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To feel is to know relations: James' concept of stream of thought and contemporary studies on procedural knowledge

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ABSTRACT

The theory of William James concerning the temporal and dynamic nature of mind is analyzed as implying that thought is a flow of subjective experience that belongs to the material flow of living beings, and therefore, that knowledge is *primarily* affective and practical rather than declarative and contemplative. In this context, we will discuss contemporary theory and research relevant to the discussion about declarative and procedural knowledge, with the focus on a literature review in the neurosciences of knowledge. Then we reconstruct James' theory of mind as flow, in terms of relatedness, feeling, and temporality of experience. The *Principles* suggest that declarative knowledge is not independent, but derived and supported by a more basic knowledge that is both procedural and affective in nature. Finally, we discuss possible lesson for nowadays efforts to develop a dynamic account of the procedural nature of knowledge.

On those who enter the same rivers, ever different waters flow

-Heraclitus, Fragment B12

1. Knowledge, mind, and cognition

What is knowledge? This question has been approached in different ways, depending on the discipline and the interest at hand. Cognitive science deals with this query, traditionally, from the point of view of the information processing in a system regarding its relation to its world. In this tradition, it is often assumed that there are two distinct kinds of knowledge, whose information-processing underpinnings are different: declarative and procedural knowledge. To 'know that something' is assumed to be essentially different from 'knowing how to do something.'

This declarative/procedural distinction can be traced back to Ryle's differentiation between propositional knowledge, which can be true or false, and the kind of knowledge needed to ride a bicycle (Ryle, 1945). This basic distinction is correlated with a set of other conceptual dichotomies, such as cognitive content/structure (Piaget, 1971), associative/rule-based memory systems (Wilson & Rolls, 2005), explicit/implicit cognition (Bowles, 2011; Ellis, 2005; Evans, 2008; Reber, 1989; Rebuschat & Williams, 2012), fast/slow learning (McClelland, 2013). Overall in current psychological theory, it is assumed that, on the one hand, the notion of declarative knowledge refers to a representation of an object, and this semantic link is the content of (declarative) knowledge, which may be employed consciously by controlled information processing and put in language. On the other hand, the idea of procedural knowledge refers to cognitive dispositions (or skills) that have been formed as a consequence of training, constrain behavioral sequences in a particular domain of action, and are relatively automatic, not conscious, and hardly put in language. Consistently, some authors have posited that there are different memory systems, one supporting each of the kinds of knowledge, and each based on a different modality of learning.

This set of conceptual dichotomies also reminds the classical distinction, made by William James (James, 1890) from Chapter VIII, between two forms of knowledge, tapping common-sense language uses of 'knowing about something' and 'knowing something by acquaintance.' We can have information *about* something we have never met, but we are *familiar-with* something only when our knowledge of it is based on a continuous and proximal existence in the flow of experience. However, according to James, these are relative terms, as he does not postulate them as an essential

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distinction between types of knowledge but a distinction between two aspects that we can recognize in various degrees in all pieces of knowledge, among the varieties of forms of relating-to. Following this line, one could claim that the declarative/procedural dichotomy is an inconvenient approach to understanding the varieties of knowledge, and thus, that radical distinctions such as rule-based/associative, or explicit/implicit cognition, are inadequate. We will reconstruct James' theory of knowledge as stating that declarative knowledge is not independent, but derived and supported by a more basic knowledge that is both procedural and affective in nature.

The relationship between declarative knowledge, whose units are evaluated as either true or false, and procedural knowledge, whose forms are ethically, economically, politically and aesthetically evaluated, is an open problem. In contemporary cognitive and neuro sciences, many will accord that cognition and mind are linked to the flow of experience, but only few would draw the radical implications for a psychological theory. We will discuss first contemporary theory and research relevant to the discussion about declarative and procedural knowledge, with the focus on a literature review in the neurosciences of knowledge. Then we analyze James' theory of mind as flow in search for lessons for further efforts to develop a dynamic account of cognition.

2. Contemporary dynamic theories and neuroscience of knowledge

In current cognitive sciences there are many approaches consistent with a dynamic view of knowledge. The following list of some examples will suffice to show that there are good reasons to conceive knowledge as linked to time, emergence and action. Among the most appealing, some connectionist and situated cognition models invite us to conceptualize declarative (semantic) knowledge as a dynamic process linked to the global activity of organisms and their environments. Another example is recurrent neural networks with contextual layers, showing how knowledge is history-dependent and based on the distributed coordination of sensorimotor exchanges and social interactions (Elman, 2005, 2009). According to this view, semantic activity, eventually expressed as declarative knowledge, is thus not *based on* propositional structures. Other connectionist models of morphogenesis have also stressed the emergent, non-propositional properties of semantic knowledge (Petitot, 1995, 2003). Other perspectives on cognition that were alternative to the information-processing paradigm, have promoted a process-view of 'higher', semantic, or declarative cognition. For instance, the concept of situated cognition implies that knowledge is structured in the social, ecological, and physical environment shaping experience (Brighton, Kirby, & Smith, 2003; Clark, 1997; Cole & Engeström, 1993; Kirsh, 2009; Lynn & Stein, 1991; Suchman, 2007; B. G.; Wilson & Madsen-Myers, 1999). The notion of embodied cognition means that mental properties are rooted in bodily embeddedness in particular contexts (M. L. Anderson, 2003/9; Clark, 1997; Coates, 2002; Dourish, 2001; Haugeland, 1995; Prem, 1996; Thelen & Esther, 2000; Varela, Thompson, & Rosch, 1991; R. A. Wilson, 1994; among others). Semantic activity is made up by organism-environment coordination processes, rather than by abstract representational structures. Two important specific contributions in these lines have been cognitive linguistics (Johnson & Lakoff, 2002; Lakoff & Johnson, 1999) and enaction theory (Klin, Jones, Schultz, & Volkmar, 2003; Petitot, 2003; Thompson & Varela, 2001; Varela et al., 1991). Despite theoretical differences among these perspectives on cognition, all express a wide consensus about the challenge of developing dynamic-oriented accounts of knowledge. Overall, contemporary dynamic approaches to cognition are consistent with the understanding of knowledge in terms of a self-organizing process (Beer, 2000; Kelso, 1995; Port & Van Gelder, 1995; Tschacher & Dauwalder, 2003). In addition, most agree that higher cognition emerges from low-level, sensorimotor activity of the organism in relation to the environment, with a critical role played by temporal dynamics. However, among and within perspectives such as embodied cognition, situated learning and recurrent networks modeling, there are relevant differences regarding the nature of knowledge, the scale of descriptions, and the very notion of dynamics and the role of time in experience.

Among the dynamic conceptions of knowledge, one would expect that a key place must have the research on procedural knowledge but attention to it in contemporary cognitive sciences is paradoxically insufficient. On the one hand although all the dynamic approaches abovementioned strongly suggest a dynamic view of knowledge, most of them offer perspectives not specifically contributing to research on procedural knowledge. On the other hand, the neuroscience of (declarative vs. procedural) knowledge addresses procedural knowledge specifically, withing a program searching for an explanation of the multiple forms of memory and knowledge with empirical grounding, but the concepts and characterization of these types of knowledge are inconsistent accross studies and, overall, not clear enough regarding their nature as knowledge, their differences, and their relationships - as we will argue. What is, then, the notion of knowledge used in empirical research on procedural/declarative knowledge? What is the relationship between these forms of knowledge? How are they linked to the flow of experience?

We reviewed literature covering empirically grounded basic research on the concept of procedural knowledge since 1980. The most spread and largely developed research program was on the internal distinction of different systems of memory that supports different types of knowledge, with their corresponding biological substrates that evidence "how the brain actually stores information" (Squire & Dede, 2015, p. 1). Distinctions such as procedural/declarative, implicit/explicit, conscious/unconscious, and others, are used equivalently for investigation on memory systems. We identified the most referenced literature to track the core distinction from where the contemporary research and concepts were developed and sustained. Then we followed the development of that distinction on basic research up until the 2010s.

3. The neuroscience of procedural knowledge

We searched indexed papers performing basic empirical research on procedural knowledge since 1980 up until early 2015 in several databases (EBSCO, JSTOR, PubMed, among others). After reading more than 400 potentially relevant abstracts, we selected 126 papers. We considered articles researching on knowledge, memory or learning characterized as 'procedural', 'implicit', 'unconscious' or 'know how'. Based on the reading of introduction, discussion and conclusion of these articles, we selected those that were presented as advancements, and not merely replications or applications, in the understanding of procedural knowledge, or synthesis/wrap-ups of empirically grounded research programs. From the 21 articles that met those conditions, we traced back the references that were common in the conceptualization of the phenomena, not only as historical precedents used as vague inspiration of certain ideas, as was the case of the works of Bergson or James, for example, but as the actual basis for research design. These were the works on the identification of the neurophysiological substrates that supports the different declarative and non-declarative memory systems.

The first works on the neurophysiological evidences of this distinction are from Milner (1962; Scoville & Milner, 1957) and

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