

Integrating Peirce and IIT: how integrated information theory and Peircean semiotics mesh with respect to conscious systems

Integrando Peirce e IIT: como a teoria da informação integrada e a semiótica peirciana enredam-se com respeito aos sistemas da consciência

Steven Skaggs

University of Louisville
sxskag01@louisville.edu

Abstract: Integrated Information Theory (IIT), first proposed by Giulio Tononi in 2004 and updated (v.3) through 2014, seeks to explain conscious experience by understanding the action of elements within an experiential system such as the brain, and setting forth principles and measurement operations that can be used to decide levels of consciousness. Some of the postulates of IIT have much in common with Peircean semiotics. Among these are the presence of recursively nested operations, the importance of relational structures in forming conscious experience, subject/object dichotomy, and an objectivist stance that requires a system be really affected in order for consciousness or semiosis to proceed. However, difficult problems confront anyone hoping to find a translation between the two programs, especially with respect to the foundational concepts of time (duration) and continuity (i.e. Peirce's synechism). I argue that it is possible to overcome the problems of time and continuity through two moves. First, I put forward the notion of *dwell*, a period of real, if indeterminate, duration in semiosis, during which a judgment or tentative conclusion is reached. Secondly, with respect to continuity, I argue that an *analysis* of an interpreting system never has the ontological purity of the system it attempts to understand. Instead, any analytical assessment of an interpreting system must be considered a synthetic and expedient cut into the continuum. Thus, the continuum of experience remains unaffected even as the (tentative) understanding of the continuum happens through such artificial analytical frames. The value of "meshing" IIT and Peircean semiotics is that the semiotics can be seen as a structural outline that maps the conceptual territory of conscious experience for which the principles and measurements of IIT, in turn, provide useful tools of empirical data collection.

Keywords: Dwell. Integrated information theory. Peirce. Systems theory. Theories of consciousness.

Resumo: *A teoria da informação integrada (IIT), proposta inicialmente por Giulio Tononi em 2004 e atualizada (v.3) em 2014, pretende explicar*

a experiência consciente por meio do entendimento das ações de elementos dentro de um sistema experimental tal como o cérebro, e o estabelecimento de princípios e operações de mensuração que podem ser utilizados para decidir níveis de consciência. Alguns dos postulados da TII têm muito em comum com a semiótica peirciana. Entre esses estão a presença de operações hierarquizadas recursivamente, a importância de estruturas relacionais na formação da experiência consciente, a dicotomia sujeito/objeto, e uma instância objetivista que requer um sistema que seja verdadeiramente afetado para que a consciência ou a semiose avance. Entretanto, problemas desafiadores confrontam alguém que espera encontrar uma tradução entre os dois programas, em especial, com respeito aos conceitos fundacionais de tempo (duração) e continuidade (isto é, o *sinequismo* de Peirce). Argumento que é possível transpor os problemas de tempo e continuidade através de dois movimentos. Primeiro, apresento a noção de *dwell*, um período do real, se indeterminado, duração na semiose, durante a qual um juízo ou tentativa de conclusão é atingido. Em segundo, com respeito à continuidade, argumento que uma análise de um sistema de interpretação não possui a pureza ontológica do sistema que ela tenta entender. Em vez disso, qualquer avaliação analítica de um sistema de interpretação deve ser considerado corte sintético e expediente dentro do *continuum*. Assim, o *continuum* da experiência permanece não afetado mesmo que a (tentativa) de entendimento do *continuum* aconteça através de tais estruturas analíticas artificiais. O valor de TII de “emaranhamento” e a semiótica peirciana é que a semiótica pode ser vista como um esquema estrutural que mapeia o território conceitual da experiência consciente para a qual os princípios e mensurações de TII, por sua vez, fornecem ferramentas úteis de compilação de dados empíricos.

Palavras-chave: Intervalo. Teoria de informação integrada. Peirce. Teoria de sistemas. Teorias da consciência.

1 Introduction

Integrated Information Theory (IIT) was first proposed in 2004 by Giulio Tononi.¹ IIT seeks to explain conscious experience by understanding the operation of elements within an experiential system, starting with the brain, but generalizing the concept. It begins by stipulating five axiomatic conditions that are required for consciousness: 1) consciousness has an *actual existence*; 2) consciousness is *composed*—i.e. made up of various distinctive phenomenal qualia; 3) consciousness is *particular* information—that is, each conscious experience is unique and cannot be duplicated across other consciousnesses; 4) conscious experience is *whole*, so that, despite its being comprised of parts, the sense within consciousness is of wholeness; 5) conscious experience *excludes* “sub experiences”, being a single definite and specific actuality in its wholeness.

2 Postulates of IIT

From these foundational axioms, IIT asserts five postulates:

1 This and the following outline of principles appear in the opening passages of IITv3.0

- 1) A conscious system's state has cause and effect powers within itself. It is not dependent, for consciousness per se, upon factors extrinsic to the system. This implies that the limit of the interactive cause-effect network represents the boundary of the IIT system.
- 2) The nodes of such interactive cause/effect combinations, functioning as the elements of the overall conscious system, are called mechanisms.
- 3) A system in a given state of consciousness has a specific cause/effect combinatorial repertoire. A system being in that particular state (and no other) thereby differs from other systems and other states.
- 4) The cause/effect structure of a conscious system must be whole. Its unity entails that the conscious system is not simply the collection, or sum, of independent (i.e. separate, non-integrated) subsystems. This postulate entails that every portion of the integrated system must be affecting—and being affected by—every other part. The IIT literature refers to this feedback process as *recurrence* (when referring to the entire system) or *re-entrant* (when referring to particular nodes). Recurrent systems comprised of re-entrant mechanisms are the hallmark of an integrated information system.
- 5) Exclusion principle: If a system were to break into two or more discreet parts that lack recurrence, then the overall system is not, by definition, integrated, and therefore would not be conscious. This implies that within an integrated information system, consciousness is a trait possessed only by the largest networked set of integration, not by its sub-parts and mechanisms.

IIT hopes to be able to quantize experience or consciousness by essentially measuring the complexity of the network of nodes contributing to the maximally integrated system. The resulting value is called *phi* (Φ) which can be considered to be a measure of a system's conscious-capacity.

3 Observations on IIT

Tononi conceives IIT within the umbrella of general system theory.² From its early days a half century ago, general systems theory has been employed in response to the need to study not just the individual elements, but their interactive and emergent effects.³ A property such as consciousness is ideally suited to be studied under

2 There are particular affinities between IIT and “second-order cybernetics” as described by Bateson and Margaret Mead in 1976. See Bateson, Mead, Brand.

3 Ludwig von Bertalanffy, in his introduction to general systems theory, explicitly pointed to the ecological impulse: “General system theory, therefore, is a general science of wholeness [...] The meaning of the somewhat mystical expression, ‘The whole is more than the sum of its parts’ is simply that constitutive characteristics are not explainable

such a scheme. In systems theory, a system is defined as a set of elements that interact in order to further some purpose (MEADOWS, 2008, p. 11). Presumably, the elements or mechanisms of a conscious system interact for the purpose of creating an experience, and that experience performs the function of allowing the system to engage with the broader contextual world of which the conscious system is a part, thereby performing an evolutionary role.

For IIT, the recurrently interactive system does not simply permit consciousness, or prepare the way for consciousness to occur, nor is it merely associated with consciousness; on the contrary, through an identity principle, such a system is essentially what we mean by consciousness: “An experience is thus an *intrinsic property* of a complex of mechanisms in a state.” (TONONI, IITv3.0). Such a system is *being conscious*.

Tononi does not specify any particular kind of materiality or substance that should comprise the mechanisms of a conscious system. Although many of the advocates of IIT are neurologists and brain scientists, IIT claims validity for other networks of various materialities (for example, potentially, silicon computer chip networks). As long as the reentrant structure is maintained, the integrated information is retained. Whether there are, or can be, any conscious systems outside of the neural biological ones we are part of, remains an open question.

Finally, although Tononi specifically cites Descartes as a starting point for thinking about consciousness, one cannot help noticing other closer alliances, especially with the thought of Whitehead, Dewey and process philosophy generally. Semiosis, as envisioned by Charles Sanders Peirce, is one such process philosophy. It seems natural to lay the two accounts side by side and see how they compare, but as far as I know, Peirce is not referenced in the IIT literature, nor am I familiar with Peirceans referencing IIT.

4 Peircean semiosis

At the time Peirce was writing of the semiotic logical relations necessary to perception and consciousness, those very terms were in the process of development and their meanings with respect to psychology were in considerable flux. Peirce’s 1891 review of William James’s *The Principles of Psychology* consisted primarily of a lengthy analysis of whether perception could be considered to be inference of a general kind, a more narrowly construed kind, or no kind of inference at all. In the process of excoriating James for murky analysis when James concludes “To call perception unconscious reasoning is thus either useless metaphor or a positively misleading confusion between two different things”, Peirce gives one of the clearer statements of his sense of perception, contra James: “There is no room for doubt that perception and, more generally, associative suggestion, may truthfully be considered as inference in a generalized sense...” (CP 8.71).

However, Peirce’s central concern was not the psychological state, but something broader and more comprehensive: the metaphysically necessary logical structure that lay beneath all living systems. This broader structure would of course

from the characteristics of the isolated parts. The characteristics of the complex, therefore, appear as new or emergent...” (BERTALANFFY, 1968, p. 37).

include, but not be limited to, psychological phenomena. Consequently, Peirce's semiotics was based on more fundamental principles: three basic ontological modes, or categories, of relation. The first category consists of something that is independent of any other (even a background against which a figure might appear); the second category consists of something in relation with another; the third category consists of something that is in a mediated relation to another, so that one thing relates to another *by means of* a third. This third, mediating, thing is the sign.⁴

The result is a semiotics which famously holds a modular triadic complex to be the fundamental and vitiating principle. Various latter-day Peircean constructions (and indeed Peirce's own writings over fifty years) exhibit slightly divergent terminology to describe this triadic structure. In this article, I will use the terms "sign," "referent" and "interpretant." A sign stands for its referent to an apprehension known as the interpretant. In what follows, the holistic S-R-I triadic complex will be referred to as the semiotic moment (Figure 1).



Figure 1

For Peirce, all perception, cognition, information, knowledge, and thought itself happen through the mediating action of signs, a process he called "semiosis." Semiosis flows. An interpretant is only a stage—a decision point in one moment—before becoming "a more developed sign"⁵ for a subsequent moment as interpretation continues in semiosis.

As Peircean semiotics developed in the late twentieth century and into the twenty-first, increasing attention began to be paid to the transactional mechanisms by which this system of modular triads can be transformed into the flowing current of semiosis. Early studies (See: Savan, Liszka) focused primarily on this translation function, by which an interpretant of one semiotic moment becomes a sign for a subsequent moment. Elsewhere, I have suggested (SKAGGS, 2006) three additional

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- 4 In one of his earliest attempts to define a sign, Peirce suggested: "A sign [...] is something that stands to somebody for something in some respect or capacity." (CP 2.228). But later, especially after 1903, he stressed that such appeals to personhood were merely to communicate his general idea and that sign exchange need not be limited to people as is implied in the term "somebody."
 - 5 The phrase "more developed sign" is one of Peirce's more pregnant and felicitous indications of the transformative power of the modular triadic moments. See CP 2.228.

transactions—selection, nesting and sequence.⁶ While the distinguishing details of these transactions exceed the purposes of this paper, the key attribute of each of them for our present purpose is that while accounting for the functional transition from static moment to the flowing exchange of information found in semiosis, they do not construct a new semiotic structure. Instead, they are structural replicants, each transactional mechanism being, in its own right, a recursively bundled set of (smaller scale) semiotic moments. This recursion is replete throughout the emerging process, from the macro level (conscious awareness) down to (unconscious and subconscious) infinitesimal levels. That is to say, at a synchronic level, a given experience can be seen as consisting of micro-level triads, semiotic moments nested in Russian doll fashion; at a diachronic level, an interpretant of one triad becomes the “more developed” sign in the next triad, such transformations forming sequences, branchings, chains, and so on.

5 Parallels between IIT and Peirce

Given this brief sketch, there are four important respects in which Peircean semiosis and IIT agree.

5.1 Consciousness is a result of a relational structure within the system

Both Peirce and IIT dispense with notions of a spiritual or psychical “energy,” pure phantasms of non-material substance that would explain consciousness. In both programs, experience naturally occurs given the presence of the right kind of interactions: triadic semiotic ones in the case of Peirce, recurrent feedback operations in the case of IIT. Whether labeled *phi* (Φ), thirdness, or the more developed sign, consciousness develops and is entailed in endlessly adaptive ways strictly through the structure of relations. Hence, in neither system is consciousness limited to human experience.

5.2 Nesting is an inherent attribute of conscious systems

While IIT’s exclusion principle grants experience only to the maximally integrated set of mechanisms, it accepts that this maximal set is comprised of sub-mechanisms—smaller sets of interactive nodes (figure 2). While being subsumed in the larger integrated whole, these sub-clusters of interaction are nevertheless recursively nested variants that repeat the same formal structure possessed by the entire system. This is certainly similar to the kind of nesting we see in Peirce’s semiosis in which a sign results in an interpretant that may become “a more developed sign.” In this respect, IIT and Peirce each offer a single structural device that permits transformation and growth from finer to more enveloping systems.

5.3 Consciousness (for a subject) stands in relation to an environment (as object)

The adaptations afforded by consciousness are in response to (and represent an effort to reconcile with) an environment that is beyond the conscious subject. In IIT,

6 SKAGGS, 2006, p. 133-149.

this environmental context is the domain beyond the boundary of the integrated system. In Peirce, the environment is the reality that is represented by the dynamic object (EP 2:477), “outward clash,” (CP 8.41) “brute actuality,” (CP 6.455)—basically all that is “objective” in his objective idealism. In both IIT and Peirce, we find a two-way interdependency between the knowing (as process) and the known.

5.4 No consciousness without an effect on the system

For both, the importance of the *effect-on-system* is crucial and defining (See: IITv3.0, and CP 4.534). In both IIT and Peirce there is something that *impinges* on a system such that the system’s future interactions are causally changed by the impingement. For IIT information is “a difference that makes a difference”⁷ on the system that receives it. It is a reception that not only fleetingly changes the state of the system in that instant, but changes the system’s capacity or tendency for responding to future signals. This impinging entity in IIT is called the input; any input that causes an effect on the receiving system such that the system is actually structurally altered is information. For Peirce, the impinging entity is called the sign, and it is this sign which produces an effect upon the interpreting system, such effect being the interpretant. This effect brings the interpreting system into a “condition of understanding” of the sign’s object, transforming the interpreting system and preparing the interpreter for future semiotic exchanges.⁸ In this way, both Peirce’s semiotics and IIT’s theory depend upon transformational processes of interpretation.

6 Continuity and the question of the “exclusion principle”

Now we come to an area in which Peirce and IIT would seem to be difficult to reconcile.

IIT stipulates that sub-mechanisms of a conscious system are not themselves conscious; this is called the exclusion principle. For IIT, experience is the executive summary or capstone of its constitutive mechanisms; experience is not granted to any of the sub-mechanisms, but the maximally integrated set of reentrant mechanisms can be said to have “an experience.” For Peirce, while consciousness may be an emergent property of semiosis, it is “smeared” across past and future with an uncertain temporal status based upon infinitesimals.⁹ It is less clear in Peirce that consciousness is actually excluded from prior semiosis that is “less-developed” when it leads to a “more developed” sign. Notice how, in this passage from 1897, Peirce speaks of past mind and present mind as if they are somehow temporally (and spatially) intertwined during awareness:

7 IITv3.0 Supplement, (p 1) [after Bateson]

8 For instance, compare the discussions in both CP 4.534 and CP 5.484.

9 The difficulty Peirce had in squaring his synechism with experience can be found in passages such as: “Continuity involves infinity in the strictest sense, and infinity even in a less strict sense goes beyond the possibility of direct experience.” CP 1.166 I interpret that statement as placing an emphasis on the word “direct”, – implying that Peirce thought of experience as a generalization of sorts, an abstracted tentative conclusion made across an inherently continuous, un-split-able, manifold.

We may say then that one portion of mind acts upon another, because it is a measure immediately present to that other: just as we suppose that the infinitesimally past is in a measure present. And in like manner we may suppose that one portion of matter acts upon another because it is in a measure in the same place. (CP 1.170).

Again, we get a similar kind of blurring of the here-and-now boundary lines in his discussion of perceptual judgment, antecept and ponecept (CP 7.648). He sees the percept as possessing components of both memory and anticipation, so that, as Douglas Anderson puts it, “the entire passage from percept to judgment [is] an instance of a continuum.” (ANDERSON, 2012, p. 127). Here, Peirce suggests that what is “present in experience” is already an on-going negotiation between past action and anticipated future, concepts that are required by the continuum vital to his metaphysics.¹⁰ The idea of a single, granular, conscious experience, even if it is supervening upon sub-mechanisms (that are denied consciousness) is simply a construction that doesn’t make sense from a Peircean point of view. To try to understand the “present instant” is to make an artificial cut into the continuum, a slice that must already admit both sides of the continuum it synthetically interrupts.

So whereas IIT treats experience as discrete (i.e. one experience is like no other) and grants it only to the largest integrated cluster of sub-mechanisms, Peirce appears to do the opposite, treating experience as continuous and permitting lower level mind-like entities beneath an emergent larger scale self.

However, perhaps this can be looked at a different way. When Peirce speaks of past and future being brought together in the “now” of the percept, rather than implying that sub-systems possess consciousness for a perceptual “now,” he may be interpreted as saying that a discrete cut is simply not possible at all, that the cut itself is necessarily of a triadic structure. This way of interpreting Peirce leads inevitably to an infinite regression of triadic micro-structures, so that any experience of now-ness is not only emergent, but actually a particular *über-interpretant*, a generalization, a tentative conclusion. Such a particular generalization can never be a true cut (which is synthetic, an artifice that must possess parts of both sides) but rather an interpretation, a judgment. It is this decision, conclusion, ever-fallible interpretant that is particular and individual.

By this viewpoint, IIT and Peirce may yet be reconciled: IIT simply has a more “deeply wound” structure of a variety of re-entrant combinations, while for Peirce the fundamental structure remains—more simply—triadic, although now seen to be recursively scaleable down to infinitesimals. Continuity prevails as an ontological real, while as an experiential real (or “semiotic real” as Floyd Merrell has it¹¹) the world seems individualized.

10 These “elements” of a percept should not be seen as structurally separate-in-kind species; like the percept, they are triadic semiotic moments, although at “smaller scale.” Their discrimination is not due to their structure, but to their functional role comprising the more “molar” percept. In this entire discussion (see for example, CP 7.625) Peirce is clearly struggling to reconcile the “portions” or ingredients of experience with his synechistic continuum.

11 Merrell suggests suspending, as a topic of analysis, the ontologically real in favor of the semiotically real, that is, all that can be known through the play of signs – a quasi-idealistic view.

Ultimately, while the question of a Peirce-IIT agreement around continuity and the exclusion principle remains somewhat contentious or at least ambiguous, what remains critical is that in both views, experience doesn't simply depend upon, but simply *is* a composition of structural components: semiotic relations in the case of Peirce and recurrent mechanisms in the case of IIT.¹²

7 Rapprochement?

Putting aside for now the vexing issue of the exclusion principle, and given the other areas of substantial overlapping agreement, is it possible to propose a hybrid construction that allows the two theories to be seen, at least in part, as different vantage points on a single object? The remaining challenge comes from the way the two systems of thought deal with the issues of time and flow: is time an inherent part of the concept or is it to be jettisoned in favor of a more static logical framework? If, in the attempt to manage it, I stretch both theories a bit outside their familiar zones, as long as I steer clear of violating anything absolutely vital to them, the benefit of seeing them mesh will be worth the risk.

8 Dwell

In an attempt to manage such a rapprochement around the issues of flow and time, recognize that IIT sees the conscious system as being made up of an input, a node in which a feedback process of re-entrant exchange occurs, and an output. Each of the sub-systems that make up the maximally integrated conscious system within the node is likewise comprised of recursively similar nodal structures: input-node-output. As IIT intends to observe this process for actual physical systems, there must be some duration, after the input and before the output, in which the exchanging is happening. Let's call this duration period the node's "dwell."¹³ Given an input, *dwell is the period during which the node is determining its output.*¹⁴

12 But when Peirce speaks of matter as "effete mind" (CP 6.25), it is doubtful that he intends to introduce "layers of independent mind" into each neuron in the brain. This potential problem in Peirce (which the IIT program handles through its exclusion principle) can, it seems to me, be dealt with by assuming that increasing levels of organization both subsume and suppress lower level mindedness.

13 The term "dwell" is borrowed from the tradition of operating hand printing presses in which the dwell is a brief pause—the period of time during which the paper is allowed to sit upon the type form—before lifting and removing the imprinted sheet.

14 This brings other interesting questions to light: Is the dwell period the same for all intelligent systems? Can a conscious system whose mechanisms are, say, silicon chips work the dwell more quickly than the carbon-based neurons of the human system? If there are differences in functional dwell times, then in addition to a measurement of overall quantized integration, Φ , we may need to have an additional term for Φ -responsiveness, Φ -quickness. "Q-phi" would be the dwell time value within the system.

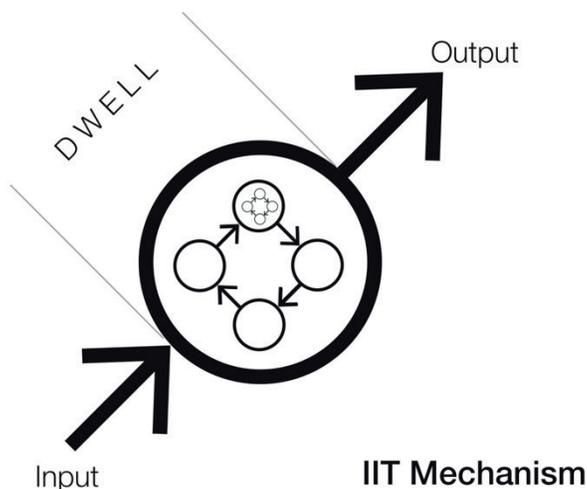


Figure 2

Although Peircean semiotics permits time to play a role by being “semantic content,” Peirce’s insistence on continuity would seem, at first, to reject the notion of a discreet time-framed period such as dwell – at least not as something inherent to the nature of the fundamental triadic semiotic moment.¹⁵ (This is so because, as we have seen, the semiotic moment is conceived as simply a logical relation.) But here is where I suggest a fudge factor: to address this inconvenience, instead of ignoring the issue of duration in Peirce, we can simply assign to the concept of semiotic moment a dwell factor of an *indeterminate value*.

$$SM_{d(n)}$$

Here, SM is the semiotic moment, d is the dwell variable, (n) is the observed duration which is left unassigned when discussing the semiotic moment as a general concept. But in practice, we can determine d 's value through IIT observations of any actual system, then in a Peircean semiotic moment we'll give $d(n)$ the appropriate dwell value observed in a particular IIT experiment. In the example below, it is given the (hypothesized) observed value of 3 milliseconds.

$$SM_{d(3ms)}$$

We bridge from Peirce’s logical relations to IIT’s testing labs. Peirce is now partially defined empirically by IIT and IIT is operating within a system map or

15 The use of the term “semiotic moment” to identify a Peircean triad of sign/referent/interpretant is one the author introduced about a decade ago and which is perhaps most accessibly found in *FireSigns* but which receives its full semiotic defense in SKAGGS, 2006, p. 133-149.

frame of Peircean semiotics. Retaining the dwell as a viable concept permits us to acknowledge the theoretic presence of some (even if unknown or unspecified) duration, while allowing the issue to simply reduce to irrelevance vis-a-vis solely Peirce's logical triadic structure.

By making this slight allowance, IIT begins to map neatly onto Peirce. The distinction now becomes one of the perspective of the analyst, either viewing the system's structure from within the system (usually the Peircean vantage point) or the system's process from without (usually the IIT vantage point). The terms of the two perspectives also begin to translate into each other. During the dwell, an input (the sign) causes an effect (the interpretant) on an interpreting system (node) such that it outputs a new (more developed) sign. Semiosis is underway. The referent is that which, from *within* the system, the system determines (through re-entrant exchange) the sign to refer to. Simultaneously, from a viewpoint *outside* the system, the referent is that which "determines the sign" (in Peirce's sense) by behaving as an entity that permits, motivates and constrains the sign (input) to adequately serve as its system proxy.¹⁶ The node is a triadic semiotic moment when viewed in its *logical functional structure* from within the system (where emphasis is placed upon the relation of sign-object-interpretant); meanwhile, observed from outside the semiotic moment, the emphasis is placed upon a *sequence*: input, output, with the dwell constituting a nodal pause between.

It should be noted that this view of a triadic semiotic moment that nevertheless dwells, while satisfying Peirce's conception of the triadic structure, foregrounds in a noteworthy way the element of judgment—judgment being just that determination which is made within the dwell. The interpretant, the expressed product of judgment, now becomes output, the more developed sign, the signal which moves semiosis forward in time.

Time, which serves as "subject matter" (sign, referent or interpretant) for Peirce's triadic relations, is only reintroduced as structural form upon crossing the nodal boundary of the integrated system—and indeed this system boundary must be crossed by any observer who hopes to measure time. Only then can the dwell be compared to other dwells, other spatial entities and conscious and unconscious mechanisms. In fact, it is precisely this comparative process that is what we mean by time. As an internal function within the triads in relation, time remains irrelevant: insofar as it is essentially a description of a logical structure of exchange, the semiotic moment is without duration per se. But in the judging, in the sequencing, and as process, semiosis demands a determination of a time value, which must

16 This use of "determine" is the exception to the pattern that the Peircean viewpoint is generally within the system. The fact that Peirce is referring to a determination made possible by some mechanism (such as habit in the case of symbols) that is external to the semiotic moment system is due to Peirce's use of the word determine in a logical or mathematical sense. The object or referent of the sign constrains the kinds of things or events that can successfully tally, or successfully act as substitute. It is only in this sense that the determination is "outside" the system, though, as the mechanism of connection also involves an interpretant which is strictly inside the system and which most of us find more accessible when we think of a sign determining what it stands for. The distinction between these two kinds of "determining" has been a source of difficulty in understanding C. S. P. for many students for a long time.

inevitably be made comparatively, from outside the boundary of the system itself, and specific to a particular system's environmental conditions. IIT and Peircean semiotics observe the same relational mechanisms, but the former sees time because it is looking at a large scoop of processional nodes from outside, while the latter ignores time as it looks to the fundamental interactive structure from within "a given chunk" of isolated process.

9 Conclusion: semiotics, the map of integrated information

Peircean semiotics and IIT both describe certain kinds of structures. IIT outlines a structure that is what is meant by the term "conscious experience." Although the envelope of Peirce's project encompasses far more than human "conscious experience," his semiotics clearly includes it. For Peirce, the structure is found in the triadic relations of the semiotic moment; for Tononi et al, it is the integrated flow of information, the "difference that makes a difference." For Peirce, an interpretant is an effect upon a receiving system. I believe it can be said that for both Peirce and IIT there is zero- Φ without this effect upon the recursively integrated interpreting system—and such a system is roughly what they both mean by "mind."

IITers speak of Φ being measured, of integration and experience being quantifiable. Peirce has no equivalent measuring scheme, yet in his system, mind (of some sort and some extent) is present once triadic action happens, just as Φ is present once information is maximally integrated. When Peirce speaks of an interpretant becoming the sign or a more developed sign for a subsequent interpretant, he sounds a great deal like Tononi arguing for the inevitability of low-level integrated systems rolling into more developed, better integrated, higher- Φ systems.

Semiotics then – especially the semiotics following the work of C. S. Peirce—becomes the system map that explains what neurons do, what integrated information systems are about. Conversely, IIT fills in, for semiotics, particular mechanisms of behavior at a certain scale, becoming a bridge between the abstract map and the particular physical case.

Meanwhile, undergirding both frameworks is the notion of a system and its boundaries, and the system's requirement that there be members within the system that are differentiated from non-members lying outside the boundary of the system. Mind systems must have such boundaries, even if perhaps, like waves, the boundary's edges ultimately prove to be ambiguously fuzzy. The idea of extremely fuzzy boundaries to conscious minds and what those implications would be must wait for further development. Perhaps at those moments the observational platforms that separate the IIT and Peircean perspectives would collapse completely. We would begin to perceive the sub-systems starting to de-integrate in those moments, and the clarity of viewing the system from "the inside" or "the outside" of the boundary would disappear. Perhaps we experience the shade of such occurrences when we begin to fall asleep. Then, as Peirce says in discussing the connection of percepts to infinitesimals, "In this last moment, the whole series will be recognized, as known or known before, except only the last moment, which of course will be absolutely unrecognizable to itself." (CP 6.111).

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