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2 **44 Iconicity in Peircean situated cognitive** 3 4 **Semiotics**

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6 A psychologist cuts out a lobe of my brain . . . and then, when I find I cannot express myself,
7 he says, ‘You see your faculty of language was localized in that lobe.’ No doubt it was; and
8 so, if he had filched my inkstand, I should not have been able to continue my discussion
9 until I had got another. Yea, the very thoughts would not come to me. So my faculty of
10 discussion is equally localized in my inkstand. It is localization in a sense in which a thing
11 may be in two places at once. (CP 7.366, 1902).

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13 Although only recently a more systematic discussion upon the distributed nature
14 of the mental processes have been established in empirical fields, the philo-
15 sophical basis of this thesis and its variations have well-known precursors.
16 Among them, the most quoted are William James, Wittgenstein, Dewey, James
17 Gibson, Vigotsky, Merleau-Ponty, Heidegger (see Gallagher 2009, Kirsh 2009,
18 Wheeler 2005). However, Charles Sanders Peirce, the least mentioned among
19 the pragmatists in this context, can be considered an *avant-garde* situated and
20 embodied cognition proposer. In fact, Peirce should be considered an important
21 precursor of situated mind and distributed cognition thesis. But differently from
22 the anti-cartesianism defended by some embodied-situated cognitive science, which
23 is predominantly anti-representationalist, as recently explored in a Merleau-
24 Pontyan (Dreyfus 2002), Heidegerian (Wheeler 2005), or a Gibsonian (Chemero
25 2009) trend, for Peirce, mind is semiosis in a dialogical – hence communica-
26 tional – materially embodied form, and cognition is the development of available
27 semiotic artifacts in which it is embodied as a power to produce interpretants. It
28 takes the form of development of semiotic artifacts, such as writing tools, instru-
29 ments of observation, notational systems, languages, and so forth, as stressed
30 by Skagestad (2004) and Ransdell (2003) with respect to the concept of intelli-
31 gence augmentation. For Kirsh (2009: 297), “Peirce first mentioned this idea –
32 that people use external objects to think with – in the late nineteenth century,
33 when he said that chemist think as much with their test tubes as with pen and
34 paper”.

35 The core of Peirce’s arguments combines two theses: the mind is a kind of
36 semiosis; sign processes are extended within the spatiotemporal dimension, so

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1 that something physical has to instantiate or realize them. According to the first
2 one, the mind is the nature of the sign-action (CP 5.313–14). The second thesis
3 asserts that signs cannot act unless they are spatiotemporally realized. Thus, if
4 a sign is to have any active mode of being, it must be materially embodied (or, at
5 least, it results from a previous operation with material signs). A direct conse-
6 quence of this combination leads us directly to the ideas on distributed cogni-
7 tion. The basic idea of distribution cognition thesis is that humans can alter
8 the space for better organization of thought, by building artifacts that scaffold
9 cognitive processes and increase and/or modify problem-solving activities, by
10 simplifying choice, perception or internal computation and leading to the reduc-
11 tion of environment complexity (see Clark 1998 & Kirsh 1995). Cognitive artifacts
12 are tools that work as prostheses capable of extending human capacities, creat-
13 ing new abilities and changing the way we structure and solve problems. More
14 radically, it can be said that such mind-tools not only help thinking but rather
15 that the mental activity itself is embedded in them. Mental activity takes place
16 outside the head in a space designed and built to think (Sterelny 2003).

17 Peirce's insights on the relevance of external semiotic processes in different
18 forms of reasoning are interwoven in his cognitive semiotics. Semiosis exhibits a
19 rich variety of morphological patterns. The morphological space of semiotic pro-
20 cesses in which cognitive systems are embedded include proto-symbols (quasi-
21 symbolic structures) and variations of indexical signs, besides symbolic and
22 iconic processes (images, diagrams, metaphors). The icon is an important com-
23 ponent in his semiotic view of mind, because it embeds a kind of signification
24 especially dependent on the material of which the sign is made. We know little,
25 however, about 'how' semiotic resources, their typological variations and their
26 specific properties, are capable of changing or influencing cognitive performance,
27 or as certain physical properties *constrain* different forms of inferences, e.g.,
28 abductive inference. According to Paavola (2011), in abduction the iconic char-
29 acter of reasoning is more prominent, which renders plausible that in this kind
30 of inference external aspects are specially relevant. Magnani (2005), with focus
31 in this particular property, has developed the concept of "manipulative abduc-
32 tion" to refer to those cases where the inference depends on the exploration of
33 external resources – it "happens when we are thinking *through* doing and not
34 only, in a pragmatic sense, about doing" (Magnani 2005: 274). It is described as
35 concrete manipulative reasoning, an extra-theoretical behavior that implies the
36 application of strategies related to extra-rational (emotional, esthetical, ethical,
37 economic) components. (Magnani 2005: 274).

38 Peirce's fundamental typology of signs exhibits a property capable of func-
39 tioning as a conceptual criterion to distinguish different kinds of signs: the rela-

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1 tive dependence of sign-object-interpretant (S-O-I) components in triadic relation
2 (S-O-I) (see Queiroz 2012). A symbol is an S-O relationship logically dependent of
3 I (CP 2.307). In a different way, an index is dependent of O. Constraints resulting
4 from the space-time existence of the object represented by the index are irrelevant
5 in symbolic processes. Icons, in turn, are deeply dependent on the material,
6 form and structure that they are made of – “An Icon is a sign which refers to
7 the Object that it denotes merely by virtue of characters of its own, and which
8 it possesses, just the same, whether any such Object actually exists or not”
9 (CP 2.247). According to this basic criterion, the icon is the only type of sign
10 which is S-dependent (that means, dependent on the sign material and struc-
11 tural organization itself) and is able to reveal, through its manipulation, some
12 information about the object. This operational property of iconicity is considered
13 a detrialization of the notion that the icon is fundamentally based on a relation
14 of similarity (see Stjernfelt 2011), with important implications here. According
15 to Hookway (2002: 102), “The key of iconicity is not perceived resemblance
16 between the sign and what it signifies but rather the possibility of making new
17 discoveries about the object of a sign through observing features of the sign
18 itself”. If the notion of iconicity attests the capacity of material features to be the
19 semiotic basis of important cognitive operations, and not only play a secondary
20 role, then it is a strong candidate to clarify situatedness and distributedness of
21 reasoning as a matter of manipulation of external resources.

22 Zhang & Norman are two of the scientists whose investigations have been
23 helping in the comprehension of external representational processes and problem-
24 solving tasks. As we try to demonstrate with the example of Zhang & Norman’s
25 (1994) experiments with the Tower of Hanoi game, the icon is a main character
26 involved in the process of externalization of constraints. The way the artifacts
27 operate, in problem solving, creates a space of action which is dependent on
28 the material (and structural organization) of which the manipulated sign is
29 made. Zhang & Norman have used the tower of Hanoi game to study the influence
30 of external representations in cognition. More specifically, they were dealing
31 with the Representational Effect: difference in cognitive behavior caused solely
32 by external representational features. The Representational Effect is investigated
33 through the comparison of performance upon isomorphic representations in
34 problem solving tasks. We claim that the authors’ experiment investigating the
35 level of isomorphism of rule representations (Zhang & Norman 1994: 20–23)
36 function as an example of externalized problem-solving based on iconicity.

37 There were three rules in the game for this experiment (see table 1) and two
38 ways in which these rules could be introduced in play: internally (given as a list
39 of instruction read before the experiment and memorized by the players) or
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1 externally (automatically embedded in the material of play). Three isomorphs of
 2 the game were designed (see figure 1), which represented either internally
 3 or externally each of the rules. The experiment measured the time required for
 4 solution, the number of steps required for solution and the number of wrong
 5 moves for each of the three isomorphs. In the three cases, the results for the
 6 most internalized version were the worst: more time to solve, more number of
 7 steps required to solve and more wrong moves. For the most externalized version,
 8 the results were the best: less time to solve, less number of steps required and
 9 almost no wrong moves (see figure 2). This experiment, together with others in
 10 the same article, have led the authors to propose that more externalized repre-
 11 sentations are also more efficient representations for problem solving (see also
 12 Zhang 1997; Chuah, Zhang & Johnson 2000).

Table 1: The three rules of the Tower of Hanoi experiment. The rules could be introduced either externally (E) or internally (I), generating the isomorphs I123, I12-E3, I1-E23.

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1. Only one piece can be transferred at a time
 2. A piece can only be transferred to a place on which it will be the largest
 3. Only the largest piece in a place can be transferred to another place
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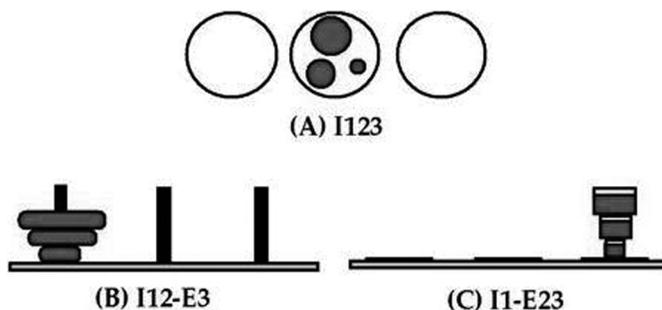


Figure 1: The three isomorphs used in Zhang & Norman's experiment. (A) uses balls of different sizes moved between plates, so that all rules are presented internally; (B) uses disks of different diameters stacked one on top of the other between poles, so that rule 3 is presented externally; (C) uses cups of different sizes filled with liquid stacked one on top of the other plates, so that rules 2 and 3 are presented externally.

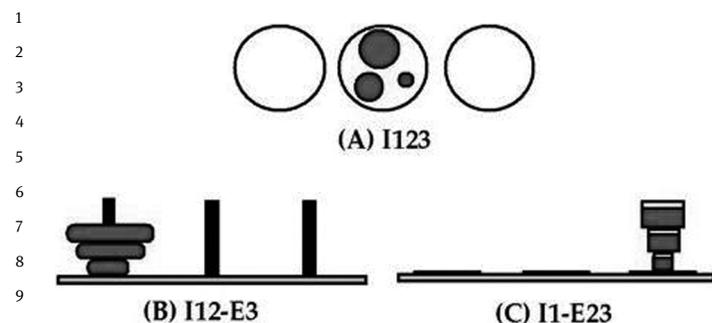


Figure 2: The time required to solve, the number of steps required to solve and the number of wrong moves made in which of the isomorphs. The more internalized version (I23) proved itself to be the most difficult version to play, and the more externalized (I1 E23) the easier.

The criterion the authors have used to classify between internal and external rules matches a criterion for iconicity, namely, dependence of material properties, or S-dependence. The different isomorphs of the experiment can be modeled as semiotic processes of communication of a form or habit from an object to an interpretant through the mediation of the sign.³ The object (O) of this triadic relation is the formal structure of the game that is common to all isomorphs. The sign (S) is the medium through which the game is played, i.e., the specific pieces and places and also the list of written instructions. The interpretant (I) is the constraining in behavior that characterizes the act of play itself. With this framework in mind, and taking into consideration the criterion of relative dependence of terms for the fundamental classification of signs, we conclude that, for the (i) internal and (ii) external cases:

- (i) O (formal structure of the game) is independent of S (material of play). If you change the materials used to play, the game remains the same. The S-O relation cannot be established by these two terms alone, it requires the mediation of a third term (I). The constraining upon the specific material of play, that makes it correspond to the formal structure of the game, only happen as a cognitive constraining in the behavior of the player, in the act of play itself. As S-O relation is dependent of I, this is an example of symbolic semiosis.
- (ii) The game is S-dependent. If you change the materials used to play, the formal structure of the game changes. The S-O relation is already established inde-

³ A sign can be defined as a medium for the communication to the interpretant of a form (habit) embodied in the object, so as to constrain, in general, the interpreter's behavior (EPII: 544, n.22; see Queiroz & El-Hani 2006).

1 pendently of the third term (I), because the constraints of S are a materializa-
 2 tion of the formal structure of the game. The constraining upon the specific
 3 material of play, which makes it correspond to the formal structure of the
 4 game, is already given in the material of play before the game is played. As
 5 S-O is dependent of S, this is an example of iconic semiosis.

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 7 To say that a representation is external in respect to some constraints already
 8 implies that these constraints are S-dependent, and that we are dealing with
 9 iconic semiosis. Accordingly, the claim for the efficiency of externalization of
 10 constraints in problem solving is viewed here as a claim for the distribution of
 11 problem-solving cognitive abilities through iconic artifacts.

14 **Conclusion: If mind is exosomatically embodied** 15 **in signs ...**

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 18 The acceptance of external signs as part of human cognition leads to different
 19 conceptions on the relation between cognition and environment that put much
 20 more emphasis on the active participation of the latter in shaping our minds. We
 21 actively participate in the construction of niches (semiotic structures and pro-
 22 cesses physically available in the environment), which fundamentally alter our
 23 capabilities (see Sterelny 2003; Sinha 2009; Bardone 2011). They make complex
 24 semiotic processes available to attention, consciousness, perception, opening a
 25 new range of semiotic operation; permitting, for instance, deep self-inspection
 26 of complex semiotic processes.

27 We have used the Tower of Hanoi game experiment to identify a mechanism
 28 through which iconicity influences in cognitive performance. Zhang & Norman's
 29 experiment indicated the process of externalization of constraints as a strategy
 30 to improve performance in problem-solving tasks. This process of externaliza-
 31 tion of constraints necessarily relies on the iconic character of signs because it
 32 makes signification dependent on the materiality of the sign itself. Under this
 33 framework, to distribute part of our tasks to external constraints in the 'outside
 34 world' is an example of iconic semiosis.

35 How the dynamics of cognition depend on the material properties of signs
 36 and the context of sign-action? The notion that we use external signs to think
 37 with is uncontentious when signs are typically symbolic (which can be described
 38 as borderline cases), such as maps and diagrams, algebraic notations, written
 39 systems, etc. But the morphological space of semiotic events and processes in
 40 which cognitive systems are embedded always include intermediary and mixed

1 classes of signs. The semiotic part of a theory of thinking with external resources
2 should provide the formal and analytic tools for evaluating why certain things
3 can function as signs that can be thought with. Peirce's semiotics offers a highly
4 consistent framework to investigate the use of different kinds of signs in cogni-
5 tive processes. Peirce's broad ideas concerning different types of signs and infer-
6 ences are an important tool for advancing in the development of an externalist
7 theory of mind. His treatment suggests that a reconsideration of the embodied-
8 situated paradigm's own philosophical foundations can behave in semiotic
9 terms. Peircean semiotic theory of mind neither restricts representations to
10 symbolic semiosis and inferential processes to deduction and induction as in
11 ortodox representationalism, nor rejects representations as in anti-representa-
12 tionalism.

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