A tale of paradigm clash: Simon, situated cognition and the interpretation of bounded rationality

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Abstract

The intellectual figure of Herbert A. Simon is well known for having introduced the influential notion of *bounded rationality* in economics. Less known, at least from the economists' point of view, is the figure of Simon as eminent cognitive psychologist, co-founder of so-called *cognitivism*, a mainstream approach in cognitive psychology until the 80s of the last century. In fact, the two faces of Simon's intellectual figure, as rationality scholar and as cognitive scientist, are not factorizable at all: according to Simon himself, cognitivism is bounded rationality and bounded rationality is cognitivism. This paper tries to answer a simple research question: has the notion of bounded rationality fully followed the development of cognitive psychology beyond cognitivism in the post-Simonian era? If not, why? To answer such questions, this paper focuses on a very specific historical episode. In 1993, on the pages of the journal *Cognitive Science*, Simon (with his colleague Alonso Vera) openly confronted the proponents of a new (paradigmatic) view of cognition called *situated cognition*, a firm challenger of cognitivism, which was going to inspire cognitive psychology from then on. This paper claims that this tough confrontation, typical of a paradigm shift, might have prevented rationality studies in economics from coming fully in touch with the new paradigm in cognitive psychology. A reconstruction of the differences between cognitivism and situated cognition as they emerged in the confrontation is seen here as fundamental in order to assess and explore this hypothesis.

JEL codes: B31; B41; D03; D80

Keywords: Herbert A. Simon, bounded rationality; situated cognition theory; economics and cognitive psychology.

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1. Introduction

In the era of interdisciplinary science, paradigm changes in one discipline are assumed to have significant systemic impacts on other disciplines. This should be *a fortiori* true for fields of inquiry that are programmatically at the intersection between two disciplines, as is the case with economic psychology[2]. When a paradigm change in either economics or psychology occurs, the change is expected to have a foundational impact on the other discipline. This essay starts by considering that research in cognitive psychology[3] has undergone a true paradigm shift in the last 25 years, conveyed through the labels of *situated*, *distributed* and *embodied* cognition. It then inquires whether and in which way this paradigm shift has influenced the field of economic psychology. The result of this inquiry – which is worth anticipating – will be that no significant and programmatic influence has yet taken place. In particular, this essay focuses on the field of rationality studies, which has traditionally been most conducive to cross-disciplinary fertilization, yet, as we shall see, the current situation is still characterized by the 'missing' influence of the paradigm shift as far as the notion of *economic rationality* is concerned.

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[2] The term 'economic psychology' is used here for it expresses better than others the idea of the (at least virtual) interconnections between economics and psychology. Of course, what economic psychology is and what its many historical and theoretical instantiations are is the very crucial point that also this paper tries to address.

[3] According to the American Psychological Association (APA), cognitive psychology concerns "the study of higher mental processes such as attention, language use, memory, perception, problem solving, and thinking" (see the Glossary of Psychological Terms at http://www.apa.org/research/action/glossary.aspx).

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The choice of rationality as the privileged field in which to assess the implications of a paradigm change in cognitive psychology is mainly related to the intellectual contribution of Herbert A. Simon. Simon is particularly important in this story, since the path-breaking notion of *bounded rationality* is an outcome of Simon's 'twofold' intellectual activity as both an economist and a cognitive scientist[4]. Although this has already been historiographically acknowledged (e.g. Sent 1997, 2004; Fiori, 2005, 2011), economic psychologists, economists and rationality scholars tend to overlook the role of Simon as a leading cognitive scientist, and pioneer and founding father of that specific approach to cognitive science labeled *cognitivism* [5]. This omission has important consequences, even for those who today claim to have superseded Simon's approach to bounded rationality: not being fully aware of bounded rationality's cognitivist foundations – and, in addition, not being fully aware of possible alternative foundations, as these have presented in history – leads these foundations to be retained even when one would not wish to do so.

The approach of this paper is mainly historical. It singles out a highly significant historical episode, when Simon, as spokesman of the cognitivist paradigm in cognitive psychology, (jointly with his Carnegie Mellon colleague Alonso Vera) openly confronted the leading proponents of the newly born critical approach of *situated cognition* (also called *situated action* theory, hereafter SA). It was 1993 when the journal *Cognitive Science* hosted Vera and Simon's target article, with the objective of facilitating communication between the two sides of a confrontation that argued respectively for and against a paradigm shift in cognitive psychology. Looking carefully at that confrontation, *one becomes aware of the fact that what was at stake was not only the future of cognitive psychology, but also that of rationality studies*, this being in

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[4] In what follows, the expressions cognitive psychologist and cognitive scientist will be used interchangeably, even if of course not all cognitive scientists are cognitive psychologists.
[5] For an account of Simon's cognitivism as a product of historical embeddedness see Sent (2001) and, obviously, Simon (1991).

particular due to the always-underlying twofold role of Simon as both cognitive psychologist and rationality scholar. Reconstructing that debate from the rationality studies point of view will be helpful in at least four ways. First, supported by Simon's explicit stance, we shall be able to establish the foundational link that exists between cognitive psychology and the notion(s) of rationality. Second, awareness of this link is important to the extent that it implies that a paradigm change in cognitive psychology *should* have some impact on the notion(s) of rationality. Through a reconstruction of the points of difference between Simon and the proponents of SA we shall be able to identify the issues at stake in the confrontation, and thus to better figure out which direction a revision of the notion of bounded rationality should possibly take. Third, we shall be able to identify this historical episode as a crucial fork in the subsequent development of rationality studies. In fact, the thesis of this essay is that the episode represented a watershed that has blocked the claims of situated and embodied cognition to be internalized in rationality studies until now. Last but not least, this paper aims to do justice to the intellectual figure of Simon. Some scholars have blamed Simon for his opposition to SA, using expressions such as 'Simon's paradox' (Patokorpi, 2008) or 'Simon's error' (Secchi, 2010). Although those judgments could be partially right in substance, we think that it is not fair to blame Simon for not having readily accepted a new point of view on cognition that in 1993 was an emergent but highly fragmented thread in cognitive psychology. As we will see, a paradigm change was at stake, and paradigm changes by definition involve incommensurability issues (Kuhn, 1962) that are beyond one's control. Nevertheless, as we will notice, some of Simon's claims have today re-gained momentum even in the new paradigm.

The essay will be structured as follows. Section 2 provides a cursory review of the different interpretations of the notion of bounded rationality. Since the story we are going to tell concerns a specific controversy over the interpretation of bounded rationality, this review will

provide us with the necessary background. Section 3 is devoted to theoretically and historically introducing the new paradigm in cognitive psychology known under the label of SA. In particular, this section emphasizes how SA was the first step towards a more radical paradigm shift in cognitive psychology that was then known under the label 'distributed' cognition, and today finally is known as 'embodied' cognition (in fact we will speak of a SDE paradigm shift). Section 4 reconstructs the 1993 *Cognitive Science* debate in depth, emphasizing the theoretical points of distance between Simon and the SA proponents. Particular emphasis will be put on the paradigm shift symptoms of the debate, i.e. the fact that the two sides of the controversy were using the same words but with very different meanings. Section 5 comes back to rationality, reviewing the post-Simonian theories of bounded rationality and assessing them in the light of their 'missing' SDE cognition hints.

2. Bounded rationality: variations on a theme

As Klaes and Sent (2005) have definitively shown, the conceptual history of the notion of 'bounded rationality' is a history of pluralism. As often happens in intellectual history, a conceptual nucleus, roughly encompassing some basics of the notion of bounded rationality, has floated over rationality studies, from the pre-Simonian to the post-Simonian era, but it has never reached a completely stable meaning. The role of this section is to provide some criteria with which to review the historical variations on the theme of 'bounded rationality'.

As a matter of fact, one of the major reasons why the notion of bounded rationality has generated ambiguities is due to Simon himself, who was not always consistent in his use of the notion. We can, in fact, identify two versions of bounded rationality given by Simon himself: a wider ($Simon_1$) version and a narrower ($Simon_2$) version. The first version, $Simon_1$, can also be

called the "scissors" version. It was explicitly introduced in 1972, jointly with Allen Newell, in their famous book *Human Problem Solving*, although it had already been implicitly expressed at least since Simon (1956). It reads,

"[j]ust as a scissors cannot cut paper without two blades, a theory of thinking and problem solving cannot predict behavior unless it encompasses both an analysis of the structure of task environments and an analysis of the limits of rational adaptation to task requirements" (Newell and Simon, 1972, p. 55).

The scissors hypothesis is a complementarity hypothesis: on the one hand there is the structure of an environment, on the other hand the subject whose cognition has adapted to this environment. In the course of his career, in particular when Simon interacted with professional economists, he supported an amended version of this view, which we can call $Simon_2$. $Simon_2$ consists in the simple hypothesis that individuals are limited information processors, i.e. that they are limited in knowledge and computational capacity (see e.g. Simon, 1987b; Simon et al, 1992, p. 1). In this sense, $Simon_2$ may be read as a narrow version of $Simon_1$, focusing only on one blade of the scissors (i.e. the cognition of individuals, and thus neglecting the structure of the environment). However, this last version is what has percolated into economics (see, e.g., Sent, 1998). Commenting on this state of affairs from a broad epistemological point of view, Callebaut (2007) calls Simon's a "silent revolution", in the sense that the real revolutionary nucleus of $Simon_1$ – i.e. the complementarity between cognitive abilities and tasks – has been mostly 'silenced' into an amended version of the rational choice framework ($Simon_2$) (see e.g. Rubinstein, 1998 and Simon's related complaints as expressed in Chapter 11 therein).

The dichotomy $Simon_1$–$Simon_2$ still characterizes current research in rationality studies in economics. Simon's heritage can in fact be reconstructed following either the heirs who have

followed Simon$_1$ or those following Simon$_2$. On the one hand, Kahneman and Tversky's *heuristics and biases* approach (e.g. Kahneman, Slovic and Tversky, 1982) – the Simonians$_2$ – considers heuristics and cognitive limitations on the same footing as systematic 'imperfections' in human cognition, leading to those imperfections being equated with the outcome of 'irrationality' of people's judgment[6]. On the other hand, Gigerenzer's *ecological rationality* research program (see, e.g., Gigerenzer et al., 1999) – the Simonians$_1$ – emphasizes the 'complementarist' and also 'evolutive' view of cognition and environment. Heuristics, which in Kahneman's framework are the sources of errors and irrationality, are, from Gigerenzer's point of view, the outcome of adaptation between cognition and environment. If heuristics are often a source of errors – as they undoubtedly are – this is only because those heuristics are used in contexts that are not their original evolutionary ones (e.g. Gigerenzer and Selten, 2002). If, on the contrary, they are used in their original evolutionary contexts, they succeed better than 'rational choice' procedures: this is the rationale behind the *homo heuristicus* point of view (Gigerenzer and Brighton, 2009)[7].

The notion of bounded rationality can be factorized into more minute conceptual components, each one subject to variation, which would then constitute the ingredients of different historical specifications of bounded rationality. Katsikopoulos (2014), for instance, tries to accomplish such a conceptual decomposition, identifying the crucial variables of bounded rationality into i) the reliance on either normative axioms or empirical facts in modeling; ii) the assumption of either optimization or satisficing as bounded rationality's objective; iii) the

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[6] The consistency of Kahneman and Tversky's thought with Simon's framework has sometimes been put into question, simply because Simon himself did not look at himself as a true Simon$_2$ theorist. Nonetheless, as Kahneman and Tversky themselves clearly remark, their results "are consistent with the conception of bounded rationality originally presented by Herbert Simon" (Tversky and Kahneman, 1986, pp. S272-S273).

[7] Fiori (2011) also takes into consideration also the reconceptualizations of the notion of bounded rationality as developed by James March (1978) and Nelson and Winter (1982). Davis (2010) identifies another strand of Simon's tradition in Litchtenstein and Slovic's (2006) program of endogenizing preferences. We will not consider these further variations in this essay extensively. However, some important remarks are presented in note 18.

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practice of fixing parameters or letting them vary freely; iv) the reliance (or not) on psychological theories. This last point is particularly important, since allow us to reconstruct bounded rationality along its disciplinary belonging. The general characterization of bounded rationality as a research domain in 'economic psychology' is not in fact able to exhaust the actual bounded rationality's disciplinary instantiations. Ross (2014), for instance – following a tradition in economics that can be called the 'anti-psychological' tradition (see Giocoli, 2003, Chapter 2) – disputes that psychology constitutes the ultimate foundations of the notion of bounded rationality. In this vein, he distinguishes between a 'psychological' notion and an 'economic' notion of bounded rationality: while the former is an attempt to give an account of the features of human judgment in general, the latter is allowed to consider a more restricted version of 'bounded' human judgment, given the presence in the economic domain of institutional factors that restrict and constrain 'general' human judgment[8].

The issue of the irreducibility of 'economic' to 'psychological' bounded rationality points to another direction in which the notion of bounded rationality can be plural, i.e. its relationship with cognitive science in general, and cognitive psychology in particular. This issue can be said to take the question of whether psychology has to be the ultimate foundation of bounded rationality to an higher level: if psychology does not provide the foundations of bounded rationality, this could also be true for cognitive psychology[9]. Simon's point of view on this issue was clear: he claimed forcefully that bounded rationality should be constitutively rooted in psychology and cognitive psychology[10] (see, e.g., Simon, 1959; Simon, 1976a; Simon, 1978). It

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[8] Such disciplinary distinctions may also be at the basis of the different experimental practice implemented in economics and psychology in order to study 'bounded rationality' (Hertwing and Ortmann, 2001).

[9] This does not hold, of course, for cognitive science. As we have already remarked, cognitive psychology is a branch of cognitive science. The latter can also be interested in 'not-strictly-psychological' factors, such as neurobiological aspects of cognition.

[10] As far as we know, Simon never really distinguished cognitive science from cognitive psychology.

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is the main starting point of this essay that Simon's version of bounded rationality is indissolubly linked with his 'cognitivist' psychology stance. From a general point of view, identifying a connection between cognitive psychology and bounded rationality would open the space for a (at least virtual) possibility that the plurality of views of bounded rationality can parallel the plurality of views on cognitive psychology. The following sections will be devoted to identifying both the virtual space of such plural connections and the actual processes that brought bounded rationality to be linked to just one specific thread of cognitive psychology, not by chance the one that had Simon among its founding fathers.

3. The situated, distributed and embodied (SDE) turn in cognitive psychology: 1985-

This section is devoted to shedding light on the paradigm shift that has occurred since the mid-1980s in cognitive psychology in the form of the so-called *situated*, *distributed* and *embodied* cognition (SDE) turn. In particular, the section will emphasize that Simon was one of the founding fathers of 'cognitivism', the perspective in cognitive psychology and artificial intelligence (AI) that the SDE shift has put decisively and maybe irreparably into question.

The 'cognitivist' paradigm in cognitive psychology is a product of the 1950s, born as a paradigm shift, in its turn, with respect to 'behaviourist' cognitive psychology (see Gardner, 1985). One of the conceptual pillars of cognitivism was erected by Simon himself and Allen Newell (Newell and Simon, 1976) in the notion of the *physical symbol system hypothesis* (PSSH). PSSH consists in the idea that human intelligence (i.e. judgment, reasoning, etc.) is or can be traced back (reduced) to symbolic information processing. This hypothesis was to become foundational for both cognitive psychology and AI research, to the point that these two

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disciplinary fields, thanks to the PSSH, arrived at coinciding in what was to be known as the view of 'the human mind as a computer'. There should not be any ontological difference between the human mind and an artificially constructed mind, to the extent that the former could be replicated just by replicating a suitable 'software program' that mimics the internal states of a subject. The convergence of AI and cognitive psychology is directly founded on the idea that AI can shed decisive light on human cognition itself (Winston, 1984).

This is because the validity of the PSSH was first challenged in the field of AI: if PSSH was, as Newell and Simon claimed, "the necessary and sufficient condition for intelligence" (Newell and Simon, 1976, p. 116), robots showing undisputable signs of intelligence should be built *uniquely* by relying on this assumption. It is at this crucial point that the cognitivist assumptions and the PSSH began to creak. The first step of departure from the cognitivist assumptions is identifiable in the 1980s 'connectionist' models of AI, which against symbolic and sequential computing opposed parallel and adaptive computing (e.g. neural networks, cellular automata, etc.). A further step of departure came in the late 1980s, when Rodney Brooks at the *MIT Computer Science and Artificial Intelligence Laboratory* built robot prototypes that showed signs of intelligence without relying on any fundamental ingredients of the cognitivist framework (e.g. centralized system information processing, centralized representation of the external environment). The basic functioning of Brooks' robots was a 'distributed' and 'reactive-behavioral' conception of intelligence, an expression of a new point of view called the *physical grounding hypothesis* (Brooks, 1991). In fact, the behavior of Brooks' robots emerged from a continuous interaction of a minimalist programming with the resources of the environment[11].

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[11] 'Herbert' was the name of one of Brooks' robots (note the ironic reference to Simon's first name) (see Brooks, 1990). Its task was to collect soda cans in a laboratory environment, and it accomplished this task in an apparently intelligent way. Nonetheless, its principle of functioning was not representationist or symbolic: Herbert did not rely

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This was a direct challenge to the PSSH's claim to provide the necessary and sufficient conditions for intelligence. Brooks showed that the cognitivist assumptions were excessive requirements for his robots.

The attack on cognitivism and the PSSH was, however, not confined to AI, but it had its counterparts in the field of human psychology and the study of human behavior as well. A crucial notion which the early debate focused around was, for instance, the notion of a *plan of action*. What was a plan of action and which were the cognitive requirements for successful action? According to the cognitivist assumptions, a plan of action consisted in a set of pre-specified rules of behavior implemented on a detailed description (representation) of the environment in which action takes place. The ethnographer of technology Lucy Suchman (1987), from the *Xeros Palo Alto Research Center*, contrasted this account of a plan of action with an 'interactionist' picture. Her favorite counterexample was the way users approach new technological objects: how, she asks, does a subject learn to use a new technology? Does the subject implement a plan based on the instruction kit or approach the machine just by interacting with it? Trying to answer such questions, a vast anthropological inquiry took place in different and disparate environments, in order to establish that interactionism is the real way in which cognition works (Winograd and Flores, 1986; Lave, 1988, Hutchins, 1995).

Another notion that underwent a reconceptualization was the notion of *action* itself. In the cognitivist framework, action was conceived as a pragmatic activity to be performed after reasoning, oriented to accomplishing whatever goal. The SA and distributed framework found a non-pragmatic foundation for action under the notion of 'epistemic action': action is not only 'pragmatic' but it is also 'epistemic', in the sense of being able to elicit information from the

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on any map of the laboratory and nor did it chart courses for picking up the cans. It was simply provided with a sensor to detect can-like shapes, along with a locomotion system relying on impact-preventing sensors.

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environment that would be otherwise unattainable (Kirsh and Maglio, 1994). Thus, also the cognitive psychologists of the American Pragmatism tradition were contributing to defeat cognitivism (Johnson and Rohrer, 2007).

In this cognitive psychology revolution, some put more emphasis on the 'situated' aspects of the critique of cognitivism (e.g. Clancey, 1997) and others on the 'distributed' aspects (e.g. Clark, 1997). Nonetheless, all these sets of arguments, although coming from different perspectives and emphasizing different aspects, led in the same direction of making cognitivism collapse. In 1985 cognitivism had already been labeled, at least in the field of artificial intelligence, 'Good-Old Fashioned Artificial Intelligence' (GOFAI) (see, e.g., Haugeland, 1985). However, the 'situated' and 'distributed' aspects of SDE did not exhaust the scope and extent of the revolution. They historically constituted a sort of preparatory ground for the advent of the so-called *embodied* revolution of the 2000s (Wilson, 2002). The core position of *embodied cognition* is that cognition cannot be detached from a physical substratum that is evolutionarily connected with it. One of the main claims of this position is that high-level cognitive activities (reasoning, judgment, etc.) share the same neural patterns as low-level cognitive activities (looking, walking, breathing, etc.) being both based on the human sensory-motor system (Gomila and Calvo, 2008), and this sharing status of mutual influence cannot be recreated without a bodily dimension.

4. Reconstructing the debate

This essay identifies a precise historical event as crucial in the relationship between bounded rationality and cognitive psychology. In 1993, in the middle of a rising wave of works that proposed or embraced a new view of cognition, the journal *Cognitive Science* hosted a debate in a special issue entitled 'Situated Action' between two spokesmen for cognitivism,

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Simon and Alonso Vera, and a group of leading scholars of the emerging SA[12], the cognitive scientists James Greeno and Joyce Moore, Lucy Suchman, Philip Agre and William Clancey (see Norman, 1993). In what follows, we outline a reconstruction of that debate in order to identify the points of controversy between the two positions, and in order to comparatively assess in Section 4 whether post-Simonian rationality studies have really tackled them or not.

4.1. *Vera and Simon's defense: the 'equivalence' thesis of cognitivism*

The attitude and scope of Vera and Simon's contribution was never perceptibly conflictive or hostile, neither blindly defensive. Instead, it rather devoted itself to diminishing and subtly disarm the claims of SA theorists who were asking for a sharp dismissal of the cognitivist paradigm. Vera and Simon's thesis was that, in principle, the PSSH was able to overcome all the difficulties singled out by SA, by reabsorbing them. To achieve this objective, they first of all divided the field of their opponents into a 'hard form' SA and a 'soft form' SA. According to Vera and Simon's reconstruction, the former were those who claimed that "[cognitive psychologists] must focus on how people [behave] instead of how people think or what computers can do. They [SA, however] do not explain to proponents of the symbolic approaches why the former is antithetical to the latter" (Vera and Simon, 1993, p. 11); the latter, instead, simply claimed that cognitivism should "incorporate the SA principles of representing objects functionally and interacting with the environment in a direct and unmediated way" (ibid.).

The crucial and controversial point was whether and to what extent the notion of 'situation' and the new conceptual framework of 'situatedness' could be properly characterized

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[12] In fact, the debate featured proponents of both the distributed and the situated turns, but their arguments are most of the time too similar for a clear-cut line of demarcation to be drawn. In this section, when we speak of "SA" we mean both the 'situated' and 'distributed' cognition points of view.

and tackled by a symbolic approach. As the SA theorists claimed, referring to the authority of the philosopher Hans-Georg Gadamer,

"[t]o acquire an awareness of a situation is, however, always a task of particular difficulty. The very idea of a situation means that we are not standing outside it and hence are unable to have any objective knowledge of it. We are always within the situation and to throw light on it is a task that is never entirely completed. (ibid., p. 12, as quoted in Winograd & Flores, 1986, p. 29)

This idiosyncraticist definition of situation can be translated, according to Vera and Simon, into an operationalist one. The notion of situation could be rendered, in full accordance with SA (Winograd and Flores, 1986), by claiming that situations (which in the language of decision-making theorists are also called 'ill-structured environments') are characterized by 'breakdowns', i.e. phases in the interaction between a subject and the environment in which the course of action is broken by the subject's inability to characterize the salient traits of the environment. By accepting this operational definition of situation, Vera and Simon claim that the characterization is compatible with a representationalist, centralized and symbolic processing approach; it just needs some 'interactionist' addendum, such as 'belief revision' processing, etc. This would not put, however, into question the cognitivist assumptions.

Another part of Vera and Simon's argument concerns the broader role of symbolic representations in cognition. According to them, 'objective' representations of the environment are always a necessary condition of intelligence. Even 'minimalist' symbolic representations are a necessary condition for an entity to show some intelligent behavior (ibid., p. 20). As they claim, even Brooks' minimalist robots incorporate some form of symbolic representation, in the bits constituting their software programs. To take another example, Vera and Simon also argue that

human learning is an eminent symbolic process (a point that SA theorists will contend, see Section 4.6 below), since storing and retrieving memory are essential ingredients of it.

At a more formal level, the issue of the comparability between cognitivism and SA is tackled by comparing the formal strategies of resolution of the game Tower of Hanoi, often used as a testbed in experimental inquiries into cognition and rationality. Vera and Simon compare a 'goal-recursive strategy' – the one commonly employed by PSSH devices – with a 'perceptual strategy' in which the resolution of the task is accomplished without relying on either internal representations or elaborate goal planning. As Vera and Simon show (ibid., pp. 30-31), there is a *formal equivalence* in the ways the two strategies perform the task. Following this line of argument, they claim that in the end a 'generalized perceptual framework' can be devised which employs a minimalist symbolic system[13].

According to Vera and Simon, this controversy in cognitive science is not only linked with, but actually directly collapses into, the framework of bounded rationality. As Vera and Simon openly claim:

"we think a defensible claim, to replace the invalid one of hard SA, is that behavior can only be understood in the context of environments that change continually, and whose complexity is so great that only extremely simplified approximations of them can be handled by the systems's response mechanisms or its planning mechanisms, severally or jointly. *Bounded rationality is the name of the game, and it is as surely present in a game of chess as in any of the games that humans play in what they call "the real world".*" (ibid, p. 45, emphasis added)

Bounded rationality, from this point of view, is the principle of intelligence of robots attempting to imitate human intelligence. In the cognitivist framework, it means that it is the

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[13] Cognitivism had always put decisive emphasis on the objective of unifying and generalizing the other theories of cognition. It never conceived itself as a theory of cognition among others. This was, in a sense, its distinctive trademark (see, e.g., Newell, 1990).

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principle of intelligence of humans as well. The outcome of Vera and Simon's feeble negotiation results thus in the concession of providing artificial agents with minimalist rules of behavior (and so, consequentially, to conceive of humans as holding just minimalist rules of behavior, i.e. heuristics), that should nonetheless rely on the PSSH[14].

In what follows, we will take into consideration the responses provided by the SA theorists. We will see that the common aim informing their responses was to make clear that a paradigm shift was at stake. It was not just a problem of designing effective robots, but one of understanding the way human cognition works in a different manner, and thus of identifying the best research framework to give an account of it.

4.2. Suchman: plans and 'situational' complexity

Lucy Suchman's reply concerns a series of issues related to her research on *plans of actions* (see Suchman, 1987). In particular, she focuses – as is often the case in the exchanges in this special issue – on conceptual clarifications. According to Suchman, Vera and Simon's notion of plan simply results in cognitivism + SA addenda, i.e. pre-specified courses of action (plans) that rely on SA (interactionist) addenda when 'breakdowns' occur. This notion of 'enriched' planning, however, depends on the conceptual separateness between plans and SA, something that Suchman totally rejects: a plan *is* 'situated action' and cannot be conceptually separated from it (p. 75). Moreover, Suchman provides a significant restatement of Vera and Simon's definition of 'hard form' SA. Where Vera and Simon stated that "the central claim of hard SA [is] that behavior can only be understood in the context of complex real-world situations" (Vera and Simon, 1993, p. 45), she claims that the definition should be more properly rephrased as:

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[14] The link between bounded rationality and cognitivism has been asserted repeatedly by Simon. One becomes aware of this even by skimming cursorily over his collected papers (Simon, 1981; Simon, 1983; Simon 1979-1989; Simon, Egidi, Marris, and Viale, 1992).

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"*behavior can only be understood in its relations with real-world situations*" (Suchman, 1993, p. 74, emphasis in the original). Suchman employs two changes in this definition: i) the expression 'in the context of' is replaced with 'in its relations with', emphasizing that contexts are not pre-specifiable, but emerge from interactions; ii) the word 'complex' is also dropped, since "the complexity or simplicity of situations is a distinction that inheres not in situations but in our characterization of them; that is, all situations are complex under some views, simple under others" (ibid. p. 75).

4.3 Greeno and Moore: symbols and the necessary and sufficient conditions of intelligence

The reply by the cognitive scientists Greeno and Moore focuses on the role of symbols and of symbolic representations in cognition. They clearly identify the main point of difference with respect to Vera and Simon's position:

"[t]he question […] seems to be something like this: whether 1) to treat cognition that involves symbols as a special case of cognitive activity, with the assumption that situativity is fundamental in all cognitive activity, or 2) to treat situated activity as a special case of cognitive activity, with the assumption that symbolic processing is fundamental in all cognitive activity. We advocate the first option; Vera and Simon advocate the second" (Greeno and Moore, 1993, p. 50)

Cognitivism denies the existence of behavior that is not mediated by some form of symbolic process, while on the other hand SA denies the omnipresence of symbolic representation. In particular, Greeno and Moore emphasize the importance of *non-symbolic processing* in cognition. According to their definition, there is non-symbolic processing when signs that are used and implemented in a software program are not semanticized and referential to the external world: in other words, not all signs or code strings are symbols (p. 54). An example

of non-symbolic processing in human cognition is the Gibsonian notion of 'affordances' (Gibson, 1977), where objects in the external world induce actions without a need for a semantic processing of these objects (e.g. the handles on a cup provide an affordance for holding). In the end, the pattern of arguments that rejects the omnipresence of symbolic manipulation leads Greeno and Moore to claim that, contrary to Newell and Simon's PSSH, "the question should not be whether a system that uses symbolic processes is sufficient, but whether the symbolic processes that are hypothesized are necessary" (p. 56).

4.4. Agre: the boundaries of cognition

The reply by Philip Agre also tackles the socio-theoretical aspects of the controversy cognitivism Vs SA, by addressing the 'symbolic approach' as a scientific 'worldview', with its own heuristics and metaphors in dealing with cognition. According to Agre, what

"actually characterizes the cognitivist worldview is not the notion of a symbol but rather a certain system of metaphors. These metaphors begin by marking out a firm distinction in kind between the mental Inside and the world Outside. The "encoding" and "decoding" processes mediate between these on a causal level, and relations of "designation" hold between them on a semantic level. Knowledge on this view generally winds up looking like a copy of the world inside the head, a "world model." What's really striking throughout this literature is the tendency to confuse this world model with the reality it is supposed to represent." (Agre, 1993, p. 66)

It is the necessity of setting the debate in terms of the Inside/Outside metaphor that makes communication between SA and cognitivism difficult, since it is this very distinction that SA rejects. As Agre claims, "[m]y point is that the metaphor system of Inside and Outside finds itself unable to make any stable sense of concepts that reside neither in the agent nor in the world, but in the relationship and interaction between the two" (ibid., p. 67). The strictures imposed by the

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Inside/Outside distinction misrepresent the SA worldview, leading SA to be called 'behaviorist' just because it does not accept 'internalist representationalism' (ibid., p. 64).

4.5 Clancey: the neurobiological underpinning of SA

William Clancey addresses the target article at length, proposing arguments against Vera and Simon's cognitivism from a neurobiological viewpoint. Clancey's diagnosis of the shortcomings of cognitivism relies on the acknowledgment that "the symbolic approach conflates 'first-person' representations in our environment (e.g., utterances and drawings) with 'third-person' representations (e.g., mappings a neurobiologist finds between sensory surfaces and neural structures" (Clancey, 1993, pp. 87-88). This conflation, according to Clancey, is wrong, since it relies on the unwarranted "basic assumption [...] that perception and reasoning are possible without acting" (ibid, p. 94). However,

"*the neural structures and processes that coordinate perception and action are created during activity* [...] That is, the physical components of the brain, at the level of neuronal groups of hundreds and thousands of neurons, are always new – not predetermined and causally interacting in the sense of most machines we know – but coming into being during the activity itself, through a process of reactivation, competitive selection, and composition" (ibid.).

This perspective leads to a shift from the notion of *context* to that one of *situation* in cognitive psychology (Rohlfing, Rehm and Goecke, 2003). As Clancey puts it, his claim "is not merely a claim that context is important, but what constitutes the context, how you categorize the world, *arises together* with processes that are coordinating physical activity" (ibid. p. 95)[15]. The contribution by Clancey is also important since it provides us with a table in which all the most

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[15] Clancey establishes a connection between SA and American Pragmatist (Dewey in particular). The importance of Dewey's characterization of the notion of context for behavioral economics is emphasized by Khalil (2003).

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important topics and issues debated between cognitivism and SA are juxtaposed for comparison. It is worthwhile to reproduce it below as a synthesis of the debate.

[Table 1 here]

4.6 Situated learning

The 1993 issue of *Cognitive Science* on 'Situated Activity' was not the only occasion in which Simon confronted with his SA counterparts. In 1996, together with his colleagues John Anderson and Lynne Reder, he wrote another article devoted to tackling and challenging SA (Anderson, Reder and Simon, 1996). The article focuses on a more specific theme, "the classical and well-known problem of transfer of learning" (Vera and Simon, 1993, p. 23), i.e. the problem of establishing whether learning is about apprehending abstract structures that can be transferred from one domain to another (e.g. from classrooms to the real-world situation) or whether it is always a situated activity, as SA argued. This contribution sparked another exchange with SA, this time with James Greeno alone, to which another reply followed (Greeno, 1997; Anderson, Reder and Simon, 1997). It not necessary to review the arguments and counter-arguments, which broadly replicate the 1993 debate in a more focused domain. What is important to notice is, however, that Simon never reconciled with SA in the last years of his scientific activity, the distance between them remaining 'incommensurable'.

5. The aftermath: cognitivism and rationality in the post-Simonian era

After reviewing this debate, the question arises of what has it to do with rationality studies. The answer is that it has much to do, and in many respects. First, the main thesis of this

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essay is that the debate marked a watershed in the connection between rationality studies and cognitive psychology. To put the thesis in a nutshell, it was Simon, the father of bounded rationality who committedly and persuasively claimed that the privileged way in which bounded rationality should be conceived is in a cognitivist, technically non-situated and disembodied manner. This can be read as *the authentic interpretation* of bounded rationality. While the cognitivist content and framework of bounded rationality expressed in *Human Problem Solving* is patently clear, so that one might claim there is 'nothing new under the sun', the episode of the debate reviewed here is historically meaningful because the future of cognitive was knocking there at the door, but a fruitful dialogue could not be established.

An important claim of this essay is also that current rationality research expresses marked cognitivist residua. Looked with hindsight, such residua can be interpreted as a yet undisputed Simonian footprint on bounded rationality; whereas Simon's imprinting is lost in some other directions the cognitivist one could be substantially there. Cognitivist residua can be detected, first, in both the *heuristic and biases approach* and in the *ecological rationality* approach. While Simon's heritage has been contended by these conflicting views on the scissors argument (see Section 2 above), there seems to have been a substantial acceptance of the cognitivist core. Patokorpi (2008, p. 287) identifies the main source of Kahneman and Tversky's implicit residua of cognitivism in the idea that there is a benchmark course of action against which actual behavior can be compared. Furthermore, human biases, given Kaheneman and Tversky's adherence to $Simon_2$, are just in the human mind, like bugs in a computer program[16], without

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[16] Heukelom (2014, p. 99) points out that Tversky stemmed from a 'mathematical psychology' tradition according to which the description of well-functioning human cognition was provided by Savage's axioms. Modifying these axioms in the direction of making them consistent with systematic experimental violations, as the behavioral economics program tries to do (see below), can be read, metaphorically, as putting bugs into an otherwise reliable computer program (this is metaphorically true even if Savage's tradition did not put particular emphasis on the phenomenon of 'computations', see Kao and Velupillai, 2015).

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reference to the environment as object of interaction. In the end, programmatically neglecting the cognition/environment coupling, the *heuristics and biases* approach can be conceived as a non-situated and disembodied approach by definition. *Ecological rationality*'s acceptance of cognitivism is, however, more explicit and programmatic. In fact, the proponents of this view claim that a heuristic

"specifies the precise steps of information gathering and processing that are involved in generating a decision, such that the heuristic can be *instantiated as a computer program*. For a fast and frugal heuristic, this means the computational model must specify principles for guiding a search for alternatives, information, or both, stopping that search, and making a decision". (Gigerenzer et al., 1999, p. 16).

Ecological rationality puts in the same effort that Simon put into the debate with SA, trying not to depict cognitivism as a 'syntacticist' approach and claiming that computational processes of thought should not be content-blind (on the content-explicitness requirement of heuristics see, e.g., Gigerenzer et al., 1999, p. 29), but it continues to embody all the basic cognitivist ingredients, i.e. the simulation of human cognition as a symbolic and serial processing computer program. As ecological rationality scholars put it explicitly, "[we follow] Simon and Newell's emphasis on creating precise computational models" (Gigerenzer et al, 1999, p. 26)[17]. It would be unfair and misleading, however, to claim that these two contemporary programs of research on rationality are detached from current research in cognitive psychology in general. In fact, while ecological rationality is founded on the well-known and fertile program to explain behavior in evolutionary terms (see Barkow, Cosmides and Tooby, 1992), the heuristics and biases program has lately, i.e. after 2002 (see Kahneman, 2003, 2011), rooted its foundations in

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[17] The 'cognitivist' version of Simon₁ was stated by Simon, claiming that "human rational behavior (*and the rational behavior of all physical symbol systems*) is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (1990, p. 7, emphasis added).

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the dual-system hypothesis of cognition (see Evans, 2008). Nonetheless, our claim here is that what rationality studies have borrowed from these research areas in cognitive psychology has been selected in order to be congruent with some basic ingredients of cognitivism[18].

If we shift our attention to the way in which bounded rationality has been conceived and implemented in economics, we must seriously take into consideration the story narrated by Sent (1997), concerning a different approach to AI as the foundation for the notion of bounded rationality, which is expressed by the economist Thomas Sargent in that crucial year 1993 (Sargent, 1993). Against Simon's cognitivism (i.e. representationism and serial computing) Sargent opposes a 'connectionist' approach, based on adaptive and parallel computing. This approach shares a common intellectual ground with the neurobiological approach of Clancey (see above). Nonetheless, as is common knowledge today in the SDE cognition *milieu*, 'connectionism' is considered, with respect to the most relevant conceptual variables, simply a variant of cognitivism, i.e. a different kind of computer metaphor of the mind (see Calvo and Gomila, p. 4). While the connectionist approach to bounded rationality has, however, not resulted in any form of mainstream in economics, things are different if we look at the so-called New behavioral economics (Sent, 2004). The 'New' attribute to the notion of behavioral economics is

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[18] Fiori (2011) claims that the current dual-system theory foundations of the *heuristics and biases* program demonstrate a break with cognitivist foundations. This is, as we have tried to make clear, true but only half true. As Simon himself claimed (1990), dual-system theories of cognition and cognitivism were two complementary approach to the unitary 'information processing' view of human cognition. The more, dual-system theories of cognition, according to Simon, could have been reconciled with cognitivist assumptions (see, e.g., Vera and Simon, 1993, p. 18; Simon, 1986). Earl (2012) makes clear that Simon himself was particularly interested in humans' intuitive cognition (i.e. Kahneman's 'System 1'), thus emphasizing the Simonian roots of even Kahneman's latest thought. In any case, neither of them has really ever managed, or even wanted, to set the question out of the 'information processing' framework. This can still be seen in the hybrid 'dual-code' theories of cognition.

Regarding March's and Nelson & Winter's departures from bounded rationality (Fiori, 2011), they surely tackle two important 'non-cognitivist' topics, i.e. ill-structured problems and tacit knowledge, but they fail to establish a constitutive link with cognitive psychology. It is, however, true that organization studies have been more prone to overcoming Simon's cognitivism than other fields. It is also remarkable that Simon had already tackled and refuted the issue of tacit knowledge claiming that 'there is a kind of knowledge that cannot be explicitly expressed' as being paradoxical (Simon, 1976b).

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said to mark a distance of Kahneman and Tversky-inspired behavioral economics – i.e. Thaler-, Laibson-, Mullainathan-, Loewenstein-, and Camerer-like behavioral economics – from Simon's influence (see also Heukelom, 2014). What this essay wants to point out is that, irrespective of the many ways in which 'New' behavioral economics differ from Simon's ('Old') behavioral economics, the former has left unquestioned the issue of cognitivism of the latter. As Sent herself remarks,

"[i]nspired by empirical and experimental counterevidence to the strong rationality assumptions employed in mainstream economics and *by the rise of the metaphor of the brain as an information-processing device in cognitive psychology*, they [New behavioral economists] formalize and test psychological predictions" (Sent, 2004, pp. 747-748, emphasis added).

'New' behavioral economists do so by maintaining the computer metaphor of the mind, and implementing it in the form of mathematical models of bounded rationality that progressively internalize more and more psychological evidence of human' departures from perfect rationality[19]. The connection between behavioral economics and cognitivism is for instance explicitly asserted by Angner and Loewenstein:

"[t]hat representations are critical to cognitive science is evident […and] behavioral economists agree. […L]ike cognitive scientists, behavioral economists believe that it is appropriate to talk about entities such as beliefs, emotions and heuristics, which clearly are to be found at the level of representation. Much of what they study can be

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[19] A contemporary program in behavioral economics that can be considered 'hard' cognitivist research, for instance, is the so-called *Computable Behavioral Economics* program, which emphasizes the computability requirements of behavioral economics models (Kao and Velupillai, 2015). Kao and Velupillai distinguish, in a slightly different way with respect to Sent (2004), an 'Old' from a 'Modern' behavioral economics: the former, properly Simonian, puts emphasis on the computational dimension of bounded rationality, while the latter is founded on subjective probability theory à la De Finetti-Savage.

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understood *in terms of representational structures in the mind and computational procedures on those structures*" (Angner and Loewenstein, 2012, p. 659, emphasis added).

Further, there is a strand of experimental microeconomics that claims 'behaviorist' (i.e. partially or not at all cognitive psychology-based) foundations (see Lewin, 1996). This thread of inquiry is mostly related to the work of Vernon L. Smith (e.g. 2007), finding its own identity demarcation through the label 'experimental economics' (see Heukelom, 2011). Nonetheless, even regarding this behaviorist, non-psychologist, Robbins-Samuelson (Ross, 2005) approach to microeconomics a couple of remarks concerning some residuals of cognitivism have to be claimed. Loewenstein (1999), for instance, criticizes experimental economics for it does not pay attention to 'contexts' in experiments, while should instead provide some. As we have seen, if even a 'contextualized' experimental setting is considered by SA theorists as expression of the 'third-person dogma' (i.e. the dogma according to which contexts are perceived by experimental subjects exactly in line with experimenters' intentions), programmatically contextless settings are thus the peak of non-situatedness[20].

6. Concluding remarks: a lost thread to pick up again?

As Bruni and Sugden (2007) perceptively remark, the history of the relationship between economics and psychology is a history of 'forks', that is, of choices that, once accomplished, bind a discipline until the next fork. This is also true for the relationship between economics and cognitive psychology. The thesis of this essay is that rationality studies in economics were in

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[20] It is worth noting that Patokorpi (2008) identifies some, although heterogeneous, pieces of decision-making research that begin to internalize 'situated', 'distributed' and 'embodied' aspects. A deeply 'situated' research program in decision-making is, for instance, the 'naturalistic decision-making' research program, i.e. the study of real-world decisions (Klein, 2008). See also those works that begin to take the specific 'embodied cognition' point of view as a foundational perspective for rationality studies in economics (Spellman and Schnall, 2009; Oullier and Basso, 2010; Mastrogiorgio and Petracca, 2015).

1993 at a crucial fork for their own future: why bounded rationality at that stage did not depart with its 'cognitivistist' interpretation? As we have seen, a contrast in which people could not really understand each other, typical of paradigm clashes, prevented rationality studies from developing along a route congruent with the actual trajectory of cognitive psychology.

A few words, however, should be spent on any 'historical judgment' of Simon's position. To put the question bluntly: was Simon really an 'obscurantist' in his rejection of situatedness as the foundation of a new paradigm in cognitive science and rationality studies? This seems to be the historical judgment conveyed through expressions such as 'Simon's paradox' (Patokorpi, 2008) or, worse, 'Simon's error' (Secchi, 2010). This harsh judgment cannot, however, be shared. This is for two fundamental reasons. First, in 1993 SA, as part of the greater SDE paradigm, was just a new thread of research that, although in great expansion, was not, as we have seen, an established nor even coherent corpus of research. Under these conditions, it would have been difficult even to state which version of SA should take over the cognitivist version of bounded rationality. In this respect, adhering to the most radical version of SA could also have meant viewing situations as idiosyncratic events that cannot be systematically studied. Such a stance has a post-modernist flavor that characterized the intellectual *milieu* of the early 1990s, and that is likely to have exerted an influence on the most radical version of SA. Simon's opposition to this interpretation of SA is, with hindsight, understandable. This issue connects with another important consideration according to which Simon's point of view cannot simply be described as an 'error'. Simon's interest in the human cognitive faculty of 'abstraction' (in the current cognitive psychology jargon, the human faculty to go 'off-line'), which was substantially underplayed by the original SA theorists, has today regained centrality in the current 'embodied' point of view on cognition. In fact, according to the influential embodied cognitive psychologist Margaret Wilson,

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"a productive science of embodied cognition, if it takes seriously the claim that much or all of human cognition has its roots in embodiment, must consider *how embodied cognition can go "off-line" - decouple from situation-bound reactivity and use body-based resources for other purposes*" (Wilson, 2008, p. 380, emphasis added).

It remains to be seen whether bounded rationality research should be updated today in the light of the new advances in cognitive psychology. Our answer to this question is straightforward: if the foundations of economic rationality are in cognitive psychology, as Simon firmly believed, this update should be accomplished. In this regard, as we have remarked, the updating should point toward the embodied cognition approach, which has properly softened what may have been idiosyncratic in the original formulations of SA. Picking up the embodied thread in rationality studies again today means, however, "distinguish[ing] the conception of reason as embodied and embedded from the important but *still insufficiently radical* notion of 'bounded rationality'", as the cognitive psychologist Andy Clark claims (Clark 1997, p. 243, n.4 , emphasis added). The reconciliation between bounded rationality and the SDE cognition paradigm is something that remains to be accomplished in current economic psychology and rationality research.

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Table 1

	Symbolic Approach	Situated Cognition
Theoretical Differences Between Symbolic Approach and Situated Cognition		
memory	stored rules or schema structures in a representation language	neural nets reactivated and recomposed in-line via selection; not a place or body of descriptions of how the world or agent's behavior appears
representation	meaningful forms internally manipulated subconsciouly	created and interpreted in our activity (first person); external representations ≠ representing to self ≠ neural structures
internal processes	modularly independent; can perceive and reason without acting	codetermined, dialectic; always adapted (generalized from past coordinations), inherently chronological
immediate behavior	selected from prepared possibilities ("preexisting actions")	adapted, composed, coordinated, always new; always a sensorimotor circuit
reasoning	supplants immediate behavior: goes on subconsciously	occurs in sequences of behavior over time
speaking	meaning of the utterance is represented before speaking occurs	speaking and conceiving occur dialectically; representing meaning occurs as later commentary behavior
learning	secondary effect (chunking)	primary learning is always occurring with every thought, perception, and action; chunking occurs as categorization of sequences; secondary (reflective) learning occurs in sequences of behavior over time; requires perception.
knowledge representation	corresponds to physical structures stored in human's brain	a model of some system in the world and operators for manipulating the model; abstracts agent's behavior, explaining interaction in some environment over time.
concepts	labeled structures, corresponding to linguistic terms, with associated description of properties and relations to other concepts, i.e., meanings are symbolically represented and stored	prelinguistic categorizations of perceptual categorizations; ways of coordinating perception and action; has no inherent formal structure; cannot be inventoried; meaning and perception are inseparable.
analogy	feature mapping of concept representations	process of perceiving and acting by recomposing previous coordinations (e.g., "seeing as").

From Clancey, 1993, p. 111

Working paper