On the Psychological Reality of Practical Representation

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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, etc. Some of these representations are *mental*. It is customary for philosophers to distinguish between two main kinds of mental representations: *perceptual representation* (vision, auditory, tactile, olfactory, gustatory, proprioperception) and *conceptual representation*. This essay presupposes a version of this dichotomy but argues that it is not exhaustive of the realm of mental representations. In addition to perceptual and conceptual representation, there is a third kind of mental representation, which is, in an important sense, distinct from both perceptual representation and conceptual representation, at least from how perception and conceptual representation are widely conceived: the relevant sort of representation is *practical*. I argue that practical representation is psychologically real.

In §2, I clarify what I mean by "practical representation" and in what sense it is different from perceptual representation and conceptual representation, as usually conceived in the philosophical and psychological literature. In §3, I argue practical representation enters central stage in current psychological theories of motor behavior — particularly in control theories of motor behavior. In §4, I argue that, on certain assumptions on the nature of the representations on which procedural systems are based, the same argument can be generalized to every psychological theory that assigns to procedural systems a role in explaining skillful behavior. In §5, I distinguish my notion of practical representation from Nanay's (2013) notion of "pragmatic" representation and compare it to other recent discussions of motor representation. In §6, I argue that the notion of practical representation developed in this essay helps defuse a very common but wrongheaded argument against intellectualism about know-how. I conclude in §7.

2. Preliminaries.

2.1 *The perspectival character of mental representation*

Mental representation is perspectival. That means that we never represent things *neat*. We always represent the world and its parts *in some 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. For example, Armstrong (1973) characterizes beliefs as *maps from which we steer*, suggesting that beliefs constitute points of view or perspectives; Dretske (1986:79) utilizes the same metaphor for propositional attitudes. Burge (2010: 51) generalizes it to *every* kind of mental representation: "all representation is necessarily from some perspective or standpoint."

The perspectival character of mental representation is reflected by the inten*s*ionality of representation attributions that exploit the locution "represent Y as X" (Burge 2010: 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 involve modes of presentation and that their attributions can create intensional contexts. What about *non-conceptual* perceptual representation? (Evans 1982; Peacocke 1989; Bermudez 1998; Burge 2009, 2010; Neander 2017.)

It is certainly less obvious that this sort of representation too involves modes of presentation. Nonetheless, as Peacocke (1989: 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*. 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 2010:41). An example of how two non-conceptual perceptual representations of the same thing can differ in their modes of presentation is provided by the Mach diamond (Figure 1, cfr. Neander 2017:172-4):

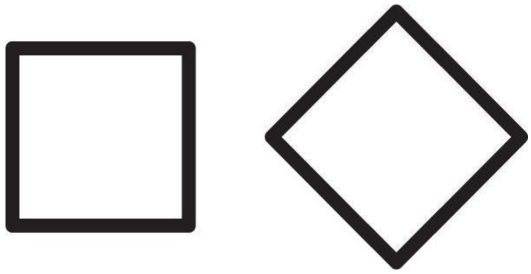

Figure 1: On the left is an ordinary square and on the right is the Mach diamond

This example illustrates that, while we might perceive a square as a square, we might also perceive it as a diamond. If so, non-conceptual perceptual representations of the same *shape* can come with different modes of presentation.

Neander (2017: 34-8) points out that ascriptions of non-conceptual perceptual representations can create inten*s*ional contexts. To make this point, Neander (2017: chapter 2) reviews the sort of non-conceptual representation posited by vision scientists (Palmer 1999; McCloskey 2009). As she points out, visual scientists routinely take visual representations to be structured along an imaginary Cartesian grid and take such representations to represent objects and features of the environment as located at coordinate points of that grid (cfr. Figure 2).

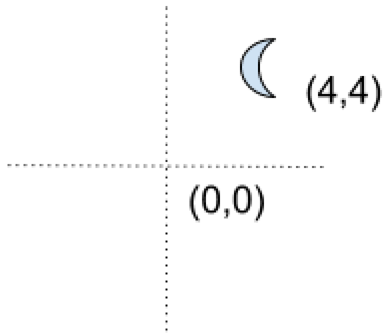

FIGURE 2 : *Representing the moon as located at coordinates of a Cartesian Grid*

For example, 2.a. might be true of Mary's visual system. But, of course, we can refer to the same point in space (4,4) in a different way, for example, *as the place mentioned in the sentence above for illustrative purposes* (Neander 2017:37). Although the descriptions "4, 4" and "the place mentioned in the sentence above for illustrative purposes" co-refer, 2.b. is not be 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*:[1]

> 2.a. Mary's visual system represents the Moon as located at 4,4.
> 2.b. Mary's visual system represents the Moon as located at the place mentioned above for illustrative purposes.

As Neander (2017: 37) points out, and as this example shows, because of the intensionality of their reports, it makes sense to talk of modes of presentation also for the visual system's representations, whether or not those representations are introspectively accessible to the subject and regardless of whether those representations are conceptual.

2.2 *Perspectives and representational abilities*

The discussion thus far suggests that both conceptual representation and non-conceptual perceptual representation involve modes of presentation. They both are

[1] Of course, the relevant false reading is *de dicto*, or with the "as…" clause taking narrow scope.

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 that representation *having a mode of presentation* (also cfr. Burge 2009:249-50).

Although the relevant perspective differs in the case of conceptual representation and in the case of perceptual representation, there is a commonality. In both kinds of representations, the nature of the relevant perspective is tied to the relevant *representational abilities:* in perception like in thought, we represent "through abilities that provide partial, incomplete, usually fallible perspectives on actual or purported subject matter" (Burge 2009:250). In other words, what we can represent and how we do it depends on the *abilities* 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? For the purpose of this paper, I will refer to "perceptual abilities" in general as to 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 varying of the environment. A long tradition in the philosophy of mind takes the perceptual system to be the paradigm case of a system apt for tracking features of the environment (Dretske 1986, 1988; Stalnaker 1999:347; Neander 2017:152-3). 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 varying of objects and their features in three-dimensional space. The auditory system, the smell system, and the touch system also track features of the environment (cfr. Coombs et al. 2010; Dau et al. 1996; Porter et al. 2007), 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.

Hence, what we can perceptually represent and how we do it depends on the perceptual abilities that we have. And although perceptual abilities can vary a lot across sensory modalities, they are all essentially *tracking abilities* — i.e., abilities to carry information about the environment.

Conceptual representations too represent in accordance with the abilities that representing subjects possess. But in this case, 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 — i.e., that can combine into more complex representations, in accordance with systematic structural rules (Fodor 1975, 1994, 1998, Gallistel 1990, Camp 2009). Following Camp 2009, I will dub 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 high-order cognitive capacities of categorization and reasoning (Figure 3). On this *robust conception* of concepts, as I will call it, many combinatorial representations that underlie low-level cognitive abilities, such as perceptual or motor abilities, do not count as concepts, if those abilities are not abilities to categorize and to reason. For the purpose of the main argument in this essay, I will assume the robust conception of concepts, as it seems to be prevailing both in psychology and in philosophy (Rosch 1978; Rosch & Mervis 1975; Peacocke 1992; Laurence & Margolis 1999; Prinz 2004: Chapter 1; Machery 2009: 7-51; Margolis & Laurence 2014).[2] Accordingly, concepts in what follows will be assumed to be representations underlying our abilities to categorize and to reason.[3]

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[2] By "reasoning," here I mean a sort of inference that can be performed by a subject at the personal level. 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 under which an individual belongs). Cfr. Printz (2004: 9). See Armstrong, Gleitman, and Gleitman (1983) for a dissenting voice among psychologists.

[3] I will remain neutral as to what these representations must be like in order to play the theoretical role of explaining high-order cognitive capacities of categorization and reasoning (i.e., as whether concepts must be definitions, or exemplars, or prototypes, or bodies of knowledge, and so on.)

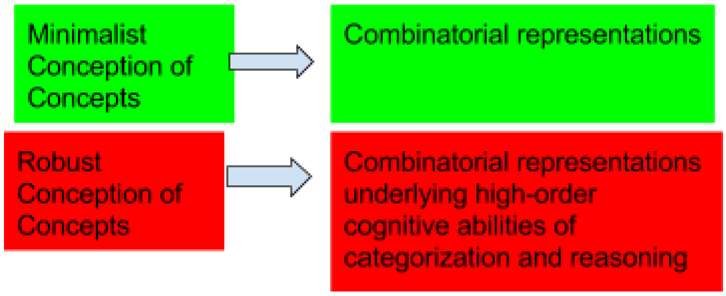

FIGURE 3 : *Robust versus minimalist conceptions of concepts*

2.3 *Practical perspectives and the main thesis*

Thus far, I have been arguing for a couple of theses. The first thesis, widely endorsed in philosophy of mind, is that both conceptual representations and (non-conceptual) perceptual representations involve modes of presentation. In this sense, they are *perspectival*. The second thesis is that the nature of their perspectives has to do with the relevant representational abilities. 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 classificatory and reasoning abilities.

This discussion puts me in position to introduce the notion of practical representation and the main thesis of this essay. The thesis that practical representation is psychologically real is the thesis that *there is a third way of representing the world, alongside with perceptual representation and conceptual representation — i.e., a practical way of representing the world*. Practically representing 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 categorize and reason. Rather, they are abilities to perform operations that are neither tracking nor classificatory. These abilities differ from tracking abilities and classificatory abilities in *their direction of fit* (Platts 1979: 257; Anscombe 1957: 56): instead of having a world-to-mind direction of fit like tracking and classificatory abilities, they have a mind-to-world direction of fit. In this sense, they are practical abilities.

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

Next section argues that practical representation enters central 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.[4] The idea behind these models is that these 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, one in lifting the bottle of wine, one in bending it, etc. According to these models, each of these parts is mapped into 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, etc. (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, the role of motor commands can then be

[4] This section follows for the most part the line of argument developed in [blinded for peer review].

characterized as twofold:

(i) 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;

(ii) motor commands prescribe to the motor system the execution of a given motor task.

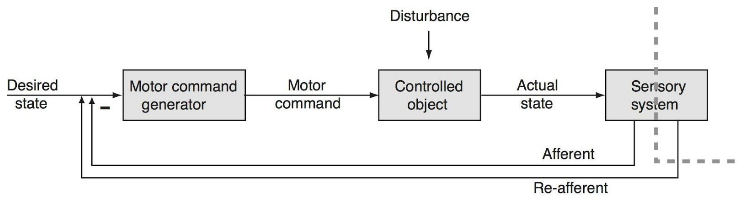

FIGURE 4 : Trappenberg's representation of the motor system (2009, 271)

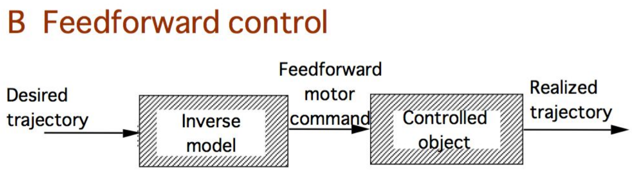

FIGURE 5 : Kawato's representation of the motor system (1999: 719)

Qua outputs of the motor planning and *qua* inputs to the computation by the motor system, it is plausible to take motor commands to be representations *of sort.* Of course, they are not representations in the sense that they have truth- or accuracy-conditions. They are, nonetheless, as Tulving (1985: 387-8) puts it, "prescriptive" representations, like imperatives in natural languages.[5]

Qua representations, it makes sense to ask what motor commands represent and *how*. On the denotational model, motor commands represent *tasks,* ones to be performed by the motor system. The denotational model dovetails well with a particular approach to

[5] 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-sidewarning signs than they are to linguistic representations. As a consequence, my discussion will be more abstract, but will hopefully gain in generality.

the semantics of imperatives that has been put forward in recent years (Lascarides and Asher 2003, Barker 2012), according to which the meaning (or denotation) of an imperative such as (1) is an *action outcome*:[6]

(1) Dance!

According to this denotational model, (1) denotes the outcome of dancing. Extending the denotational approach to motor commands, we have 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.

However, motor commands do not just denote, or just represent, action outcomes (or task outcomes). They do so *from a certain perspective, through a certain mode of presentation*. Or so will I argue.

The first premise for this conclusion is that tasks can be performed *in accordance with different methods*. Consider for example again the motor task that consists in moving the 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 are a number of velocity profiles (trajectories) the hand could follow. Even after having specified the hand path and velocity, each location of the hand 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 1997:2). In this sense of 'method', 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 through which 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 (1997:2) puts it:

Motor planning can be considered as the computational process that consists in

[6] What is an action? As Barker (2012:1) 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*, *w*i> where *w* is the world before the action and *w*i 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.

> 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 7 (from Wolpert 1997:3) shows the motor hierarchy. In it, the same task outcome— e.g. reaching for the glass on the table — corresponds to different paths the hand could take, which, in turn, correspond to different possible trajectories that can be executed by different movements of the joint, and these movements, in turn, correspond to different muscle activations that can be prescribed by still different neural commands:

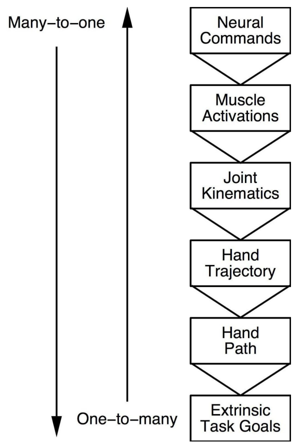

FIGURE 7 : *The motor hierarchy*, *Wolpert* 1997 : 3

If motor commands are to be the outputs of this process of motor planning, 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*. So, the denotational model is incomplete. Motor commands do not just represent tasks. They represent it in a particular way, i.e., *as to be performed in accordance with a certain method*.

These different methods can be thought of as the perspectives from which, or 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 2015: 2–5); finally, the execution of a method M would, in favorable conditions, output the task that M is a method to perform. In this sense, a method *fixes*, or *determines*, that task.[7] For example, consider Method 1, Method 2, and Method 3:

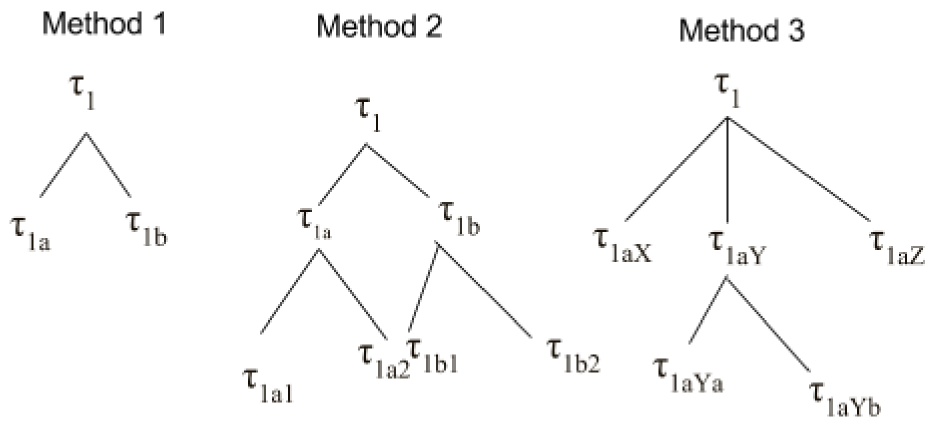

Figure 8 : *Three methods for performing a task*

They are all methods to perform $\boldsymbol{\tau}_1$, as they all "break down" $\boldsymbol{\tau}_1$ into parts. Method 1 breaks the task $\boldsymbol{\tau}_1$ into two parts: $\boldsymbol{\tau}_{1a}$ and $\boldsymbol{\tau}_{1b}$. Method 2 differs from Method 1 in that it breaks $\boldsymbol{\tau}_{1a}$ and $\boldsymbol{\tau}_{1b}$ into further parts. Method 3 differs from Method 2 and Method 1 because it breaks $\boldsymbol{\tau}_1$ down into three altogether different parts ($\boldsymbol{\tau}_{1x}$, $\boldsymbol{\tau}_{1Y}$ and $\boldsymbol{\tau}_{1Z}$); and $\boldsymbol{\tau}_{1Y}$ into two further parts ($\boldsymbol{\tau}_{1Ya}$, $\boldsymbol{\tau}_{1Yb}$). Because each of these three methods are methods to perform the same task ($\boldsymbol{\tau}_1$), they all denote or represent $\boldsymbol{\tau}_1$. But 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.

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 2017a, 2017b). *Qua* ways of breaking down a

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[7] 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 Fing with X% probability of success *determines the task of F-ing with X% probability of success.* Because methods stand to tasks into 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 2015: 3) that methods stand to tasks as Fregean meanings (or senses) stand to their denotations (or referents). Consequently, methods are plausible candidates for being the modes of presentation of tasks.

task into subtasks, they must come to an end *at some point*. They cannot divide into subtasks indefinitely. That is so because a method for a system *s* to perform the task ***τ*** must answer the question "How can *s* perform ***τ***?" — i.e., it must provide an explanation of how *s* can execute ***τ***. And a satisfactory explanation of how *s* can execute τ 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, their division of tasks into parts must reach a set of "elementary" subtasks — ones that have no further proper parts.[8]

Now, either the set of elementary subtasks is relative to a system, or it is not relative to a system — i.e., 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 system at a time* (or a set of systems which certain commonalities at a time, cfr. 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 time, and not elementary for another system at that time, or for that very same system at another time. Because of this, it is not clear that we are speaking intelligibly if we talk as if ways of breaking down a task into a set of elementary operations could be common to *every* system.

In [blinded for review], I argued for the relativity of elementary operations starting from the phenomenon of "chunking." Chunking is a process by which a sequence of elementary operations gets "chunked" into parts that then can 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, and F]. For through chunking, the sequence A, B and C loses, so to say, *theoretically interesting structure*: the system has now come to execute it directly, for it has now at its disposal a "specialized" instruction for executing at once a task that before it had to execute through three different

[8] This argument to the effect that methods cannot divide tasks into sub-operations indefinitely closely resembles Fodor's (1968;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.

instructions. In psychological theories of motor behavior, it is widely thought that practice makes improvement of performance possible precisely through chunking, for chunking makes the processing of a motor sequence more efficient (Verwey 2010; Verwey and al. 2011:407).

Now, if a chunked sequence is a specialized instruction that is partless from the point of view of its computational structure, it makes sense to think of its as a new elementary operation for the system.[9] If chunking is possible, as it seems, *the set of elementary operations of a system must change over time*, because in virtue of their lack of computational structure, the new chunks qualify to be included 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 is a method for that system to perform that task will depend on the system's stock of elementary operations. 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 elementary perform. These most basic abilities do not need to be conceptual abilities nor perceptual abilities for they do not need to be abilities to sort things into categories or to reason about things, nor do they need to be abilities to track features of the environment. Their *direction of fit* (Platts 1979: 257; Anscombe 1957: 56) is mind-to-world, rather than world-to-mind. In this sense, the perspective of motor representation is neither conceptual nor perceptual but distinctively practical.[10]

[9] If we do so, though, it is important to keep in mind that Fodor's definition of elementary operation (as one that a system can perform directly but 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. So an elementary operation is not one that the system can perform but of which it cannot perform a proper part. Rather, it is one that the system can perform without thereby performing any proper part.

[10] On certain assumptions about the semantics of mental representations, it also makes sense to assign a distinctively *practical meaning* to motor commands (Pavese 2017b). 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

Now, we have all the ingredients for an argument to the effect that motor commands are practical representation and that, through them, motor systems represent practically. Consider a motor system with the following elementary operations: τ_{1a1}, τ_{1a2}, τ_{1b1} and τ_{1b2}, but not $\tau_{1Z,}$ τ_{1X} or τ_{1Y}. We can further suppose that also τ_{1a} and τ_{1b} are not elementary for the system. Consider a motor task τ_1 and the three methods in figure 3. Although METHOD 1, METHOD 2, and METHOD 3 are all ways to perform τ1, only 3b. is true:

3.a. Motor system 1 represents τ_1 as to be performed in accordance with METHOD 1;

3.b. Motor system 1 represents τ_1 as to be performed in accordance with METHOD 2.

3.c. Motor system 1 represents τ_1 as to be performed in accordance with METHOD 3.

Moreover, although METHOD 1 and METHOD 2 partially overlap, only METHOD 2 represents τ_1 from the point of view of motor system 1's elementary abilities. By contrast, METHOD 1 does not tell the system how to further decompose τ_{1a} and τ_{1b}. Since τ_{1a} and τ_{1b} are not elementary for motor system 1, METHOD1 is not truly a method for the system 1 to perform τ1. Hence, it is not a practical mode of presentation of τ1 for motor system 1.

In this sense, ascriptions of motor representations are inten*s*ional. 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: a motor system might represent a task differently across times, with the varying

and input to the execution of the task, its function is not, like that of truth-conditional representations, of tracking the environment. More plausibly, its function is *to prescribe a task* — or to represent a task as to be executed in accordance with a method for performing a certain task. But 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 so, in this sense, it would misrepresent. Hence, from the perspective of a broadly teleosemantic 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 operation that a system can elementary perform. But since methods are relative to stock of elementary abilities, so are practical meanings (cfr. Pavese 2017b).

of the system's abilities across times, and two motor systems with different practical abilities might represent a task differently. Because it is function of a system's stock of practical abilities, 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 of "practical representations" introduced in §2: they represent a task as 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.

Does practical representation extend beyond the realm of motor tasks? Note that my characterization of practical representation in §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 enter central stage in explaining skills other than motor skills. This section documents certain widespread assumptions in psychology and neuroscience on the sort of the representations over which procedural systems are taken to be 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 system.

The distinction between declarative and procedural systems is foundational in cognitive sciences and goes back to the pioneering experiments by Milner is the late 50s. Her work with the patient known as H.M. has been taken to reveal a dissociation between different kinds of knowledge. After bilateral removal of the hippocampus, parahippocampal gyrus, entorhinal cortex, and most of the amygdala 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 for facts and events, on one hand, and the function of improving motor-skills, on the other.

Neal Cohen and Larry Squire (1980) subsequently demonstrated that the skill-learning preserved in amnesia is not limited to motor skill learning but includes cognitive skill learning as well. Cohen and Squire (1980) concluded 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 (cfr. Squire 1992; Cohen & Eichenbaum 1993; Squire 2009; Squire & Kandel 2003; Squire & Wixted 2011, 2016; Squire & Zola-Morgan 1988; Bayley & Franscino & Squire 2005; Roy & Park 2010). Although it has no shortage of detractors, even those challenging it 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 systems as *representation-based*, and to describe these representations as "prescriptive." For example, Tulving (1985: 387-8) 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 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 to solve a differential equation. For the acquisition of skills of this sort, Anderson (1982:369) distinguishes two stages: a declarative stage in which facts are learned about the skill domain, and 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 examples, a primitive rule for performing addition would have the form of a conditional instruction/imperative, conditional on the goal of the task (p. 371):

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 & Anderson (1989:165) 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 along the lines of computer program's instructions (Singley & Anderson 1989:190-1). Knowlton and Karin Foerde (2011: 107) inquire over the "neural representations supporting different forms of nondeclarative learning" across domains of skills, to include both visuo-motor skills, such as dancing and mirror-inversion drawing tasks, and cognitive skills, such as picture naming, word completion and probabilistic classificatory tasks (Knowlton & Mangels & Squire 1996; Foerde, Knowlton, & Poldrack 2006). 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 take a procedural component to support different forms of non-declarative learning in the case of cognitive skills too, and think 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 a procedural component 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. On the assumption that this practice of positing procedural representations is not misguided, the argument run 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 (whether or not motor) system. If so, far from being confined to an explanation of motor skills, practical representation enters central 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 2000; Rossetti 2001; Gallese & Metzinger 2003; Stevens 2005; Rizzolatti & Sinigaglia 2008; Pacherie 2011; Nanay 2013; Butterfill & Sinigaglia 2014; Sinigaglia & Butterfill 2015; Lex, Schütz, Knoblauch, & Schack 2015; Mylopoulos & Pacherie 2016; Levy 2016; Brozzo 2017; Fridland 2017) have discussed and emphasized the central role of motor representation in the production of intentional motor actions. Nanay (2013) has even coined a new expression — i.e., "pragmatic representation" — to characterize the intervention of a special sort of unconscious representation in the guidance of motor actions. The notion of practical representation introduced in this essay differs in some important respects both from Nanay's (2013) pragmatic representation as well as from the above authors' discussions of motor representation.

For Nanay (2013: 4-5), pragmatic representations are, though unconscious, *bona fide* perceptual representations.[11] By contrast, practical representation differs from perceptual representation as to the sort of perspective that it involves. In §§2-3, we have seen that, whereas perceptual representation represents the world through our perceptual abilities, which are essentially discriminatory and tracking abilities, practical representation represents the worlds through abilities that are not necessarily perceptual.

Secondly, neither Nanay (2013) nor most recent discussions of motor representations explicitly think of them in prescriptive terms. In fact, Nanay (2013:16-17) explicitly distinguishes between, on one hand, the cognitive or representational component (i.e., "the immediate antecedent of actions") and, on the other hand, its "conative" component. The former is said to have a world-to-mind direction of fit. By

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

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, practical representation resembles more the "conative component" of the immediate antecedents of actions than Nanay's (2013:17) pragmatic representations proper.

Finally, the notion of practical representation is more general both than Nanay's (2013) notion of pragmatic representation and than that of motor representation. Nanay (2013:18), as well as Butterfill & Sinigaglia 2014, 2015, Levy 2017, Fridland 2017, and Mylopolous & Pacherie 2017, explicitly restrict their attention to motor, non-mental actions.[12] By contrast, practical representation is not exhausted by motor representation. In the last section, I tried to emphasize that motor representation is just *one* kind of practical representation: any task that can be represented in terms of a system's practical abilities can be represented practically by that system. Hence, practical representation also enters in an explanation of skillful non-motor behavior, such as cognitive skills, and captures what is common to *all sorts* of prescriptive representations.

6. Repercussion for the debate on know-how

6.1. Motor representation in a theory of motor know-how

According to intellectualism about know-how, knowing how to perform an action is a matter of being in a certain distinctive propositional state — the state of *knowing a proposition about how to perform that action under a practical mode of presentation* (Stanley & Williamson 2001; Stanley 2011; Pavese 2013, 2015a,b, 2017a). According to anti-intellectualism, instead, know-how cannot be fully understood in terms of a propositional state (Noe 2005; Devitt 2011; Glick 2011, 2012).

In the current literature, several authors have highlighted the need for motor representation in explaining intentional motor actions. These authors grant that a propositional state is also needed to explain the intentionality of these actions, as argued by Pavese (2013, 2015a,b) and Stanley & Krakauer (2013). They point out, however, that

[12] 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.

motor representation is needed *in addition to* such a propositional state. And from that, they conclude that, at least in the motor case, know-how and skill cannot be fully understood in terms of a propositional knowledge state (Levy 2017; Fridland 2017). For example, Levy (2017) argues against intellectualism that it cannot account for the role of motor representation in an explanation of skillful action. The right view for motor skill is, Levy (2017:523) claims, a *composition view*, on which know-how includes both motor representation and a propositional knowledge state:

> According to the composition view, at least with regard to many of the things agents know how to do, their knowledge-how is constituted both by propositional knowledge *and* motor representations, and it qualifies as knowledge in virtue of both the propositional knowledge and the motor representations. So long as there are some cases of knowledge-how of which the composition view is true, intellectualism is false.

We owe it to Levy (2017) to have singled out with extreme clarity the need of motor representation for an account of motor know-how. Nonetheless, we might ask: 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 intellectualism?

The problem with this argument is that, since its very first formulation (e.g., Stanley & Williamson 2001), intellectualism is the view according to which know-how *requires practical representation*. According to it, 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 2013, 2015a,b, 2016a,b, 2017). According to intellectualists, just like I may know a proposition about my pants being on fire under a first-personal mode of presentation, or under a third-personal mode of presentation, exactly in the same way, I may know a proposition about how to perform a task under a practical mode of presentation.

Now, it is true that intellectualists have not always been faithful to practical representation. For example, Stanley (2011:125-30) has argued that practical modes of presentation (that he conceived of as “ways of thinking” and so as sorts of conceptual representation in the robust sense of “conceptual” specified at the outset) are dispensable from an intellectualist account of know-how. It is also true that not all intellectualists have thought of practical representation as corresponding to the sort of procedural representations posited by cognitive scientists. For example, Stanley (2011:156) explicitly does not think of procedural knowledge in terms of practical representation as understood in this essay:

> 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).

Here, Stanley (2011) thinks of procedural knowledge as a kind of propositional state in its own terms. By contrast, practical representation as discussed in this essay is *not* propositional: as a form of *prescriptive* representation, it does not have truth-conditions. From this passage, it is clear that Stanley (2011) is not conceiving of procedural knowledge in terms of practical representation.

Practical modes of presentation do not even explicitly play a role in Stanley & Krakauer's (2013) "mixed view" of motor skills. Stanley & Krakauer (2013) do propose 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 also observed by Levy (2017) and Fridland (2017), Stanley & 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 & Krakauer (2013) fail to characterize the procedural component of skill representationally in terms of practical modes of presentation. On the other hand, they 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 perform intentionally a task, they need to "know what to do to initiate the task" (Stanley & Krakauer 2013:4). This latter knowledge, we are told, is propositional — i.e., is a matter of knowing *that certain movements are required to initiate the task* (Stanley 2011). Because Stanley & Krakauer (2013) think of the procedural component non-representationally, if *any* role is given by their view to practical modes of presentation, it doomed to be in an account of the *declarative component* — i.e., 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 4).

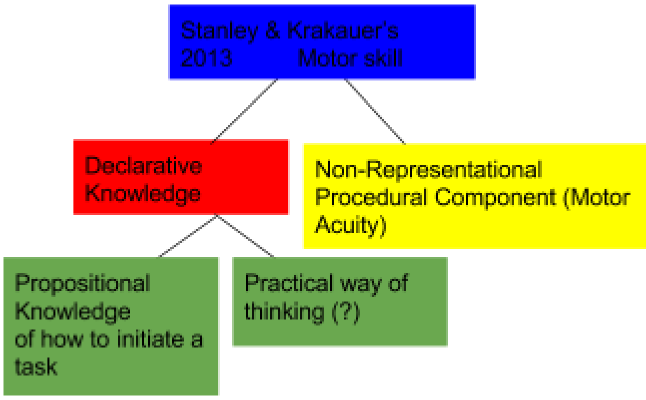

FIGURE 9 : *Stanley* & *Krakauer* (2013) *on motor skill*

So Levy (2017) is right to point out that motor representations missing from both Stanley (2011) and Stanley & Krakauer's (2013) account of skills. However, it is incorrect to thereby conclude that intellectualists cannot in principle accommodate the need for motor representation. In this essay, I have given a general characterization of practical representation (§2), one which makes it clear in what sense motor representation counts as an example of practical representation (§3). On this understanding of practical representation, it is open to the intellectualist to assign a crucial role to practical modes of presentations in their account of know-how and skills, by thinking of motor skills and know-how as combining the declarative component (corresponding to one's knowledge of a proposition) with the procedural component (corresponding to the practical mode of presentation):

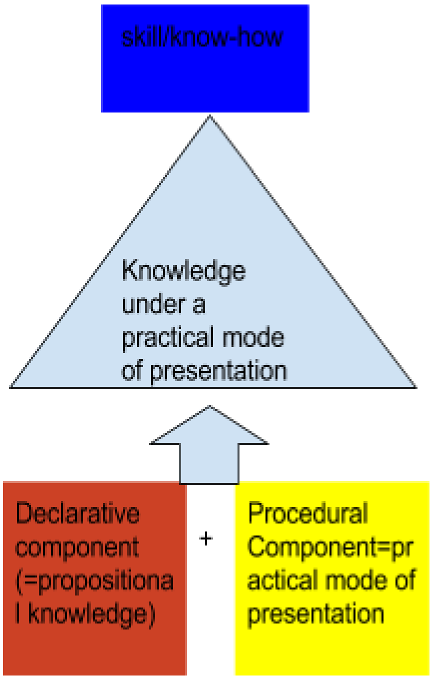

FIGURE 9 : *Intellectualism about skills*

We get to this picture of skill if we combine two insights. The first insight, that we owe to Stanley & Williamson (2001), is that practical modes of presentation can be construed in Russellian terms *as ways* whereby one stands in a propositional attitudes towards a proposition.[13] The second insight, originally due to Pavese (2013, 2015b, 2017b), is that practical modes of presentation can be modeled along the lines of programs, or more precisely, along the lines of operational semantic values of program texts. Operational semantic values for program texts are themselves ways of breaking down a task in terms of operations that a system can primitively perform. Moreover, as Pavese (2017b) argues, operational semantic values can also model the meaning of motor commands. Therefore, practical senses in Pavese's (2015, 2017b) sense qualify as

[13] Russellian ways of construing knowledge states are independently motivated from the debate on first-personal thoughts. Hence, it is not *ad hoc* for intellectualists to appeal to them.

practical representations.[14]

6.2 Two objections

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 is well-taken but only raises a *prima facie* worry. That is so because motor commands are not the only kind of practical representation that there is. Besides motor commands, control theorists posit *motor schemas* (Bernstein 1967; Schmidt 1975, 2003; Arbib 1981, 1985, 2003; Jeannerod 1997). Motor schemas are more general, less context-specific, and more enduring 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 also are prescriptive representations, only more general. They are supposed to be revisable through trial and error and to store information about the invariant aspects of an action (Arbib 1981; Jeannerod 1997: 51-5).

That suggests a hierarchy of motor representation analogous to the hierarchy of perceptual representation (Burge 2009; Siegel 2011). Just like we might distinguish between *particular* perceptual representations and *attributive* perceptual representations, similarly we might distinguish between particular practical representation and general practical representation (Figure 10):

[14] Although it is true that, at points, Pavese (2015a, b) talks as if practical representation were conceptual but there, quite explicitly, she understands conceptual in accordance with a *minimalist* conception of concepts, rather than in accordance with a robust conception of concepts. As she (2015: 2, fn 4) points out, her view of practical modes of presentation is compatible with a Russellian construal, also favored originally by Stanley & Williamson 2001, on which practical modes of presentation are not conceptual components of propositions but are ways whereby one stands in a knowledge relation to a proposition.

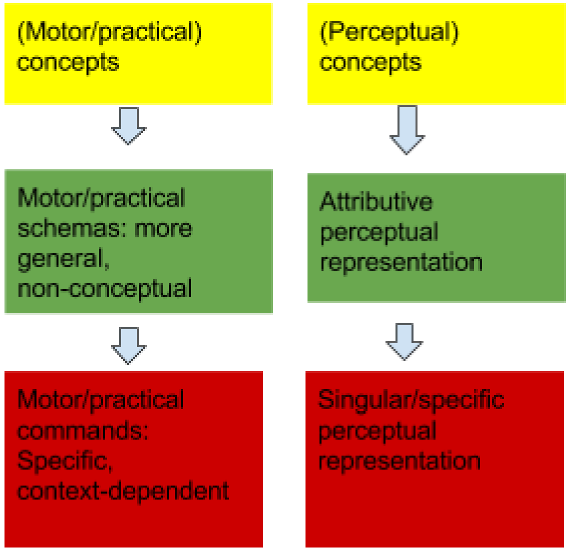

FIGURE 10 : *The hierarchy of motor versus perceptual representation.*

So much for the first objection. The second objection goes as follows. Practical modes of presentation can be understood on a Russellian construal (Stanley & Williamson 2001) or on a Fregean construal (Stanley 2011; Pavese 2015b). On a Fregean construal, practical modes of presentation are components of propositions. If being eligible as a component of propositions suffices for being a conceptual representation, the proponent of a Fregean construal is committed to taking practical modes of presentation to be kinds of conceptual representations. In this essay, though, practical representation has been introduced in *contraposition* to conceptual representation. Hence, one might wonder whether this notion of practical representation is compatible with a Fregean construal of Intellectualism theories of know-how.

In response, 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 is definitely compatible with construing practical representation as non-conceptual.

Secondly, and more importantly, the Fregean construal is not *in*compatible 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). Neuroscientists and psychologists concur in taking motor representations to be combinatorial (Arbid 1981, 1985; Jeannerod 1997:51; Lewis, Vera & Howes (2004); Wolpert & Diedrichsen & Flanagan 2011). Hence, it is plausible that practical representation qualifies as conceptual in the minimalist sense. It is an open question, one that would require carefully investigation, whether conceptual representation in the minimalist sense can appear as components of propositions.[15]

Third, the parallel with perceptual representation (Figure 10) does make room for the possibility of a *third* kind of practical representation, a form of practical but also conceptual representation, like Pavese's (2015a) "practical concepts" and Mylopolous & Pacherie's (2017) "action-based concepts", where "concept" is understood on the robust conception of concepts. As Pavese (2015a) and Mylopolous & Pacherie (2017) put it, practical concepts are concepts whose possession entails ability, for their possession entails representing a task practically. That 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 — i.e., one must also represent that task in accordance with one's practical abilities.

[15] Some have mentioned the fine-grainedness of motor representation as the main reason for why this sort of representation cannot enter as component of propositions (Carruthers, 2006: 284; Levy 2017: 520, fn 8). The idea is that its fine-grainedness would outstrip any subject's conceptual abilities. It is worth noting that this argument relies on several assumptions. First, it assumes that motor representation is too fine-grained for being 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, 2003; Jeannerod, 1997). They are less context-specific, more abstract and 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*. But note that that is hardly true even for *bona fide* conceptual representations. For example, I might have the concept of parrot, and so possess a complex representation that underlies my ability to sort parrots from non-parrots and to 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 subpersonal 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 classificatory 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.

The idea that there might be concepts that are especially linked with non-conceptual representations is, of course, not at all new or exotic. In fact it is plausible that many concepts are derivable from non-conceptual perceptual representations through copying and abstraction (Prinz 2004: chapters 5-6; Neander 2017: Chapter 8). Along the same lines, there might be concepts that may be derivable from, and as a result be especially linked to, practical representations.

Given the current state of the discussion and research, I take it to be very much an open question whether a complete psychological theory of skills must feature practical concepts too, in the robust sense of "concepts," alongside with non-conceptual practical representation.[16] I have to leave arguing for the need of practical concepts in a complete psychological theory of skills 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. 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 are neither perceptual (i.e. tracking) nor conceptual (i.e. classificatory). I argued that motor commands and motor schemas, as they figure in current psychological theories of motor control, are examples of practical representation. If so, then our best theories of motor control routinely and essentially invoke practical representations: *Practical representation is psychologically real*. Moreover, on the assumption that the general practice of cognitive scientists of positing procedural representations is not misguided, the scope of practical representations goes well beyond the realm of motor skills and extends to more distinctively cognitive skills too. In the second part of the essay, I have argued that, by appeal to the notion of practical

[16] Some have already argued for a positive answer to this question: Mylopolous & Pacherie (2017) contend that practical concepts might indeed be needed to overcome Butterfill & Sinigaglia's (2014) interface problem — the problem of explaining how motor, and more generally practical representation, can compose with intentions in producing motor skillful behavior.

representation developed in this essay, intellectualists can countenance a place for motor representation, and more generally for procedural representation, in their account of know-how.

References

Anderson, J. (1982). "Acquisition of cognitive skill" *Psychological review* 89.4: 369.

———. (1985). "Cognitive psychology and its implications." *A series of books in psychology.*

———. (1987). "Skill acquisition: Compilation of weak-method problem situations." *Psychological review* 94.2: 192.

———. & J. Douglass, D. (1997). "The Role of Examples and Rules in the acquisition of a cognitive skill" *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 23(4): 932–945.

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: Motor Control, Baltimore: Williams et Wilkins, pp. 1449-1480.

———. (1985) Schemas for the temporal organization of behavior. *Human Neurobiology*, 4: 63-72.

Armstrong, D. (1973). *Belief, truth and knowledge*. CUP Archive.

Armstrong, S. L., L. R. Gleitman, and H. Gleitman. (1983). "What some concepts might not be." *Cognition* 13.3: 263–308.

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) pp. 550–553.

Bernstein, N. (1967). *The Coordination and Regulation of Movements*. Pergamon Press, Oxford.

Bermúdez, J. L. (1995). "Nonconceptual content: From perceptual experience to subpersonal computational states." *Mind & Language* 10.4: 333–369.

Boghossian, P. A. (1995). “Content,” in J. Kim and E. Sosa (eds.), *A Companion to Metaphysics*, Oxford: Blackwell, 94–96.

Brown, J. (2013). Knowing-how: linguistics and cognitive science. *Analysis* 73 (2):220–227.

Brozzo, C. (2017). Motor Intentions: How Intentions and Motor Representations Come Together. *Mind and Language* 32 (2):231–256.

Burge, T. (2003). “Perceptual Entailment” *Philosophy and Phenomenological Research*, 67.3: 503–548.

———. (2009). “Five theses on *de re* states and attitudes” *The Philosophy of David Kaplan:* 246–324.

———. (2010). *Origins of objectivity*. 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.

Campbell, J. (1999). “Schizophrenia, the space of reasons, and thinking as a motor process.” *The Monist* 82.4: 609–625.

Carey, S. (2009). *The origin of concepts*. Oxford University Press.

Carruthers, P. (2006). *The architecture of mind*. Oxford: Oxford University Press.

Cohen, N. J. & Eichenbaum, H. (1993). *Memory, Amnesia, and the Hippocampal System* MIT Press, Cambridge, MA.

———. and Squire, L. (1980). “Preserved Learning and Retention of Pattern-Analyzing Skill in Amnesia: Dissociation of Knowing How and Knowing that”, *Science.* 210(4466), pp. 207–210.

Connolly, K. (2011). “Does perception outstrip our concepts in fineness of grain?” *Ratio* 24.3: 243–258.

Coombs, S., R. R. Fay, and A. Elepfandt. (2010). “Dipole source encoding and tracking by the goldfish auditory system.” *Journal of Experimental Biology* 213.20: 3536-3547.

Corkin, S. (1968). “Acquisition of Motor Skill After Bilateral Medial Temporal-Lobe Excision,” *Neuropsychologia*, Vol. 6, pp. 255–265.

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

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.

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

———. (1994). “Concepts: A potboiler.” *Cognition* 50.1: 95–113.

———. (1998). *Concepts: Where cognitive science went wrong*. 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. (2013). “Problems with intellectualism.” *Philosophical Studies*, *165*, 879–891.

———. (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).

Glick, E. (2011). “Two methodologies for evaluating intellectualism.” *Philosophy and Phenomenological Research* 83.2 (2011): 398–434.

———. (2012). Abilities and know-how attributions. *Knowledge Ascriptions*, 120-38.

Dau, T., D. Püschel, and A. Kohlrausch. (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.

Devitt, M. (2011). “Methodology and the nature of knowing how.” *Journal of Philosophy* 108 (4):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.

Henke, K. (2010). “A model for memory systems based on processing modes rather than consciousness.” *Nature Reviews Neuroscience 11.7*, 523–532.

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

———. J. A. Mangels, and L. R. Squire (1996). “A neostriatal habit learning system in humans.” *Science* 273.5280: 1399.

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

———. (2006). *Motor Cognition: What actions tell the self*. New York, NY: Oxford University Press.

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.

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

Lewis, R. L., Vera, A. H., & Howes, A. (2004). “A Constraint-Based Approach to Understanding the Composition of Skill.” In *ICCM* (pp. 148-153).

Laurence, S., and E. Margolis. (1999). “Concepts and cognitive science.” *Concepts: core readings*: 3–81.

Margolis, E. and Laurence, S. (2014). “Concepts,” *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/spr2014/entries/concepts/>.

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

Mandler, J. M. (1998). “Representation.” In W. Damon (Ed.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (pp. 255–308). Hoboken, NJ: John Wiley.

Milner, B. (1962). “Physiologie de l’hippocampe.” Paris: Cen. Natl. Rech. Sci; *Les troubles de la memoire acompagnant des lesions hippocampiques bilaterales*; pp. 257–272.

———. (1965) “Memory disturbance after bilateral hippocampal lesions.” In *Cognitive Processes and The Brain*, P.M. Milner and S. Glickman Eds., Princeton, N.J.: Van Nostrand, pp. 97–111.

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

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

McDowell, J. (1994). *Mind and World*, Cambridge, MA: Harvard University Press.

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

Neander, K. (2017) *A Mark of the Mental: In Defense of Informational Teleosemantics*. Cambridge, Massachusetts; London, England, MIT Press.

Newell, A. (1990). *Unified theories of cognition*. Cambridge, MA: Harvard University 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. *Vision science: Photons to phenomenology*. MIT press, 1999.

Pavese, C. (2013). *The Unity and Scope of Knowledge*, Dissertation, Rutgers University.

———. (2015a). “Knowing a Rule,” *Philosophical Issues* 25.1: 165–188.

———. (2015b). “Practical Senses,” *Philosophers’ Imprint* 15.29: 1–25.

———. (2016a). “Skill in epistemology I: Skill and knowledge.” *Philosophy Compass* 11.11: 642–649.

———. (2016b). “Skill in epistemology II: Skill and know how.” *Philosophy Compass* 11.11: 650–660.

———. (2017a). “Know-how and Gradability,” *Philosophical Review* 126.3:345–83.

———. (2017b). “A Theory of Practical Meaning” *Philosophical* Topics vol. 45 no 2 (45.2), Fall 2017, pp. 85–116.

———. Manuscript. “The Language of Motor Behavior”.

Peacocke, C. (1992). *A Study of Concepts*. Cambridge, MA.: MIT Press.

———. (1998). “Nonconceptual content defended.” *Philosophy and phenomenological research* 58.2: 381–388.

———. (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., et al. (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*. MIT press.

Reder, L. M. H. P., and Kieffaber, P. D. (2009). “Memory systems do not divide on consciousness: Reinterpreting memory in terms of activation and binding.” *Psychological Bulletin 135.1,* 23–49.

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.

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

Rosch, E. (1978). “Principles of Categorization,” in E. Rosch & B. Lloyd (eds.), *Cognition and Categorization*, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 27–48.

———. & 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 Peter G. Grossenbacher (ed.), *Finding Consciousness in the Brain: A Neurocognitive Approach. Advances in Consciousness Research*. John Benjamins. pp. 133–181.

Roth, M. and Cummins, R. (2011). “Intellectualism as cognitive science.” In Newen, A., Bartels, A., & Jung, E-M (eds.) *Knowledge and Representation*. CSLI Publications.

Roy, S. & N.W. Park. (2010). “Dissociating the memory systems mediating complex tool knowledge and skills.” *Neuropsychologia* 48.10: 3026–3036.

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

———. (2003). “Motor schema theory after 27 years: Reflections and implications for a new theory.” *Research quarterly for exercise and sport*, *74*(4), 366-375.

Squire, L.R., & Zola, S.M. (1997). “Amnesia, memory & brain systems.” Philosophical Transactions of the Royal Society of London, B: Biological Sciences, 352, 1663–1673.

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

Singley, M. K. & J. Anderson. (1989). *The transfer of cognitive skill*. No. 9. Harvard University Press.

Sinigaglia, C. & Butterfill, S. A. (2015). “On a puzzle about relations between thought, experience and the motoric.” *Synthese* 192 (6):1923–1936.

Smith, E., & Medin, D. (1981). *Categories and Concepts*, Cambridge, MA: Harvard University Press.

Squire, L. R. (1992). “Memory and the hippocampus: a synthesis from findings with rats, monkeys, and humans.” *Psychological review* 99.2: 195.

———. (2009). “Memory and Brain Systems: 1969-2009”, *Journal of Neuroscience*, 29(41), pp. 12711–12716.

———. and Kandel. (2003). *Memory: From Mind to Molecules*, (New York, N.Y.: Owl Books).

———. and Wixted, J. (2011). “The Cognitive Neuroscience of Human Memory Since H.M.”, *Annual Review of Neuroscience*, 34, pp. 259–288.

———. and Wixted, J. (2016). “Remembering”, In *Memory in the Twenty-First Century: New Critical Perspectices from the Arts, Humanities, and Sciences,* (Hampshire, England: Palgrave MacMillan) pp. 251–262.

Squire, L. and Zola-Morgan, S. (1988). “Memory: brain systems and behavior”, *Trends in Neurosciences.*

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

Stanley, J. (2011). *Know How* Oxford U.P.

———. and Williamson, T. (2001). “Knowing How”, *Journal of Philosophy*, 98:8, pp. 411–444.

———. and Williamson, T. forthcoming. “Skill”, *Noûs*, pp. 1–14.

———. (2011b). “Intellectualism and the language of thought: a reply to Roth and Cummins.” In Newen, A., Bartels, A., & Jung, E-M (eds.) *Knowledge and Representation*. CSLI Publications.

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.
Taatgen, N. A. (2013). “The nature and transfer of cognitive skills.” *Psychological review* 120.3 (2013): 439.
Tulving, E. Schacter, D., & Stark H. (1982). “Priming Effects in Word-Fragment Completion Are Independent of Recognition Memory”, *Journal of Experimental Psychology: Learning, Memory, and Cognition.* 8(4) pp. 336–342.

Verwey, W. B., Abrahamse, E. L., Ruitenberg, M. F., Jiménez, L., & de Kleine, E. (2011). Motor skill learning in the middle-aged: limited development of motor chunks and explicit sequence knowledge. *Psychological research*, *75*(5), 406–422.
———. (2010). Diminished motor skill development in elderly: indications for limited motor chunk use. *Acta Psychologica,* 134, 206–214.
———. (2001). Concatenating familiar movement sequences: the versatile cognitive processor. *Acta Psychologica*, 106:69–95.
———. (1996). Buffer loading and chunking in sequential keypressing. *Journal of Experimental Psychology Human Perception and Performance,* 22,544–562.
Warrington, E. & Weizkrantz L. (1970). “Amnesic Syndrome: Consolidation or Retrieval?”, *Nature*, 14, pp. 628–630.

Wallis, C. (2008). “Consciousness, context, and know-how.” *Synthese* 160.1: 123–153.

Winograd, T. (1975). “Frame representations and the declarative/procedural controversy” in Bobrow, Daniel and Collins, Allan Eds. *Representation and Understanding: Studies in Cognitive Science*, New York, N.Y.: Acamedic Press Inc., 185–210.

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

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

——— & Flanagan, J. R. (2001). Motor prediction. *Current Biology*, 11(18), R729-R732.

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

——— & Diedrichsen, J., & Flanagan, J. R. (2011). Principles of sensorimotor learning. *Nature Reviews Neuroscience*, *12*(12), 739-751.

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

——— & Miall, R. C., & Kawato, M. (1998). Internal models in the cerebellum. *Trends in cognitive sciences*, 2(9), 338-347.