Journal of Applied Research in Memory and Cognition 4 (2015) 191–196

Contents lists available at ScienceDirect

Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

Original Article

Interpreting psychological notions: A dual-process computational theory

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ARTICLE INFO

Article history:
Received 15 October 2013
Accepted 23 September 2014
Available online 2 October 2014

Keywords:
Dual process
CLARION
Cognitive architecture
Cognitive modeling
Implicit
Explicit
Instinct
Intuition

ABSTRACT

The distinction between implicit versus explicit processes (or "intuitive" versus "reflective" thinking) is arguably one of the most important distinctions in cognitive science. Given that there has been a great deal of research on explicit processes ("reflective" thinking), it is important in studying the human mind to consider implicit processes, treating them as an integral part of human thinking. A cognitive architecture (a comprehensive computational theory) may be used to address, in a mechanistic and process-based sense, issues related to the two types of processes (including their relation, interaction, and competition) and their relevance to social and organizational research.

1. Introduction

The distinction between "intuitive" and "reflective" thinking has been, arguably, one of the most important distinctions in cognitive science. There are currently many dual-process theories (two-system views) out there. However, although the distinction itself is important, the terms involved have been somewhat ambiguous. Not much fine-grained analysis has been done, especially not in a precise, mechanistic, process-based way (Kruglanski & Gigerenzer, 2011; Sun, 1994, 2002). In this article, toward developing a more fine-grained and more comprehensive framework, I will adopt the more generic but less loaded terms of *implicit* and *explicit* processes (Reber, 1989; Sun, 2002) and present a more nuanced view of these processes, centered on a computational "cognitive architecture".

Given that there has been a great deal of research on explicit processes ("reflective thinking") and the apparent significance of implicit processes (Sloman, 1996; Sun, 1994), it is important, in studying the human mind, to more seriously consider implicit processes. I have argued that we need to treat implicit processes as an integral part of human thinking, reasoning, and decision-making, not as an add-on or an auxiliary (Sun, 1994, 2002). This point applies not only to studying the individual mind, but also to studying collective processes involving multiple individuals (and the interaction of their minds) such as in organizational research (Sun & Naveh, 2004).

In this short summary article, a brief review of the background concerning implicit and explicit processes will be given. Then a theoretical framework (based on a computational cognitive architecture) will be presented that addresses, in a mechanistic, process-based sense, issues concerning dual-process theories. Specifically, issues concerning different types of implicit processes, their relations to explicit processes, and their relative speeds may be addressed within the framework. The notions of instinct, intuition, and creativity are important in this regard and will be briefly discussed also. This framework will then be applied to social and organizational modeling where its relevance will also be demonstrated. Connections will also be made to the notion of rationality in economic and organizational research.

2. Some background

To better explore the distinction between implicit and explicit processes, let us examine some background first. There are many dual-process theories (two-system views) currently available (e.g., as reviewed by Evans & Frankish, 2009). One such two-system view was proposed early on in Sun (1994, 1995). In Sun (1994), the two systems were characterized as follows:

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http://dx.doi.org/10.1016/j.jarmac.2014.09.001

> *"It is assumed in this work that cognitive processes are carried out in two distinct 'levels' with qualitatively different mechanisms. Each level encodes a fairly complete set of knowledge for its processing, and the coverage of the two sets of knowledge encoded by the two levels overlaps substantially."* (Sun, 1994, p. 44)

That is, the two "levels" (i.e., the two modules or components) encode somewhat similar or overlapping content. But they encode their contents in different ways: symbolic and subsymbolic representation is used, respectively. Symbolic representation is used by explicit processes at one "level", and subsymbolic representation is used by implicit processes at the other. Different mechanisms are involved at these two "levels" due to the representational differences. It was hypothesized that these two different "levels" can potentially work together synergistically, complementing and supplementing each other (Sun, Slusarz, & Terry, 2005; Sun, 1994). This may in part explain evolutionarily why there are these two levels.

However, some more recent two-system views are somewhat different, and their claims seem more contentious. For instance, a more recent two-system view was proposed by Kahneman (2003, 2011). The gist of his ideas was as follows: There are two styles of processing: intuition and reasoning. Intuition (or System 1) is based on associative reasoning, fast and automatic, involving strong emotional bonds, based on formed habits, and difficult to change or manipulate. Reasoning (or System 2) is slower, more volatile, and subject to conscious judgments and attitudes.

Evans (2003) espoused a similar view. According to him, System 1 is "rapid, parallel and automatic in nature: only their final product is posted in consciousness"; he also notes its "domain-specific nature of the learning". System 2 is "slow and sequential in nature and makes use of the central working memory system", and "permits abstract hypothetical thinking that cannot be achieved by System 1". Moreover, in terms of the relation between the two systems, he argued for a default-interventionist view: System 1 is the default system, while System 2 may intervene when feasible and called for (see Evans, 2003, for more details).

However, some of these claims seem, in a way, simplistic to me. For one thing, intuition (System 1, and implicit processes in general) can be very slow, not necessarily faster than explicit processes (System 2) (see Bowers, Regehr, Balthazard, & Parker, 1990; Helie & Sun, 2010). For another, intuition (and implicit processes in general) may sometimes be subject to conscious control and manipulation; that is, it may not be entirely "automatic" (Berry, 1991; Curran & Keele, 1993; Stadler, 1995). Furthermore, decisions made implicitly can be subject to conscious "judgment" (Gathercole, 2003; Libet, 1985). In terms of the relationship between the two systems, implicit and explicit processes may be parallel and mutually interactive in complex ways instead of being limited to being default-interventionist (Sloman, 1996; Sun, 1994, 2002) and so on.

It thus seems necessary that we come up with more nuanced and more detailed characterizations of the two systems (the two types of processes) in order to avoid painting the picture in too broad strokes. To come up with a more nuanced, more detailed, and more justifiable characterization, it is important that we ask some key questions. For either type of process, in any given situation, the following questions, for instance, may be asked:

- How deep is its processing (in terms of precision, certainty, and so on)?
- How much information is involved (how broad is its processing)?
- How incomplete, inconsistent, or uncertain is the information available?
- How many processing "cycles" are needed considering the factors above?

And there are many other similar or related questions. See also Evans and Stanovich (2013) and Kruglanski and Gigerenzer (2011). Asking such questions may lead to better characterizations of the two systems and useful interpretations of related notions. But in order to do so, one has to rely on some basic theoretical frameworks to begin with.

3. A theoretical framework

In order to sort out these issues and answer these questions in a manageable way, below, I will describe a theoretical framework that can potentially provide some clarity to these issues and questions. The framework is based on the CLARION cognitive architecture (Sun, 2002, 2003, 2014), viewed at a theoretical level, used as a conceptual tool for generating interpretations and explanations (Sun, 2009).

The framework consists of a number of basic principles. The first principle is the distinction and division between procedural (i.e., action-oriented) and declarative (i.e., non-action-oriented) processes, which is rather uncontroversial (see, e.g., Anderson & Lebiere, 1998; Tulving, 1985). The next two principles concern implicit and explicit processes, but not just one simple division as in many other dual-process theories. Thus the next two principles are unique to this theoretical framework, and may require some justifications, which have been argued in, for example, Sun (2012) and Sun (2014). The second principle is the distinction and division between implicit and explicit procedural processes (e.g., Sun et al., 2005). The third principle is the distinction and division between implicit and explicit declarative processes (e.g., Helie & Sun, 2010). Therefore, in this framework, there is a four-way division: implicit and explicit procedural processes and implicit and explicit declarative processes. These different processes may run in parallel and interact with each other in complex ways (e.g., as described in Sun, 2014).

The divisions above between implicit and explicit processes may be related to some existing computational paradigms, for example, symbolic–localist versus connectionist distributed representation (Sun, 1994, 1995). As has been extensively argued before (e.g., Sun, 1994, 2002), the consciously (relatively) inaccessible nature of implicit knowledge may be captured by distributed connectionist representation, because distributed representational units are subsymbolic and generally not individually meaningful. This characteristic of distributed representation, which renders the representational form less accessible computationally, accords well with the relative inaccessibility of implicit knowledge in a phenomenological sense. In contrast, explicit knowledge may be captured by symbolic–localist representation, in which each unit is more easily interpretable and has a clearer conceptual meaning.

4. A sketch of a cognitive architecture

Now with the basic principles outlined, I will sketch an overall picture of the CLARION computational cognitive architecture itself, which is centered on these principles. Only a quick sketch is possible here (without getting into too much technical details though); for details, the reader is referred to the references cited below.

CLARION is a generic cognitive architecture – that is, a comprehensive, generic model of psychological processes of a wide variety, specified computationally. It has been described in detail and justified on the basis of psychological data (Sun, 2002, 2003, 2014).

CLARION consists of a number of subsystems. Its subsystems include the Action-Centered Subsystem (the ACS), the Non-Action-Centered Subsystem (the NACS), the Motivational Subsystem (the