as Anderson's (1982) notion of procedural representation suggests. Hence, motor representation provides but one example of practical representation, and the notion of practical representation captures what is common to all sorts of "procedural representations" (to use Anderson's 1992 expression) upon which procedural systems are based.

In conclusion, the present discussion of practical representation differs from previous discussions of motor representation, including from Nanay's (2013) notion of pragmatic representation, in that (1) it emphasizes the prescriptive character of practical representation, in that it is based on a functional characterization of procedural representation in terms of its distinctive perspective; (2) it is more general, in that it purports to capture what is common to procedural representations across different domains of skill; and, partly as a consequence of that, my view differs from Nanay's (2013) in that (3) it contrasts practical representation to perceptual representation.

## 6. Know-how and practical representation

Intellectualism about know-how is a family of views that share the idea that knowing how to perform an action is a matter of being in a certain distinctive knowledge state with propositional content – the state of knowing a proposition about how to perform that action under a practical mode of presentation (Stanley & Williamson, 2001; Stanley, 2011; Pavese, 2001, 2001, 2001, 2001, 2001; Pavese, 2001). According to anti-intellectualism, instead, know-how cannot be understood entirely in terms of a knowledge state (Noe, 2005; Devitt 2011; Glick, 2011, 2012).

The best motivation for intellectualism comes from action theory (Pavese, 2001, 2001, 2001, 2001). Know-how characteristically manifests through intentional actions. To use Ryle's (1949) example, the clown falls and tumbles skillfully, whereas the simply clumsy person also falls and tumbles but not skillfully, because the clown falls and tumbles on purpose. Moreover, one cannot know how to perform operations that

cannot be done intentionally: For example, one cannot know how to digest, for digestion is not an action (Stanley & Williamson, 2001). Thus, know-how characteristically manifests through intentional action, and a good case can be made for the claim that the best explanation of intentional action will require that one has knowledge of the means to perform it (e.g., Gibbons 2001; Pavese, 2001, 2001). If this is so, know-how cannot characteristically manifest without propositional knowledge of the means. Intellectualism explains why that is by taking know-how itself to require knowledge of the means.

In the current literature, however, several authors have highlighted the need for motor representation, in addition to propositional knowledge, in order to explain intentional motor actions (e.g. Butterfill & Sinigaglia, 2014; Levy, 2017). From that starting point, Levy (2017) has concluded that, at least in the motor case, know-how and skill cannot fully be understood in terms of a propositional knowledge state. In particular, Levy (2017) argues that a view identifying know-how with a propositional knowledge state cannot account for the role that motor representation plays in skillful action. The right view for motor skill is, Levy (2017, p. 523) claims, a composite view, according to which know-how includes both motor representation and a propositional knowledge state. Levy (2017, p. 523) concludes that "so long as there are some cases of knowledge-how of which the composition view is true, intellectualism is false."

Levy (2017) has singled out with extreme clarity the role that motor representation plays in motor know-how. Nonetheless, we might ask the following: Is it correct to argue, as Levy (2017) does, from the role of motor representation in an explanation of intentional action to the falsity of a view that identifies know-how with a knowledge state with propositional content?

The problem with this argument is that, from its very first formulation (e.g., Stanley & Williamson, 2001), intellectualism is the view according to which know-how requires practical representation. According to this view, know-how is not just any propositional knowledge state; it is a state of knowing a proposition under a practical mode of presentation (Stanley & Williamson, 2001; Pavese, 2001, 2001, 2001, 2001). Hence, Levy's (2017) objection that motor representation is missing from intellectualism's picture of know-how is wrongheaded, if motor representation can be understood as an instance of practical representation.

To understand the intellectualist view correctly, it is helpful to make a comparison with other sorts of knowledge states that involve modes of presentation. Compare an instance of perceptual knowledge (e.g., the knowledge that I acquire by seeing that there is a table in front of me) to an instance of non-perceptual knowledge with the same content (e.g., the knowledge that I obtain by mere testimony when I am told that there is

a table in front of me). It is natural to distinguish between these two knowledge states in terms of the modes of presentation by which they represent the state of affairs that there is a table in front of me. According to this view, in the former case (when I see the table), I know that there is a table in front of me by a perceptual mode of presentation, whereas in the latter case (when I am merely told that there is one), I know that proposition under a non-perceptual mode of presentation.

Intellectualism thinks of know-how along similar lines. Accordingly, know-how is a matter of being in a knowledge state under a mode of presentation, but the mode of presentation is not necessarily perceptual, as in the case of perceptual knowledge; rather, it is a practical mode of presentation.[16] The view of practical representation developed in this essay shows that there is no reason why intellectualism could not countenance motor representation in its account of know-how, for, as we have seen, motor representations come with distinctively practical modes of presentation. According to intellectualism, knowing a proposition about, say, how to grab a bottle using a motor representation of that task is just one way of knowing a proposition under a practical mode of presentation.

Now, Levy (2017) is right that many proponents of intellectualism have indeed failed to provide an account of practical modes of presentation; in some cases, they even commit themselves to construals of practical modes of presentation which are incompatible with motor representations being practical. For example, when Stanley (2011, p. 125–30) does talk of practical modes of presentation, he argues that practical modes of presentation are ways of thinking, and he conceives of them as conceptual representations in the robust sense of "conceptual" which he specifies at the outset. However, we have seen that motor representation and, more generally, practical representation, does not need to be conceptual in this robust sense. Hence, motor representation cannot be accounted for by Stanley's (2011) view. Finally, Stanley (2011, p. 156) explicitly does not think of procedural knowledge in terms of practical representation but, rather, as a kind of propositional state in its own terms:

> The content of procedural knowledge is *propositional*, but *involves different kinds of propositions* than stock cases of declarative literature. That is, it is completely consistent with a strong reading of the neuroscience distinction between declarative and procedural knowledge – that it concerns states of knowledge with different kinds of content, and not merely points about implementation – that *procedural knowledge is propositional knowledge of the sorts of propositions* that I take states of knowing how to do something to have as their contents. In fact, given that the other types of memory – episodic and semantic – clearly seem to be propositional in character, this is the most natural way to take the distinction between procedural and declarative knowledge. (my italics)

In this passage, it is clear that Stanley (2011) is not thinking of procedural knowledge in terms of what I call practical representation, for neither motor representation nor practical representation is propositional. In

fact, as a form of prescriptive representation, practical representation does not even have truth-conditions.

Practical modes of presentation do not even explicitly play a role in Stanley and Krakauer (2013) "mixed view" of motor skills. Stanley and Krakauer (2013) do propose that we think of motor skills as composed of a declarative component and a procedural component, but on their view, the procedural component does not correspond to a practical mode of presentation. Rather, according to them, the procedural component is to be understood in terms of "motor acuity." As Levy (2017) also observes, Stanley and Krakauer (2013) do not think of motor acuity in representational terms. They think of motor acuity along the lines of perceptual acuity or discrimination, which they conceive of non-representationally, in terms of a disposition or a bare ability. Hence, Stanley and Krakauer (2013) fail to characterize the procedural component of skill representationally in terms of practical modes of presentation. On the other hand, they do take the declarative component of skills to be a sort of know-how, and following Stanley (2011), they construe this know-how propositionally. For example, we are told that, in order for a subject to intentionally perform a task, she needs to "know what to do to initiate the task" (Stanley & Krakauer, 2013, p. 4). This latter knowledge, we are told, is propositional – it is a matter of knowing that certain movements are required to initiate the task (Stanley, 2011). Because Stanley and Krakauer (2013) think of the procedural component non-representationally, if any role is assigned, by their view, to practical modes of presentation, it is doomed to be in an account of the declarative component – in an account of the propositional knowledge state that, on their account, is to be combined with motor acuity to give rise to skills (Figure 8).

Hence, Levy (2017) is right to point out that motor representation is missing from both Stanley's (2011) and Stanley and Krakauer (2013) accounts of skills. However, it is not true that intellectualists cannot, in principle, make room for motor representation and, more generally, for procedural representation in a theory of know-how.[17] In this essay, I have given a general characterization of practical representation (Section 2), one which makes clear in what sense motor representation counts as an example of practical representation (Section 3). On this understanding of practical representation, it is possible for the intellectualist to assign a crucial role to motor and procedural representation in her account of know-how and skills by thinking of motor skills and know-how as combinations of a declarative component (roughly corresponding to one's knowledge of a proposition) with a procedural component (roughly corresponding to the practical mode of presentation):

Consider the model in Figure 9. According to this model, we can understand the relation between skills, on the one hand, and declarative and procedural knowledge, on the other, as corresponding to different
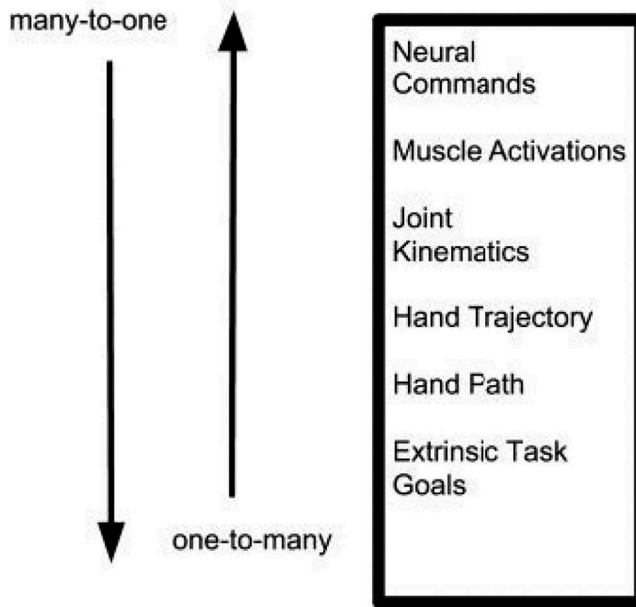
**Figure 6.** The motor hierarchy (Wolpert, 1997, p. 3).

levels of analysis in Marr's (1982) sense. On this model, the folk-psychological notions of know-how and skill are analyzed at the "functional" or "task-level" of analysis, in terms of propositional knowledge-under-a-practical-mode-of-presentation. Such characterization is theoretically helpful, for it captures the distinctively practical functions of know-how and skill and, in particular, how they constitute intentional action. The distinction between declarative and procedural knowledge is, instead, a distinction at the algorithmic level of analysis, at which computational theories of motor skills and skill in general proceed: Know-how and skill are understood, at the task-level of analysis, in terms of propositional knowledge-under-a-practical-mode-of-presentation, and that state of knowing-under-a-practical-mode-of-presentation is implemented at the algorithmic level by a combination of the declarative component and the procedural component.

We get to this picture of skill if we combine three ideas. The first idea is that practical modes of presentation can be construed in Russellian terms as ways whereby one stands in a propositional attitude toward a proposition. The second idea is that practical modes of presentation can be modeled after programs, or more precisely, after operational semantic values of program texts. The final idea is the aforementioned idea that propositional knowledge is required of skills because it is required for intentional action, as skills characteristically manifest through intentional action. (For more support of the claim that knowledge is central for
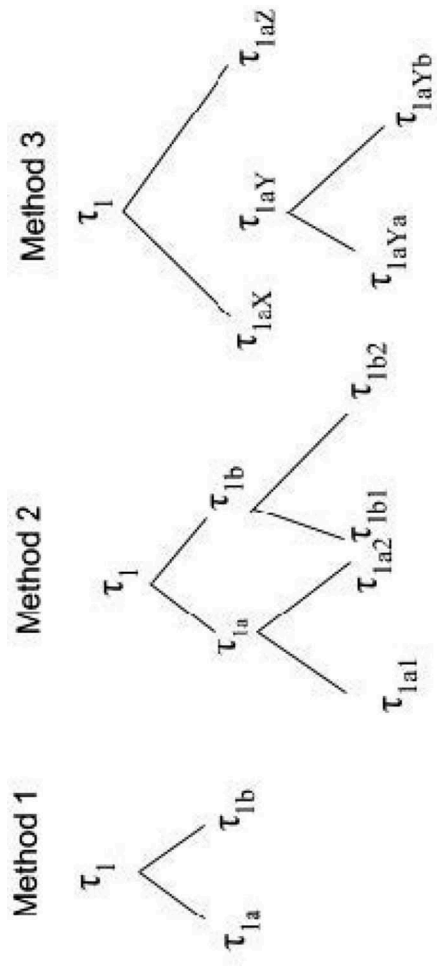
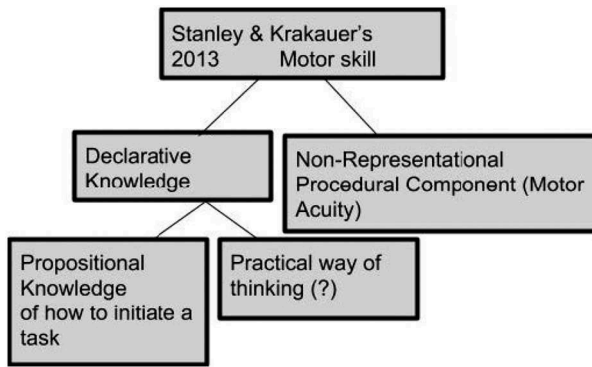**Figure 7.** Three methods for performing a task.

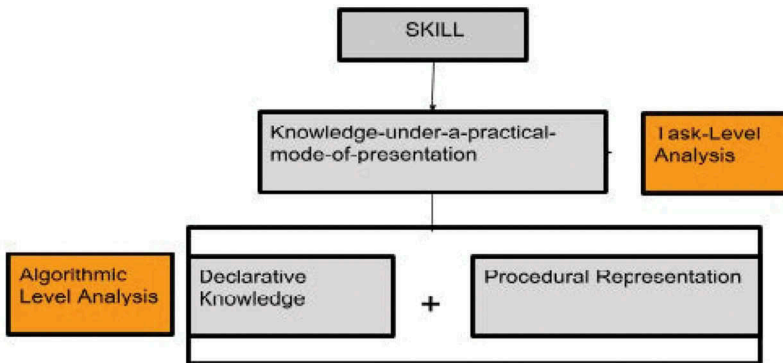Figure 8. Stanley and Krakauer (2013) on motor skill.



Figure 9. Intellectualism about skills.

explaining intentional behavior, I refer to other work (Williamson 2000; Gibbons 2001; Nagel, 2013; Pavese, 2001, 2001, 2001, 2001)).

In considering Figure 9, a caveat is needed. According to Figure 9, the state of knowing-a-proposition-under-a-practical-mode-of-presentation is grounded by, or implemented through, a combination of declarative knowledge and procedural knowledge. This may suggest that the notion of propositional knowledge maps onto cognitive scientists' notion of declarative knowledge. However, the match between propositional knowledge and declarative knowledge is much less than perfect. That is so, in part, because psychologists' current notion of declarative knowledge is narrower and more demanding than epistemologists' understanding of propositional knowledge. As noted also by Stanley and Krakauer (2013), declarative knowledge is often confined by cognitive scientists to the sort of propositional knowledge that a subject can articulate through verbal reports. By contrast, fewer and fewer epistemologists today would impose this requirement on propositional knowledge; this is shown by the fact that, for example, most epistemologists are willing to ascribe knowledge to at least some non-human animals. Moreover, psychologists' talk

of declarative knowledge often discloses internalist assumptions about knowledge that few epistemologists today would accept. For example, psychologists sometimes talk as if knowledge ought to be "luminous" and introspectively accessible. By contrast, many epistemologists today, especially those of an externalist bent, will deny that. With these caveats, the present model is meant as a good approximation, one that could be progressively refined if cognitive scientists' notion of declarative knowledge becomes more and more closely modeled on an externalist notion of knowledge.

## 6.1. Fleeting modes of presentation?

Having summarized the import of this discussion for the debate on know-how, this section and the next ones consider a few objections.

The first goes as follows: Motor commands are highly specific and context-dependent. They are produced here and now when the task is executed, so one might worry that such a fleeting sort of representation may not be suitable to play a role in a theory of know-how as a *general standing* knowledge state.

The objection only raises a *prima facie* worry. That is so because motor commands are not the only kind of practical representation that exists, even within the motor domain. Besides motor commands, control theorists posit *motor schemas* (Bernstein, 1967; Schmidt, 1975, 2003; Arbib, 1981, 1985; Jeannerod, 1997). Motor schemas are less context-specific, and they are longer-lasting motor representations that mediate between intentions and motor commands (Mylopolous & Pacherie 2017). A motor schema is a predetermined set of commands, often characterized as a "control program." Hence, motor schemas are also prescriptive representations, only they are more general ones. They are supposed to be revisable through trial and error, and they are supposed to be able to store information about the invariant aspects of an action (Arbib, 1981; Jeannerod, 1997, p. 51–5).

These considerations suggest of motor representation analogous to the hierarchy of perceptual representation (Burge, ; Siegel, 2011). Just like we might make distinctions between a hierarchy of perceptual representation and different kinds of attributive perceptual representations based on their levels of specificity, we might also distinguish between more specific practical representations (such as motor commands) and more general practical representations (such as motor schemas and other intermediate representations).

## 6.2. Practical representation and the personal–Sub-personal distinction

One might worry that motor and, more generally, procedural representations cannot play the role that intellectualists want practical modes of presentation

to play, on the ground that procedural representations are implicit and sub-personal, whereas modes of presentation ought to be explicit and personal.[18]

This objection relies on several assumptions. To start with, as we have seen in Section 2 when reviewing Neander's (2017) argument for perceptual modes of presentation, modes of presentation do not need to be personal: It makes sense to talk of modes of presentation for sub-personal perceptual representations too, that is, for the kind of representation that cognitive scientists are willing to attribute to the visual system. Hence, thinking of motor representations and procedural representations as involving modes of presentation is not incompatible with those representations being sub-personal.

Secondly, the assumption that procedural representations ought to be sub-personal is questionable. There are, notoriously, many ways of drawing the personal–sub-personal distinction, and not all of them neatly line up with the implicit–explicit distinction. On at least some ways of drawing it, a representation is "personal" if it is "available" at the personal level. The relevant notion of availability is rather fuzzy, but if the availability of a representation at the personal level includes its intentional retrievability and its accessibility to the subject's attention, then motor representation must sometimes be available at the personal level, as there is plenty of evidence that it can be refined through attention and mental rehearsal (e.g., Epstein, 1980; Feltz & Landers, 1983). Some have even argued that, in order to explain the impact that motor representations can have on the content of thought, motor representations must come with a distinctive phenomenology. These authors argue that there is such a thing as *motoric experience* (e.g., Sinigaglia & Butterfill, 2015). However, evidence from both conceptual and perceptual priming (e.g., Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991; Mulligan, 1997) suggests that also conceptual and perceptual representation do not need to be personal and intentionally retrievable. Although these points would require more discussion than I can provide here, the available psychological evidence seems to be compatible with the theoretically attractive hypothesis that each of the three main species of mental representation (conceptual, perceptual, and practical) can come in both varieties – as personal-level representation or as a sub-personal-level representation.[19]

## 6.4. Practical representations and practical concepts

The third objection goes as follows. Practical modes of presentation can be understood on a Russellian construal (Stanley & Williamson, 2001) or on a Fregean construal (Pavese, 2001; Stanley, 2011). On a Fregean construal, practical modes of presentation are practical senses, and it is customary to take practical senses to be components of propositions.[20] If being eligible to appear as a component of propositions suffices for being a conceptual representation, then the proponent of a Fregean construal is committed to

understanding practical modes of presentation as a kind of conceptual representation. In this essay, however, practical representation has been introduced in opposition to conceptual representation. Hence, one might wonder whether this notion of practical representation is compatible with a Fregean construal of intellectualist theories of know-how.

First, recall that the Fregean construal is not demanded by an intellectualist theory of know-how. The Russellian construal serves intellectualists' theoretical goals perfectly well, and it is definitely compatible with holding practical representation to be non-conceptual. After all, perceptual modes of presentation are often invoked in characterizations of perceptual knowledge, and they certainly are not conceptual (. Kulvicki, 2007), nor are they necessarily accessible to the subject's introspection or awareness (. Section 2 and Neander, 2017: Chapter, p. 2).

That said, the Fregean construal is not incompatible with the view defended here either. Practical representation is not conceptual in the robust sense of "conceptual" specified at the outset, but it might still be conceptual according to the minimalist sense of "conceptual" (Camp, 2009). Many neuroscientists and psychologists concur in their understanding of motor representations as combinatorial (Arbib, 1981; 1985; Jeannerod, 1997:51; Lewis, Vera, & Howes, 2004; Wolpert et al., 2011). Hence, it is plausible that practical representation qualifies as conceptual in the minimalist sense. It is an open question, one that would require much more careful investigation than anybody has given it so far, whether conceptual representation in this minimalist sense can appear as a component of propositions.[21]

The third and more important point is that the parallel with perceptual representation makes room for the possibility of a hybrid kind of practical representation, a form of practical but also conceptual representation. This practical and conceptual form of representation can be modeled along the lines of Pavese's (2001) "practical concepts" or Mylopolous and Pacherie's (2017) "action-based concepts," where "concept" is understood according to the robust conception of it. As Pavese (2001) and Mylopolous and Pacherie (2017) put it, practical concepts are concepts of which their possession entails ability, for their possession entails representing a task practically. This claim amounts to saying that if one possesses a practical concept of a task, one must also represent it practically in the sense outlined in this essay – in accordance with one's practical abilities. Although practical modes of presentation do not need to be conceptual, there is no reason to think that some conceptual representations could not also represent practically, in the sense clarified in this essay.

The idea that there might be concepts that are linked with non-conceptual representations is, of course, not at all new or exotic. It is rather plausible that many concepts are derivable from non-conceptual perceptual representations through copying and abstraction (Prinz, 2001,

Chapter 5–6; Neander, 2017, Chapter, 8). Along the same lines, there might be concepts that may be derivable from and, as a result, tightly linked to motor representation and, more generally, to practical representation. Given the current state of the research, it is very much an open question whether a complete psychological theory of skills must feature practical concepts too, in the robust sense of "concept," as well as non-conceptual practical representation.[22] I have to leave arguing for the need of practical concepts in a complete theory of skill to another occasion.

## 7. Conclusions

Practical representation is, like other sorts of mental representation, "perspectival": It represents what it does from a certain point of view or under a certain mode of presentation. In this respect, nothing is special about practical representation: Mental representation, in general, is, to cite Burge (2009:247) again, "fundamentally and ineliminably perspectival." What is distinctive about practical representation is that its perspective is distinctively practical, for it is constituted by abilities that do not need to be either perceptual or conceptual (or, at least, not entirely). Motor commands and motor schemas, as they figure in current psychological and neuroscientific theories of motor control, are examples of practical representation. If this is so, then our best theories of motor control routinely and essentially invoke practical representation whenever they invoke motor representation: Practical representation is psychologically real. Moreover, on the assumption that cognitive scientists' general practice of positing procedural representations is not misguided, the scope of practical representation goes well beyond the realm of motor skills and extends to more distinctively cognitive skills too.[23] In the second part of the essay, I argued that, by appealing to the notion of practical representation developed in this essay, an intellectualist view of know-how can grant a place to motor representation and, more generally, to procedural representation in their account of know-how.

## Notes

1. On the perspectival character of perceptual representation, see also Lande (2018b).
2. Of course, the relevant false reading is *de dicto* – with the "as…" clause having a narrow scope.
3. Not everybody understands perception in terms of tracking. For example, Lupyan and Clark (2015) defend a view of perception as a predictive process rather than as a tracking process. It is an interesting question, but one that I cannot fully address here, whether on such a "predictive" view of perception the taxonomy I am proposing for mental representation would radically change. I am grateful to Felipe De Brigard for discussion here.

4. I am following Burge (2010) in taking predication to be a kind of categorization, one that is distinctive of concepts. I am allowing that perceptual representations can categorize too, although they cannot predicate.By "categorization," I mean both category production (when a person identifies which attributes an individual possesses if it is a member of a certain category) and category identification (when a person identifies the category to which an individual belongs). Cfr. Prinz (2001, p. 9).

5. I will remain neutral on what these conceptual representations must be like in order to play the theoretical role of explaining higher-order cognitive capacities of predication and thinking – for example, whether concepts must be definitions, exemplars, prototypes, bodies of knowledge, or anything else.

6. It is important to clarify that the current claim is not that whenever one mental state has a mind-to-world direction of fit, it also represents practically. For example, desires have a mind-to-world direction of fit, but they do not represent practically in the sense clarified here. This is because they do not represent the world differently depending on the subject's practical abilities. I will return to this point later in the text.

7. Indeed, it is quite natural to think of motor commands as linguistic representations, on the model of programming languages' commands. However, for the purpose of this discussion, I do not want to lean on the assumption that motor commands must be linguistic. I want to allow that motor commands might be more akin to imperatival pictures such as architectural plans or road-side warning signs than they are to linguistic representations. As a consequence, my discussion will be more abstract but will hopefully gain in generality.

8. What is an action? As Barker (2012, p. 1) puts it, "Actions change the world. This means that actions can be characterized by before-and after pictures, that is, by a picture of the world before the action is performed, and a picture of the world afterwards. Technically, then, an action will be a relation over worlds, a set whose elements are ordered pairs $<w, wi>$ where $w$ is the world before the action and $wi$ is the world after the action in question has been performed."Thus, for example, the meaning of an imperative such as (1) is the set of world pairs in which the second world is a continuation of the first world in which the addressee dances.

9. One might think that probabilistic methods are a counterexample to this "determination" claim, for they enable the execution of a task only with a certain probability of success. However, the determination claim can still be upheld by being careful about what task it is which a probabilistic method determines or fixes: A probabilistic method for $F$-ing with $x$ percent probability of success determines the task of $F$-ing with $x$ percent probability of success. Because methods stand to tasks in a many-to-one relation and can be said to determine tasks, several people have pointed out (Girard 1989: chapter 1; Moschovakis 1994:17; Muskens 2005; Pavese 2001:3) that methods stand to tasks in the same way that Fregean meanings (or senses) stand to their denotations (or referents). Consequently, methods are plausible candidates for being the modes of presentation of tasks.

10. This argument to the effect that methods cannot indefinitely divide tasks into sub-operations closely resembles Fodor's (1968, p. 629) argument against the objection from the "proliferation of homunculi." Like Fodor's, my argument focuses on the need for a satisfactory explanation (e.g., of how a system $s$ performs a task) to be finite.

11. If we do so, though, it is important to keep in mind that Fodor's definition of elementary operations (as operations that a system can perform directly but of which it cannot perform a proper part) is not entirely correct, for the system may still be able to perform parts of the chunked sequence in isolation. Thus, an elementary operation is not correctly defined as one that the system can perform but of which it cannot perform a proper part. Rather, an elementary operation should be thought of as one that the system can perform without *thereby* performing any proper part.

12. On certain assumptions about the semantics of mental representations, it also makes sense to assign a distinctively practical meaning to motor commands (Pavese, 2001). Start by asking "What is the function of a motor command within the motor system?" Within the motor system, as output of the motor planning and input for the execution of the task, its function is not, like that of truth-conditional representations, to track the environment. More plausibly, its function is to prescribe a task, or to represent a task as to be executed in accordance with a certain method for performing a certain task. However, note that, if the motor command represented the task as to be performed in accordance with something less of a method – that is, in accordance with a way of breaking down a task in terms of something else than its elementary operations – then the motor command would fail its function. In this circumstance, the system would malfunction, and, thus, in this sense, it would misrepresent. Hence, from the perspective of a broadly teleo-semantic approach to the meaning of mental representations, it makes sense to think of the meaning of a motor command in terms of a practical meaning, where a practical meaning is a way of breaking down the task in terms of operations that a system can elementarily perform. However, since methods are relative to the stock of elementary abilities, so are practical meanings.

13. For a dissenting view, see Sutton (2007).

14. Although, see Feinberg (1978) and Campbell (1999) for a view on which motor processes and (presumably) motor representations may also enter in thinking and thought.

15. Later, Nanay (2013, p. 4) clarifies that pragmatic representations are kinds of perceptual states: "Pragmatic representations are perceptual states but not all perceptual states are pragmatic representations."

16. The analogy is helpful also because it highlights that, just like perceptual modes of presentation do not need to be conceptual, practical modes of presentation do not need to be conceptual either.

17. Fridland (2017) makes a similar mistake in objecting to intellectualism.

18. The first occurrence of the personal–sub-personal distinction is in Dennett (1969).

19. I am grateful to Felipe De Brigard for having drawn to my attention the case of conceptual priming as evidence for the possibility of conceptual but sub-personal representation.

20. I would resist taking senses to be necessarily conceptual in a robust sense. In Pavese (2001), I took the view that practical modes of presentation are practical senses, primarily in order to highlight that they determine their referent and that they are compositional, rather than in order to emphasize their conceptual character. Yet, the thesis that senses are conceptual (in a robust sense) is very widespread. Because of this, I will engage with this idea in the main text.

21. Some have mentioned the fine-grainedness of motor representation as the main reason for why this sort of representation cannot be a component of propositions (Carruthers, 2006: 284; Levy, 2017: 520, fn, p. 8). The idea is that a motor

representation's fine-grainedness would outstrip a subject's conceptual abilities. It is worth noting that this argument relies on several assumptions. It assumes that motor representation is always too fine-grained to be grasped by a subject, but more general motor representations, such as *motor schemas*, do not need to be quite as fine-grained. Motor schemas are motor representations that mediate between intentions and motor commands; they store knowledge about the invariant aspects and the general form of an action and are implicated in the production and control of action (Schmidt, 1975, 2003; Arbib, 1981,; Jeannerod, 1997). They are less context-specific, more abstract, and longer enduring representations than motor commands. As such, they are less detailed. Hence, it is not at all clear that the argument from fine-grainedness against the Fregean construal of practical modes of presentation applies to motor schemas too. Secondly, the current objection assumes that, in order for a subject to be able to grasp a representation, one must be capable of grasping (or of introspectively accessing) all of its details. However, note that that is hardly true even for *bona fide* conceptual representations. For example, I might have the concept of a parrot and thereby possess a complex representation that underlies my ability to sort parrots from non-parrots and engage in reasoning about parrots. That may be true even though not every detail of the representation that accounts for my sorting abilities may be accessible to me by introspection. For example, there may be all sorts of sub-personal perceptual clues of which I may not be aware, such as the smell of parrots, that intervene in enabling me to sort parrots from non-parrots. These details are part of the complex representation that underlies my classification abilities, even though they are not accessible to me by introspection. Hence, it is not clear, and it should not be taken for granted, that for one to be able to grasp a representation underlying one's classificatory abilities, one needs to be aware of all of its details.

22. Mylopolous and Pacherie (2017) contend that practical concepts might indeed be needed to overcome Butterfill and Sinigaglia (2014) interface problem – the problem of explaining how motor and, more generally, practical representation can compose with intentions in producing motor skillful behavior.

23. This essay leaves open that there might be practical representations over and beyond what cognitive scientists call "procedural representations." I am also leaving to further work the task of providing more principled reasons – that is, reasons not simply having to do with cognitive scientists' current practice of positing procedural representations – for thinking that practical representation is psychologically real. See Pavese (manuscript) for developments.

## Acknowledgments

## Disclosure statement

## Funding

## Notes on contributor

Carlotta Pavese currently the Andrew W. Mellon Assistant Professor of Philosophy at Duke University, where I have been an Assistant Professor since 2014. In 2013-2014, I was a Bersoff Assistant Professor/Faculty Fellow of Philosophy at NYU. Before that, I was a graduate student at Rutgers University.

## References

Anderson, J. (1982). Acquisition of cognitive skill. *Psychological Review*, *89*(4), 369.

Anderson, J. R. (2005). *Cognitive psychology and its implications*. New York,NY: Macmillan.

Anscombe, G. E. M. (1957). *Intentions*. Oxford: Basil Blackwell.

Arbib, M. A. (1981). Perceptual structure and the distributed motor control. In V. B. Brooks (Ed.), *Handbook of physiology, section I: The nervous system* (Vol. 2, pp. 1449–1480). Motor Control, Baltimore: Williams et Wilkins.

Arbib, M. A. (1985). Schemas for the temporal organization of behavior. *Human Neurobiology*, *4*, 63–72.

Armstrong, D. (1973). *Belief, truth and knowledge*. Cambridge, MA: Cambridge University Press.

Barker, C. (2012) Imperatives denote actions. In: *Proceedings of Sinn und Bedeutung*. Cambridge, MA: MITWPL, 57-70.

Bayley, P., Franscino, J., & Squire, L. (2005). Robust habit learning in the absence of awareness and independent of the medial temporal lobe. *Nature*, *463*(7050), 550–553.

Bermúdez, J. L. (1995). Nonconceptual content: From perceptual experience to subpersonal computational states. *Mind & Language*, *10*(4), 333–369.

Bernstein, N. (1967). *The coordination and regulation of movements*. Oxford: Pergamon Press.

Braddon-Mitchell, D., & Jackson, F. (1996). *Philosophy of mind and cognition*. Cambridge, MA: Blackwell Publish.

Brozzo, C. (2017). Motor intentions: How intentions and motor representations come together. *Mind and Language*, *32*(2), 231–256.

Burge, T. (2009). "Five theses on de re states and attitudes" in Almog J. and Leonardi P, The Philosophy of David Kaplan. Oxford, UK: Oxford University Press, pp. 246-324.

Burge, T. (2010). *Origins of objectivity*. Oxford, UK: Oxford University Press.

Butterfill, S. A., & Sinigaglia, C. (2014). Intention and motor representation in purposive action. *Philosophy and Phenomenological Research*, *88*, 119–145.

Camp, E. (2009). Putting thoughts to work: Concepts, systematicity, and stimulus-independence. *Philosophy and Phenomenological Research*, *78*(2), 275–311.

Carruthers, P. (2006). *The Architecture of Mind*. Oxford: Oxford University Press.

Cohen, N. J., & Eichenbaum, H. (1993). *Memory, amnesia, and the hippocampal system*. Cambridge, MA: MIT Press.

Cohen, N. J., & Squire, L. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of knowing how and knowing that. *Science*, *210*(4466), 207–210.

Coombs, S., Fay, R. R., & Elepfandt, A. (2010). Dipole source encoding and tracking by the goldfish auditory system. *Journal of Experimental Biology*, *213*(20), 3536–3547.

Dau, T., Püschel, D., & Kohlrausch, A. (1996). A quantitative model of the "effective"signal processing in the auditory system. I. Model structure. *The Journal of the Acoustical Society of America*, *99*(6), 3615–3622.

DeBrigard, F. (forthcoming). Know-how, intellectualism, and memory systems. In *Philosophical Psychology*.

Dennett, D. C. (1969). *The intentional stance*. Cambridge MA: MIT Press.

Devitt, M. (2011). Methodology and the nature of knowing how. *Journal of Philosophy*, *108*, 205–218.

Dew, I. T., & Cabeza, R. (2011). The porous boundaries between explicit and implicit memory: Behavioral and neural evidence. *Annals of the New York Academy of Sciences*, *1224*(1), 174–190.

Dretske, F. (1988). *Explaining behavior: Reasons in a world of causes*. Cambridge, MA, US: The MIT Press.

Epstein, M. L. (1980). The relationship of mental imagery and mental rehearsal to performance of a motor task. *Journal of Sport Psychology*, *2*(3), 211–220.

Evans, G. (1982). *The variety of reference*. Oxford: Clarendon Press.

Feinberg, I. (1978). Efference copy and corollary discharge: Implications for thinking and its disorders. *Schizophrenia Bulletin*, *4*(4), 636.

Feltz, D. L., & Landers, D. M. (1983). The effects of mental practice on motor skill learning and performance: A meta-analysis. *Journal of Sport Psychology*, *5*(1), 25–57.

Fodor, J. A. (1968). The appeal to tacit knowledge in psychological explanation. *The Journal Of Philosophy*, *65*(20), 627-640.

Fodor, J. A. (1975). *The Language of Thought*. New York, NY: Thomas Y. Crowell.

Fodor, J. A. (1994). Concepts: A potboiler. *Cognition*, *50*(1), 95–113.

Fodor, J. A. (1998). *Concepts: Where cognitive science went wrong*. New york, NY: Oxford University Press.

Foerde, K., Knowlton, B. J., & Poldrack, R. A. (2006). Modulation of competing memory systems by distraction. *Proceedings of the National Academy of Sciences, USA*, *103*, 11778–11783.

Fridland, E. (2017). Skill and motor control: Intelligence all the way down. *Synthese*, *174* (6), 1539–1560.

Gallese, V., & Metzinger, T. (2003). Motor ontology: The representational reality of goals, actions and selves. *Philosophical Psychology*, *16*, 365–388.

Gallistel. (1990). *The organization of learning*. Cambridge MA: MIT Press.

Gibbons, J. (2001). Knowledge in action. *Philosophy and Phenomenological Research*, *62*(3), 579–600.

Girard, J. Y., Taylor, P., & Lafont, Y. (1989). *Proofs and types* (Vol. 7). Cambridge Mass: Cambridge university press.

Glick, E. (2011). Two methodologies for evaluating intellectualism. *Philosophy and Phenomenological Research*, *83*(2), 398–434.

Glick, E. (2012). Abilities and know-how attributions. In J. Brown and M. Gerken(Eds.), *Knowledge Ascriptions*, Oxford, UK: Oxford University Press.120–138.

Henke, K. (2010). A model for memory systems based on processing modes rather than consciousness. *Nature Reviews Neuroscience*, *11*(7), 523–532.

Humphreys, G. W. (1983). Reference frames and shape perception. *Cognitive Psychology*, *15*(2), 151–196.

Humphreys, G. W., & Quinlan, P. T. (1988). Priming effects between two-dimensional shapes. *Journal of Experimental Psychology: Human Perception and Performance*, *14*(2), 203–220.

Jeannerod, M. (1997). *The cognitive neuroscience of action*. Oxford, UK: Blackwell Publishers, Inc.

Jeannerod, M. (2006). *Motor cognition: What actions tell the self*. New York, NY: Oxford University Press.

Kawato, M. (1999). Internal models for motor control and trajectory planning. *Current Opinion in Neurobiology*, *9*(6), 718–727.

Keane, M. M., Gabrieli, J. D., Fennema, A. C., Growdon, J. H., & Corkin, S. (1991). Evidence for a dissociation between perceptual and conceptual priming in Alzheimer's disease. *Behavioral Neuroscience*, *105*(2), 326.

Knowlton, B. J., & Foerde, K. (2008). Neural representations of nondeclarative memories. *Current Directions in Psychological Science*, *17*, 62–67.

Knowlton, B. J., Mangels, J. A., & Squire, L. R. (1996). A neostriatal habit learning system in humans. *Science*, *273*(5280), 1399.

Kulvicki, J. (2007). What is what it's like? Introducing perceptual modes of presentation. *Synthese*, *156*(2), 205–229.

Lande, K. (2018a). *Parts of Perception* (PhD Dissertation). University of California, Los Angeles.

Lande, K. (2018b). The Perspectival Character of Perception. *The Journal of Philosophy*, *115*(4), 187–214.

Lascarides, A. and N. Asher (2004) Imperatives in Dialogue, In P. Kuehnlein, H. Rieser and H. Zeevat (Eds.), *The Semantics and Pragmatics of Dialogue for the New Millenium*, Benjamins

Laurence, S., & Margolis, E. (1999). Concepts and cognitive science. In S. Laurence and E. Margolis (Eds.), *Concepts: Core Readings*, Boston: MIT Press. 3–81.

Levy, N. (2017). Embodied savoir faire: Knowledge-how requires motor representations. *Synthese*, *194*(2), 511–530.

Lewis, D. (1994). Reduction of mind. In S. Guttenplan (Ed.), *Companion to the philosophy of mind* (pp. 412–431). Oxford: Blackwell.

Lewis, R. L., Vera, A. H., & Howes, A. (2004). A constraint-based approach to understanding the composition of skill. In M. C. Lovett, C. D. Schunn, C. Lebiere, P. Munro (Eds.), *ICCM* Proceedings of the Sixth International Conference on Cognitive Modeling (pp. 148–153) Mahvah NJ: Lawrence Earlbaum.

Lex, H., Schütz, C., Knoblauch, A., & Schack, T. (2015). Cognitive representation of a complex motor action executed by different motor systems. *Minds and Machines*, *25* (1), 1–15.

Lupyan, G., & Clark, A. (2015). Words and the world: Predictive coding and the language-perception-cognition interface. *Current Directions in Psychological Science*, *24*(4), 279–284.

Machery, E. (2009). *Doing without concepts*. Oxford, UK: Oxford University Press.

Margolis, E., & Laurence, S. (2014). Concepts. In E. N. Zalta Ed., *The stanford encyclopedia of philosophy*. Retrieved from URL=<https://plato.stanford.edu/archives/spr2014/entries/concepts/>

Marr, D. (1982). *Vision: A computational investigation*. Into. New york, NY: WH Freeman.

McCloskey, M. (2009). *Visual reflections: A perceptual deficit and its implications*. New york, NY: Oxford University Press.

Millikan, R. G. (1984). *Language, thought, and other biological categories: new foundations for realism*. Boston Mass: MIT press.

Milner, B. (1962). Physiologie de l'hippocampe. In Passouant, P. (Ed.), *Cen. Natl. Rech. Sci; Les troubles de la memoire acompagnant des lesions hippocampiques bilaterales* (pp. 257–272). Paris: Éditions Recherche Scientifique.

Milner, B. (1965). Memory disturbance after bilateral hippocampal lesions. In P. M. Milner & S. Glickman (Eds.), *Cognitive processes and the brain* (pp. 97–111). Princeton, N.J.: Van Nostrand.

Moschovakis, Y. N. (1994). Sense and denotation as algorithm and value. *Lecture Notes in Logic*, *2*, 210-249.

Mulligan, N. W. (1997). Attention and implicit memory tests: The effects of varying attentional load on conceptual priming. *Memory & Cognition*, *25*(1), 11–17.

Muskens, R. (2005). Sense and the computation of reference. *Linguistics and Philosophy*, *28*(4), 473-504. doi:

Mylopoulos, M., & Pacherie, E. (2016). Intentions and motor representations: The interface challenge. *Review of Philosophy and Psychology*, 1–20.

Mylopoulos, M, & Pacherie, E. (2017). Intentions and motor representations: The interface challenge. *Review Of Philosophy and Psychology*, *8*(2), 317–336.

Nagel, J. (2013). 10. Knowledge as a mental state. *Oxford Studies in Epistemology*, *4*, 273.

Nanay, B. (2013). *Between perception and action*. Oxford, UK: Oxford University Press.

Neander, K. (2017). *A mark of the mental: In defense of informational teleosemantics*. Cambridge, Massachusetts; London, England: MIT Press.

Noe, A. (2005). Against intellectualism. *Analysis*, *65*(4), 278–290.

Pacherie, E. (2011). Nonconceptual representations for action and the limits of intentional control. *Social Psychology*, *42*(1), 67–73.

Palmer, S. E. (1999). *Vision science: Photons to phenomenology*. Cambridge, MA: MIT press.

Papineau, D. (1984). Representation and explanation. *Philosophy Of Science*, *51*(4), 550–572. doi:10.1086/289205

Pavese, C. (2013). *The unity and scope of knowledge* (Dissertation). Rutgers University.

Pavese, C. (2015a). Knowing a rule. *Philosophical Issues*, *25*(1), 165–188.

Pavese, C. (2015b). Practical senses. *Philosophers' Imprint*, *15*(29), 1–25.

Pavese, C. (2017a). Know-how and gradability. *Philosophical Review*, *126*(3), 345–383.

Pavese, C. (2017b). A theory of practical meaning. *Philosophical Topics*, *45*(2), Fall, 85–116.

Pavese, C. (2018). Know-how, action, and luck. *Synthese*.

Pavese, C. (forthcoming). Probabilistic knowledge in action. *Analysis*.

Peacocke, C. (1992). *A study of concepts*. Cambridge, MA.: MIT Press.

Peacocke, C. (2001). Does perception have a nonconceptual content?. *The Journal of Philosophy*, *98*(5), 239–264.

Peacocke, C. (2001). *Does Perception Have a Nonconceptual Content? The Journal Of Philosophy*, *98*(5), 239-264.

Platts, M. (1979). *Ways of meaning*. London: Routledge and Kegan Paul.

Porter, J., Craven, B., Khan, R. M., Chang, S.-J., Kang, I., Judkewitz, B., . . . Sobel, N. (2007). Mechanisms of scent-tracking in humans. *Nature Neuroscience*, *10*(1), 27–29.

Prinz, J. J. (2004). *Furnishing the mind: Concepts and their perceptual basis*. Cambridge, MA: MIT press.

Ramsey, F. (1931). General propositions and causality. In D. H. Mellor (Ed.), *The foundations*: Essays in Philosophy, Logic, Mathematics and Economics. (pp. 133–51) London, UK: Routledge

Rizzolatti, G., Fogassi, L., & Gallese, V. (2000). Cortical mechanisms subserving object grasping and action recognition: A new view on the cortical motor functions. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 539–552). Cambridge, MA: MIT Press.

Rizzolatti, G., & Sinigaglia, C. (2008). *Mirrors in the brain: How our minds share actions, emotions*. Oxford: Oxford University Press.

Rock, I. (1973). *Orientation and form*. Cambridge,MA: Academic Press.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. Lloyd (Eds.), *Cognition and categorization* (pp. 27–48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rosch, E., & Mervis, C. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology*, *7*, 573–605.

Rossetti, Y. (2001). Implicit perception in action: Short-lived motor representation of space. In P. G. Grossenbacher (Ed.), *Finding consciousness in the brain: A neurocognitive approach. Advances in consciousness research* (pp. 133–181). Amsterdam, The Netherlands: John Benjamins.

Roy, S., & Park, N. W. (2010). Dissociating the memory systems mediating complex tool knowledge and skills. *Neuropsychologia*, *48*(10), 3026–3036.

Ryle, G. (1949). *The concept of mind.* London, UK: Hutchinson

Sakai, K, Kitaguchi, K, & Hikosaka, O. (2003). Chunking during human visuomotor sequence learning. *Experimental Brain Research*, *152*(2), 229-242. doi:10.1007/s00221-003-1548-8

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. *Psychological Review*, *82*(4), 225.

Schmidt, R. A. (2003). Motor schema theory after 27 years: Reflections and implications for a new theory. *Research Quarterly for Exercise and Sport*, *74*(4), 366–375.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science*, *171*(3972), 701–703.

Siegel, S. (2011). *The contents of visual experience*. New york, NY: Oxford University Press.

Singley, M. K., & Anderson, J. (1989). *The transfer of cognitive skill* (Vol. 9). Cambridge, MA: Harvard University Press.

Squire, L., & Zola-Morgan, S. (1988). Memory: Brain systems and behavior. *Trends in Neurosciences*, *11*, 170–175.

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review*, *99*(2), 195.

Squire, L. R. (2009). Memory and Brain Systems: 1969–2009. *Journal of Neuroscience*, *29*(41), 12711–12716.

Squire, L. R., & Kandel, E. R. (2003). *Memory: From mind to molecules*. New York, N.Y.: Owl Books.

Squire, L. R., & Wixted, J. (2011). The cognitive neuroscience of human memory since H. M. *Annual Review of Neuroscience*, *34*, 259–288.

Squire, L. R., & Wixted, J. (2016). Remembering. In Groes, Sebastian (Eds.), *Memory in the twenty-first century: New critical perspectives from the arts, humanities, and sciences* (pp. 251–262). Hampshire, England: Palgrave MacMillan.

Stalnaker, R. (1998). What might nonconceptual content be? *Philosophical Issues*, *9*, 339–352.

Stanley, J. (2011). *Know how Oxford U.P.* Oxford, UK: Oxford University Press.

Stanley, J., & Krakauer, J. W. (2013). Motor skill depends on knowledge of facts. *Frontiers in Human Neuroscience*, *7*, 503.

Stanley, J., & Williamson, T. (2001). Knowing How. *Journal of Philosophy*, *98*(8), 411–444.

Stevens, J. A. (2005). Interference effects demonstrate distinct roles for visual and motor imagery during the mental representation of human action. *Cognition*, 95(3), 329–350.

Sutton, J. (2007). Batting, habit, and memory: The embodied mind and the nature of skill. *Sport in Society*, 10, 763–786.

Taatgen, N. A. (2013). The nature and transfer of cognitive skills. *Psychological Review*, 120 (3), 439.

Trappenberg, T. (2009). *Fundamentals of computational neuroscience*. Oxford UK: Oxford University Press.

Tulving, E. (1985). How many memory systems are there? *American Psychologist*, 40(4), 385.

Verwey, W. B. (1996). Buffer loading and chunking in sequential keypressing. *Journal of Experimental Psychology Human Perception and Performance*, 22, 544–562.

Verwey, W. B. (2001). Concatenating familiar movement sequences: The versatile cognitive processor. *Acta Psychologica*, 106, 69–95.

Verwey, W. B. (2010). Diminished motor skill development in elderly: Indications for limited motor chunk use. *Acta Psychologica*, 134, 206–214.

Verwey, W. B., Abrahamse, E. L., Ruitenberg, M. F., Jiménez, L., & de Kleine, E. (2011). Motorskill learning in the middle-aged: Limited development of motor chunks and explicit sequence knowledge. *Psychological Research*, 75(5), 406–422.

Williamson, T. (2000). *Knowledge and its limits*. Oxford UK: Oxford University Press.

Wolpert, D. M. (1997). Computational approaches to motor control. *Trends in Cognitive Sciences*, 1(6), 209–216.

Wolpert, D. M., Diedrichsen, J., & Flanagan, J. R. (2011). Principles of sensorimotor learning. *Nature Reviews Neuroscience*, 12(12), 739–751.

Wolpert, D. M., & Flanagan, J. R. (2001). Motor prediction. *Current Biology*, 11(18), R729–R732.

Wolpert, D. M., & Ghahramani, Z. (2000). Computational principles of movement neuroscience. *Nature Neuroscience*, 3, 1212–1217.

Wolpert, D. M., Ghahramani, Z., & Jordan, M. I. (1995). An internal model for sensorimotor integration. *Science*, 269(5232), 1880–1882.

Wolpert, D. M., & Kawato, M. (1998). Multiple paired forward and inverse models for motor control. *Neural Networks*, 11, 1317–1329.

Wolpert, D. M., Miall, R. C., & Kawato, M. (1998). Internal models in the cerebellum. *Trends in Cognitive Sciences*, 2(9), 338–347.