An Inter-Enactive Approach to Agency: Participatory Sense-Making, Dynamics, and Sociality[*]

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ABSTRACT

An inter-enactive approach to agency holds that the behaviour of agents in a social situation unfolds not only according to their individual abilities and goals, but also according to the conditions and constraints imposed by the autonomous dynamics of the interaction process itself. We illustrate this position with examples drawn from phenomenological observations and dynamical systems models. On the basis of these examples we discuss some of the implications of this inter-enactive approach to agency for our understanding of social phenomena in a broader sense, and how the inter-enactive account provided here has to be taken alongside a theory of larger-scale social processes.

1. INTRODUCTION

It is now two decades since the emergence of Enactivism as a distinctive approach within Cognitive Science, with the publication of *The Embodied*

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Mind (Varela *et al.* 1991). This volume was a broadside against traditional conceptions of mind and agency – in particular the dominating notion that a cognitive agent's interactions with the world are essentially mediated by an internal information-processing device, epitomized by the digital computer, linked to sensors and effectors. On this picture the agent's brain receives sensory inputs which enables the brain's information-processing routines to update its internal model of the world, modify its action-plans and generate executive commands to effect physical changes in the world – what Rodney Brooks (1991) described as the 'sense-model-plan-act' view of cognition and agency. At the time of The Embodied Mind the dominant question being asked was: is the information processing device to be thought of primarily in terms of symbolic AI models or in terms of some form of connectionist architecture. Varela and colleagues were inspirational in offering 'enactivism' as a new departure from these 'internalist' models, and many other novel approaches appeared, calling themselves, variously, 'embodied', 'embedded', 'dynamic', and so on.

In fact a bewildering number of different proposals were made under the 'enactivist' banner[1] – so that it is rather difficult to find a concise summary of what enactivism, in essence, was proposing. However the enactive approach to cognition and agency can be broadly summarized in terms of five interlocking themes. See Thompson 2005, 2007; Torrance 2005, which address the foundational question: What is it to be a (cognizing, conscious) agent? The five-fold response is as follows: it is (a) to be a biologically autonomous (autopoietic) organism – a precarious, far-from-equilibrium, self-maintaining dynamic system; (b) with a nervous system that works as an organizationally closed network, whose function is to generate *significance* or *meaning*, rather than (as in the 'sense-model-plan-act' model) to act via a set of continually updated internal representations of the external world; (c) the agent's sense-making arises in virtue of the its dynamic sensorimotor coupling with its environment, such that (d) a world of significances is 'enacted' or 'brought forth' by a process whereby the enacted world and the organism mutually co-determine each other; and (e) the experiential awareness of that organism arises from its lived embodiment in the world.

These five themes draw upon a number of theoretical traditions, for example, the autopoietic theory of Maturana and Varela (1987), the

[1] See Torrance 2005 for a catalogue of some of these.

phenomenology of Merleau-Ponty (1945) and recent work on dynamical systems (e.g., Port and Van Gelder 1995), as well as (in some interpretations of enactivism) also leaning heavily on themes from Eastern mindfulness meditation traditions (stressed in particular in Varela *et al.* 1991). Putting all these various strands together we have a view of agency which stresses how an agent and the world in which that agent acts can, in an important sense, be seen as 'co-constituting' or 'co-enabling' one another. The enactive approach to cognitive science has come a long way since it was first initiated by Varela and colleagues, as demonstrated, for instance, by the subtle and extended treatment in Thompson (2007). An initial focus on the embodied phenomenology and sensorimotor dynamics of perception (O'Regan and Noë 2001, Noë 2004)[2] has come to be complemented by a renewed interest in biological autonomy (putting more emphasis, for example, on autopoiesis)[3], and this resulted in a sharpened conception of sense-making in relation to autopoiesis, a stress on the importance of adaptivity (Di Paolo 2005), and more recently, an enactively-focused characterization of agency (Thompson 2005, Barandiaran *et al.* 2009). Other recent treatments of enactivist themes include collected papers on intersubjectivity, empathy and sociality (Thompson 2001, Di Paolo 2009); on enactive experience (Torrance 2005, 2007); on autonomy (Barandarian and Ruiz-Mirazo 2008); on enactivism in relation to other post-cognitivist views of mind (Kiverstein and Clark 2009, Menary 2010); and on enactivism as a new paradigm for the cognitive sciences (Di Paolo *et al.* 2010).

During the progression of this extended discussion it has become evident that it is not just the internalism and representationalist nature of classical cognitivism that has to be challenged, but also a 'methodological individualist' or 'methodological solipsist' approach to cognition and agency.[4] This individualistic picture has been challenged in many ways by enactivist and other perspectives which stress embodied and embedded, features of agency and cognition. Thus there has been a growing focus on the intersubjective, or interactive, nature aspects of experience, knowledge and agency.[5] De Jaegher

[2] See also Torrance 2002.

[3] See Varela 1997, Weber and Varela 2002.

[4] See Fodor 1980 for a classical defence of an account of cognition which explicitly takes this character, under the label 'methodological solipsism'.

[5] This emphasis on interaction and intersubjectivity was given an important impetus by an emphasis on second-person methods for investigating consciousness, and empathy as a central feature

and Di Paolo's (2007) enactive account of social interaction provided a new departure by introducing the concept of *participatory sense-making*. Their account, which drew inspiration from autopoietic accounts of biological autonomy (e.g., Maturana and Varela 1987), and from research in artificial life and evolutionary robotics, proposed that inter-individual interaction processes can take on an autonomous organization of their own.

De Jaegher and Di Paolo's paper is a key study in a number of recent works which mark a growing interest in the role of the interaction between agents for understanding the nature of agency.[6] For instance, it has been argued that the inter-individual interaction process can constitutively shape forms of individual agency (De Jaegher and Froese 2009), that inter-agent interaction is a necessary condition for the shift from minimal to 'higher-level' cognition (Froese and Di Paolo 2009), and that historically based impersonal norms an essential background in human social agency (Steiner and Stewart 2009; see also below section 4). In addition, Di Paolo, Rohde and De Jaegher (2010) have investigated the importance of an enactive account of social cognition to understanding the nature of play. Moreover, the idea that interactive processes are defined by a certain autonomy which both conditions and is conditioned by the autonomy of the interacting individuals has profound repercussions for our understanding of emotion, values and ethics (Colombetti and Torrance 2009).

In what follows we will further substantiate the idea that many kinds of agency, in particular the agency of human beings, cannot be understood separately from understanding the nature of the interaction that occurs between agents. We begin with a discussion of some illustrative examples, drawn from common experience, that show how the relative autonomy of the interactive process itself can sometimes facilitate and sometimes hinder our individual goals. However, the majority of cognitive scientists working on interpersonal interaction and social cognition are likely to remain unconvinced that these examples show that inter-individual interaction processes can indeed play a constitutive role in determining the character of individual agency. Accordingly, we discuss a series of simulation models which serve as concrete proof of concepts, and which enable us to analyze the dynamics of the interaction process in a precise mathematical manner. Effectively, the models help us to demonstrate that it is possible to treat an inter-individual interaction

of this emphasis, as seen in the collection of papers which was published shortly after Varela's death (Thompson 2001). See also, for example, Gallagher 2005.

[6] See also Di Paolo 2009.

process as one whole dynamical system, and that this global system has properties that modulate the flow of component activity and yet cannot be reduced to the activity of any of the individual components. Having put the enactive approach to social interaction on a more solid footing, we proceed to discuss some of the implications this change in perspective has for our understanding of social processes in a sense broader than that which is limited to the inter-individual real-time interactions which are the major focus in the earlier part of our discussions.

2. When Interacting with Others Takes on a Life of Its Own

One of the key ideas to have emerged from the 'participatory sense-making' literature is that the unfolding of an interaction between two or more people has an autonomy of its own which is separate from the autonomy of the individual participants. This idea will be given more theoretical weight later on, but here it is illustrated intuitively. The relative autonomy of an inter-individual interaction process may be encountered as an organizing (enabling and constraining) influence on the unfolding events of the interaction from the perspective of the interacting individual agents. Depending on the circumstances, the autonomous organization of the interaction process itself can facilitate or hinder the realization of the autonomous goals of the agents. Here we illustrate these two types of situation by drawing on some concrete examples from common experience, at first intuitively or pre-theoretically described.

2.1 How the interaction process facilitates individual actions

To begin with, it may be easiest to illustrate the constitutive role of the interaction process for individual actions by recalling a social situation in which we were engrossed in a conversation. It can happen that the flow of the interaction carries us along quite effortlessly, with every one of our actions prompting our interlocutor to respond with a complementary reaction, which in turn evokes another response from us, and so forth, back and forth. In this way we can describe the conversation as a stable social situation because of the mutually reinforcing actions of the interlocutors.

At the same time we can also look at the role of the conversation itself. In other words, the fact that we are situated in an engaging conversation means

that in response to what the other has said we are more likely to say or do something appropriately engaging in turn, and the fact that we are more likely to respond in this way also means that our actions are ensuring that we continue to be situated in an engaging conversation. We are thus faced with a self-perpetuating social interaction process, whereby the conversational nature of the situation co-constitutes the individual's gestures, and the individual's gestures co-constitute the conversational nature of the situation.

But does it really make sense to give a co-constitutive role to the structure of the inter-individual interaction process itself? How do we know that we are not simply dealing with the linear sum of the individual gestures? In the case of a social situation in which the individual goals of the partners are mutually reinforcing, it is indeed difficult to assess whether we need to appeal to any additional interactional process at the inter-individual level in order to explain what is going on. However, what about social situations in which the goals of the individual interactors are not aligned with the self-perpetuating structure of the interaction process?

2.2 How the interaction process hinders individual actions

De Jaegher and Di Paolo (2007, 2008) nicely illustrate this possibility by pointing out that verbal arguments are often self-perpetuating even despite the best intentions of those involved. In such cases every attempt to end the conflict by one or the other of the individuals may, in virtue of the inter-individual situation, provoke a response from the partner and will therefore, in spite of the individual's original goal, inadvertently give support to the continuation of the overall argumentative situation. Anyone who has experienced being entangled in such a self-perpetuating social conflict knows the feeling of being helpless to stop what turns out to be an inevitable continuation of the argument. On the personal level it can feel like what one is saying is somehow twisted in the interaction so that it comes out wrong, is misinterpreted, or simply remains ineffective.

The self-perpetuating verbal argument that no one wants to continue having is a rather extreme example, but self-sustaining interactions in which the structure of the social situation cannot be reduced to the sum of the individual actions are actually quite common in our daily lives. As a paradigmatic non-verbal example, De Jaegher and Di Paolo (2007) refer to the situation in which we encounter someone while walking along a corridor and we step aside to make way. It sometimes happens that we both step aside in the

same direction and are thus faced by the same impasse once again, which leads us to make another synchronous sideways step together, and so forth, until one of us finally makes a concerted effort to break the undesired interaction process and lets the other pass.

A common verbal example that we can all relate to is trailing conversations that we have difficulty in terminating. This can happen for instance when trying to end a phone call in a polite manner, such that every 'bye' and 'thanks' and 'see you soon' uttered by one of the speakers is followed by a complementary response by the other speaker, which then calls forth another response from the first speaker, and so forth. In this way the 'end' of the conversation continues because the social situation as such facilitates the exchange of mutually contingent responses, as well as because the cultural norms of our society make it difficult to simply hang up on someone who is still speaking. Accordingly, even though both callers may have the personal goal of terminating the call, they can find themselves unable to easily do so because additional responses are facilitated by the interactional nature of the social situation and the cultural constraint of not hanging up prematurely.

We will return to a fuller discussion of the role of cultural norms in shaping individual actions in a later section of this paper, but for now we simply want to highlight the fact that even the most basic inter-individual interaction processes can become self-perpetuating, autonomous structures in their own right, and that these relational structures can play a constitutive role for the enaction of individual actions (De Jaegher and Froese 2009).

2.3 How to avoid falling into social mysterianism

However, as Boden (2006) has correctly pointed out, this kind of approach to social interaction confronts us with a fundamental problem: how can we leave methodological individualism, which is still prevalent in the cognitive sciences, behind us without at the same time descending into some kind of social mysterianism? How can we scientifically grasp the notion that an inter-individual interaction process is not just *constituted by* the actions of several interacting individuals, but that this whole interaction process itself is also *constitutive of* the actions of those individuals as well?

Mainstream approaches to social cognition are ill equipped to address this important challenge because they remain narrowly focused on the cognitive

abilities of the brains of isolated individuals (usually characterized in terms of either theory theory or simulation theory).[7] Fortunately, however, these cognitivist and individualist approaches to social interactions are no longer the only game in town. In what follows we will show that it is possible to systematically study the nature of social situations, including their co-constitutive impact, by making use of some minimalist technological tools. Not only does this address the worry that an acceptance of the co-constitutive role of interaction processes and a rejection of theory of mind approaches leads to a non-scientific mysterianism about sociality; on the contrary, because our framework is based on the mathematics of dynamical systems theory, we are grounding the discussion in concrete models that are open to precise analysis.[8]

3. Dynamical Models of Inter-Enaction

In the previous section we have described two distinct types of social situation in which interactions between two or more individual agents can form a self-perpetuating dynamic structure at the level of the interactions themselves. In these types of social situation the interaction process entrains the actions of the individual interactors in such a way that they support the continuation of the interaction process itself. And, depending on the organization of the interaction process, it can either facilitate or hinder the realization of the individual interactors' goals accordingly.

3.1 Methodological considerations

However, it is not enough to simply describe these social situations in a

[7] For some recent critical accounts of conventional accounts of social cognition and 'mind-reading', see Gallagher 2001, 2005, 2008; Gallagher and Zahavi 2008, pp. 171-197. Dan Hutto's Narrative Practice Hypothesis provides a particularly fertile source for criticisms of orthodox approaches to social cognition (Hutto 2004, 2007; see also Gallagher and Hutto 2008).

[8] Note that we are also avoiding the category mistake committed by Theory of Mind approaches, which attempt to devise scientific explanations of social cognition by re-describing our personal-level abilities as hypothetical brain-based mechanisms (e.g., our personal-level ability to imagine ourselves in someone else's place makes a reappearance in the supposedly sub-personal simulation capacity of so-called mirror neurons). The enactive approach, on the other hand, does not have to make use of homuncular discourse when explaining sub-personal mechanisms underlying social interactions in terms of dynamical systems.

narrative manner and to affirm in an intuitive way the personal sense of being enabled or constrained in order to establish a science of social or interactive situations. What is additionally required is a basic proof of concept, which demonstrates that these narrative and phenomenological descriptions of the efficacy of interaction processes in certain social situations are not merely metaphorical embellishments of what is essentially a sum of individual actions. To show that the social interaction process itself can play a constitutive role for the actions of individual agents, we need to be able to show this process at work in a concrete model that allows for systematic exploration of the essential parameters.

One suitable way of satisfying this additional requirement is to take advantage of recent work in Evolutionary Robotics modeling. Since its beginnings in the early 1990s, the Evolutionary Robotics approach has established itself as a viable methodology for optimizing dynamical controllers for physical robots (Nolfi and Floreano 2000), as well as for synthesizing simulation models of what has become known as 'minimally cognitive behavior' (Beer 1996). The idea here is to set up an evolutionary algorithm that can automatically shape the dynamical system of a model agent so that it performs a given task in the simplest possible way, while still raising issues that are of genuine interest to cognitive scientists (Beer 2003, Harvey *et al.* 2005, Froese and Ziemke 2009). In the last decade there has been a growing interest in using this kind of Evolutionary Robotics approach to investigate the dynamics of social interactions (e.g., Iizuka and Di Paolo 2007a, Froese and Di Paolo 2008, Di Paolo *et al.* 2008), and the methodology has accordingly been extended to include 'minimally social behavior' as well (Froese and Di Paolo in press).

We will draw on some of our own modeling work in this area (Froese and Di Paolo 2010, in press), because the specific aim of these models is to serve as proof of concepts which demonstrate that interaction processes themselves can play a constitutive role in shaping individual actions over and above the sum power of the individual agents. In fact, as we have already argued extensively elsewhere (Froese and Gallagher 2010), the methodology of Evolutionary Robotics is well suited to complement phenomenological investigations in the cognitive sciences.

3.2 The dynamics of perceptual crossing

Froese and Di Paolo (2010) used an Evolutionary Robotics approach to

generate a series of agent-based simulation models whose minimalist task-design is directly based on a psychological experiment on perceptual crossing by Auvray, Lenay and Stewart (2009). The term 'perceptual crossing' denotes social situations in which the perceptual activities of two agents interact with each other (e.g., mutual touch or catching another's eye). Essentially, the study by Auvray and colleagues is an exploration of the most basic conditions that are necessary for participants to recognize each other by means of minimal technologically mediated interaction in a shared virtual space. Since this study is the original inspiration for the simulation models, we will describe it in a bit more detail first.

A schematic illustration of the overall experimental setup is shown in *Figure 1*. Two adult participants, acting under the same conditions, can move a cursor left and right along a shared one-dimensional virtual 'tape' that wraps around itself. They are asked to indicate the presence of the other's cursor-driven virtual 'body' by clicking a mouse button. The participants are in separate rooms and can only sense a tactile stimulation (on/off) on their finger, depending on whether the location of their cursor coincides with another object in the virtual space. Apart from each other's cursor object, participants can encounter a static object on the tape, or a mobile 'shadow' object that is fixed at a distance to the partner's cursor. All objects are strictly identical in size, and the two mobile objects (the other's cursor-driven 'body' and its attached 'shadow') perform identical movements. Importantly, only the other's cursor can be responsive to one's own movements since it provides tactile feedback to the other participant.

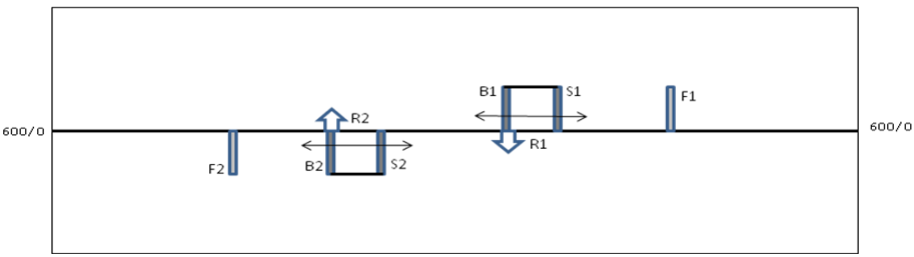


Figure 1: Visual schematic of the experimental setup of Auvray, Lenay and Stewart's (2009) study of perceptual crossing (adapted from Froese and Di Paolo 2010). Two participants inhabit a virtual space consisting of a 600 unit long 1-D toroidal (wrap-around) environment. The space is divided into two regions, 'Up' and 'Down'. Each region contains three objects,

shown as grey oblongs. These are (a) the participant's mouse-driven 'body' or 'avatar' (labeled B1, B2) which the participant can move left or right at will; (b) the body's 'shadow' (S1, S2) which moves in lockstep with the avatar; (c) a fixed object (F1, F2). In addition, each participant's has a receptor field (R1, R2 – shown as white arrows pointing into the other region), which move with the avatar's body, and which can overlap with each of the three objects in the other region as it moves left and right. In the actual experiment participants are blindfolded, and use a mouse to control the movement of their avatar; the other hand is placed on a custom-built tactile feedback device which issues an identical short vibration when the receptor field encounters an object in the opposing space.

Since all virtual objects are of the same size and only generate an all-or-nothing tactile response, the only way to differentiate between them is through the interaction dynamics that they afford. And, indeed, an analysis of the results revealed that, although they were often not aware of this fact, the participants did manage to locate each other successfully. Essentially, the reason for this success is that the ongoing mutual interaction afforded the most stable situation under these circumstances. If one participant's receptor field coincided with the other's body, thus activating the tactile feedback, the other participant's receptor field would simultaneously also coincide with the first participant's body, thus activating their tactile feedback, too. Accordingly, both participants were mutually engaged in the same interaction and neither of them had reason to disengage and to continue searching elsewhere. But if a participant happened to interact with the other's mobile shadow object (whose movements are an exact copy of the other's movements), the other would not receive any tactile feedback from their engagement and would continue searching, thus dragging their shadow object with them and terminating the other's attempt at interaction. Interaction with the shadow object is therefore inherently unstable, while mutual perceptual crossing is relatively stable. To be sure, interacting with a static object is stable too, but the lack of social contingency is given away when the interaction becomes too predictable, after a few iterations at least.

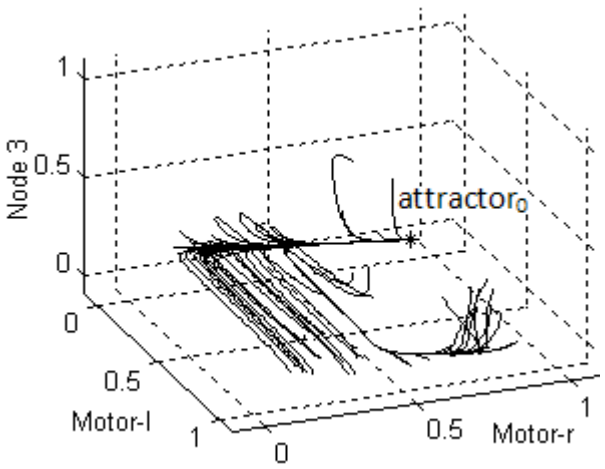
A closer look at the results reveals a special role of the interaction process in the overall outcome of the experiments. Interestingly, the participants 'failed' to achieve the task individually, because there was no significant difference between the probability of a clicking response to the other's body and the other's shadow object (Auvray *et al.* 2009, p. 39). In other words, on an interaction to interaction basis, the participants were unable to distinguish

between those situations that were characterized by social contingency and those that weren't. However, they still managed to solve the task collectively because of the self-sustaining dynamics of the interaction process. That is, *at the end of a whole trial the most clicks in total occurred during situations of actual perceptual crossing*. The upshot of these experiments therefore is that, even though it is impossible to distinguish the active partner from her irresponsive copy on an individual basis, it turns out that most clicks are made correctly because a mutual interaction is more likely to persist and participants are therefore more prone to face each other once again.

The value of modeling this psychological experiment has already been shown by Di Paolo, Rohde and Iizuka (2008), who used an Evolutionary Robotics approach to generate an agent-based simulation model which successfully replicated the main results of the study. At the same time it helped them in gaining some additional insights into the dynamics of the interaction process. For example, the problems that their model agents had with avoiding interactions with their respective static objects led them to predict similar difficulties for human participants. This prediction was already supported by the empirical data presented by Auvray and colleagues, but it had previously gone unnoticed.

Froese and Di Paolo (2010) continued this modeling research with the aim of gaining a better appreciation of the further potential of this general experimental setup and, at the same time, of improving our understanding of the constitutive role of the interaction process for individual behavior and agency. They began by using a similar modeling setup as that used by Di Paolo and colleagues (2008), and provided a comprehensive analysis of the evolved behavioral strategy by means of a set of simulated psycho-physical tests. The results of the original study and its first model were successfully replicated. The novel aspect of Froese and Di Paolo's re-implementation is the great simplicity of the 'neural' system of the evolved agents, which enables a detailed dynamical understanding of their behavior. An example of the kind of analysis that is made possible by this kind of model is shown in *Figure 2*.

(a)


Node 3
1
0.5
0
attractor0
0
0.5
Motor-l
1
0
0.5
Motor-r
1

(b)

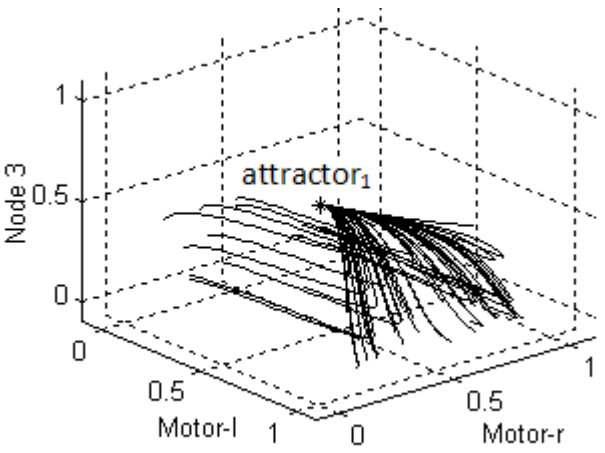

Node 3
1
0.5
0
attractor1
0
0.5
Motor-l
1
0
0.5
Motor-r
1

Figure 2: Illustration of the 3D state-space attractor landscape for the three-node continuous-time recurrent neural network (CTRNN) controlling the movements of one model agent (figure adapted from Froese 2009, p. 169). All nodes receive input from the agent′s receptor field and the output of the nodes labeled 'motor-r' and 'motor-l' determine the agent′s rightward and leftward velocity, respectively. Note that depending on whether the agent's receptor field is turned off (a) or on (b), the position of the point attractor, represented by a *, changes to a different region of state-space. The lines converging on the attractors represent a sample of possible state trajectories of the neural network (for 50 times the states of the network's nodes were initialized to random values drawn from a representative trial run and the network was allowed to settle for 8000 time steps). See text and Froese and Di Paolo 2010 for details.

When the continuous-time recurrent neural network (CTRNN) that controls movement of a model agent is decoupled from the 1-D environment, it is characterized by two fixed point attractors, (labeled attractor_0 and attractor_1) depending on whether the receptor field input is off or on. It turns out that the velocity of the agents is strongly coupled to the value of this parameter. This is indeed the basis for a tight sensorimotor coupling: the state of the receptor field input parameter is largely determined by the current movement of the agent in relation to its current environment (including potentially its relation to the other agent), and at the same time its current movement is largely determined by the state of the input parameter.

But this tight coupling should not be misunderstood as the mark of a purely reactive system, since the sensorimotor loop is mediated by a dynamical system with feedback connections. Moreover, because the contact sensor switches an agent's neural system between the two different attractor landscapes (with attractor0 and attractor1), the inter-individual interaction process is able to organize the flow of internal dynamics into a transient that makes the individual agents more responsive to the subtle changes of the interaction, thereby making it more likely that the ongoing interaction process can be sustained. Here we thus have a concrete example of how *an interaction process can be constitutive of individual behavior*.

It is also worth emphasizing that the processes that drive the necessary internal systemic changes via appropriate input-switching are largely external to the agent. In fact, they are partly constituted by the mutually responsive interaction with the other agent. An agent in an empty 1-D environment would be doomed to linear movement in a single direction, since it is lacking the

ability to internally switch between the two attractor landscapes. Only during an interaction with a responsive partner is the agent's internal organization transformed so as to allow for an open-ended entrainment that can flexibly proceed in either direction.[9] In other words, here we also have a concrete example of how *an interaction process can be constitutive of individual agency*.

3.3 Further investigations of perceptual crossing

To further illustrate the constitutive role of the interaction process on the behavior of the individual agents, Froese and Di Paolo conducted a series of additional experiments with the same computer model which we will briefly describe here. The aim of these models is to give a better sense of how the properties of the interaction process can shape individual behavior.

Receptor field switching experiment

In a first variation of the experimental setup, the receptor fields are switched between the agents such that each agent receives the other's sensory input. This modification cripples the agents' ability to interact with their environment on the basis of coherent sensorimotor correlations created by their own exploratory behavior. Nevertheless, it is found that even under this impaired condition stable perceptual crossing reliably emerges from the inter-agent interactions. Thus, even without any consistent sensorimotor correlations as a basis for individual behavior alone, the inter-individual interaction process essentially negates this lack because of the self-perpetuation of mutually responsive interactions. When the agents interact with each other, the mutuality of the interaction means that they essentially serve as each other's sensor interface, and this mutually and interactively re-established coherence of the individuals' sensorimotor loops reinforces the interaction as a whole.

In this manner, even when most individual behavior is less stable than in the original experimental setup, it is still possible for successful perceptual crossing to self-organize in terms of the relative stabilities of the interaction process. In sum, by modifying the original experimental setup Froese and Di

[9] The crucial role of mutual responsiveness in the scaffolding of individual agency and behavior, as it has been demonstrated by this model, may be able to teach us a lot about how to conduct our social relations. This is true especially in the context of nursing and in other situations of dependency, in particular those involving forms of impaired agency. See Colombetti and Torrance 2009 for a more detailed discussion.

Paolo (2010) thus demonstrated that the interaction process not only makes interaction with the shadow object *unstable*, thereby removing it as a possibility for further entrainment, but that it also plays a constitutive role in making perceptual crossing a *stable* possibility.

Individual behavior versus interaction process experiment

In a second variation, Froese and Di Paolo changed the task so as to introduce a conflict between individual behavior and global stability, namely by further evolving the agents to locate the mobile object which is precisely *not* the other agent, i.e., the other's mobile shadow object. The requirement of detecting social contingency, nevertheless, remains the same as before. This is because the individuals must still distinguish between those interactions that occur with the other's receptor field and those that result from the mobile shadow object, as well as avoid any interaction with the static object. However, in contrast to the original psychological study, here the agents are required to stay with their partner's shadow object, rather than staying with the receptor field of their actual partner. The task is therefore to detect a certain kind of mobile object that gives rise to *non-contingent* interactions, a task that can only be achieved by detecting, and then avoiding, interactions with contingently responsive mobile objects.

It should be noted that, due to the asymmetry inherent in this setup (i.e., agents face in opposite directions, but their shadows are displaced in the same direction), it is impossible for both participants to be interacting with each other's shadow at the same time. Therefore, in order to complete the task it is now necessary for the participants to avoid engaging in inter-individual interaction with each other, so that they can find the shadow object. This will not be easy because (i) engaging in perceptual crossing is still a relatively *stable* behavior, at least for as long as both interactors remain convinced that they are interacting with the other's shadow, and (ii) crossing with the other's shadow remains inherently *unstable*, since that other participant receives no stimulation from this interaction and will therefore keep on looking for the shadow of its partner. In this manner we have created an experimental setup in which the 'intentions' of the individuals and the dynamics of the whole inter-individual interaction process are in direct conflict, and which therefore allows us to further investigate what happens when individuals try to break out of interactions.

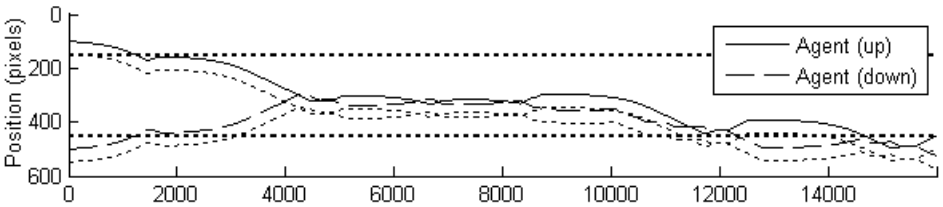


Figure 3: Illustration of the behavior of the agents and their attached shadow objects during a representative trial showing the change in positions over time (figure taken from Froese 2009, p. 164). They first encounter their respective static objects (seen as dotted lines), then continue searching, and finally locate each other and establish perceptual crossing until the end of the run (16000 time steps).

Froese and Di Paolo found that agents can temporarily succeed at this task, but only by regularly falling back into stable patterns of perceptual crossing. The beginning of a representative trial run is depicted in *Figure 3*. At time $t = 0$ the agents begin to move and are briefly distracted by encountering their respective static objects, until they first cross each other's receptor field after $t = 4000$. There then begins an extended period of mutual perceptual crossing until, after $t = 8000$, agent ('down') tries to break out of the interaction with the other agent, and to interact with the other's non-contingent shadow object. This is relatively successful until the agents fall back into mutual perceptual crossing at around $t = 12000$ and again at around $t = 15000$. The modeling results of this experimental variation therefore provide us with a simplified illustrative example of how it can be difficult for individuals to counteract the stability of mutual entrainment in an inter-individual interaction process, even if the disengagement from each other is in fact necessary or beneficial for the completion of their individual tasks.

3.4 Discussion of Results

In earlier sections we suggested that a central claim of the enactive approach to inter-individual interaction is that the dynamics of the interaction process as a whole can play a constitutive role for individual behavior (including sense-making) and for agency. The modeling results presented in the current section of the paper show that this central claim can be systematically approached in a scientific manner without recourse to some social mysterianism. By

constructing minimalist models with very simple artificial 'agents' we have been able to demonstrate how the inter-individual interaction process, *taken as a whole system*, can have important properties that in principle can neither be *separated* from the being and doing of the interacting individuals, nor be *reduced* to the being and doing of those individuals alone.

It may be argued that these modeling results are based on artificial 'agents' that are so minimalist that they have limited value when it comes to a scientific understanding of interactions between human subjects. And, of course, we do not want to claim that these kinds of model agents are actual agents or that the models include all that is essential for proper agency.[10] On the contrary, it further strengthens our arguments if we in fact choose to treat these agents merely as simple dynamical systems, since it shows that we are must be kept in mind that these models are directly based on actual psychological studies, that they replicate the main results of those studies, and that they give additional insight into these results that were not directly evident before (Di Paolo *et al.* 2008). They allow us to distill the essential features of an experimental setup and to explore the space of possible solutions in a mutually informing manner (Froese and Di Paolo in press). For instance, some initial exploratory psychological experiments of perceptual crossing conducted by De Jaegher and Di Paolo at the University of Sussex in 2009 have indicated that human subjects are indeed capable of overcoming the limitations of switched receptor fields because of the stabilizing influence of mutual interaction (Di Paolo, personal communication).

3.5 Future work: Situating interaction processes in a socio-cultural context

We have described and analyzed two types of inter-individual interaction processes in some detail, namely those in which the goals of the interacting individuals are complementary, and those that are in conflict, with the organization of the interaction process itself. But there is another important type of inter-individual interaction which we have not mentioned yet. It can happen that the way in which an interaction process unfolds ends up modifying the goals of the interacting individuals such that there is suddenly a new purpose to their actions. De Jaegher and Di Paolo (2008) discuss an illustrative example where an infant holds up a toy object and in response the

[10] See Froese and Ziemke 2009 for an extended discussion on this topic.

mother also grasps it, and then continues to hold the object when the infant releases its grip. In this situation the infant's action may have started out as a simple stretching of the arm or display and, through the interaction with the mother, the action was in the end invested with a novel social meaning, namely that of giving something to someone else. The behavioral repertoire of the infant has thus been transformed in the interaction, and the act of giving can from now on be initiated intentionally to modulate the flow of social interactions.

Note that this example also nicely illustrates the important distinction between participatory sense-making and social cognition (Gallagher 2009)[11], and a possible transition between the two forms of interaction. As Gallagher points out, while the notion of participatory sense-making denotes the process of sense-making *with* another (although this other is not necessarily the object of this sense-making), social cognition is a term used to characterize the process of cognition *about* another (although this process does not necessarily happen with another). In the case of the mother who spontaneously completes the infant's act of reaching with an object by receiving the object, such that the interaction invests the infant's original act with the new meaning of 'giving', we have an example of how participatory sense-making (the infant-mother interaction provides the infant with new meaning) enables an instance of social cognition (the intentional act of giving involves reference to someone else).

This kind of inter-individual interaction considerably complicates the picture of the constitutive role of the interaction process, because it is no longer just a matter of how an individual's goals are hindered or facilitated by that interaction process. We are now moving toward a more dynamic view of social interaction according to which the interaction process itself can modify the normative structure of the interacting agents while they are interacting. Moreover, this example illustrates how closely the real-time dynamics of an inter-individual interaction process and the historical normative order that defines the socio-cultural background are related. It is on this basis that an individual's enculturation into a social network whose interactions are explicitly and implicitly regulated by an arbitrary (symbolic and traditional) set of preexisting norms becomes a possibility.

We find this kind of inter-enaction of meaning and purpose in an exemplary

[11] Gallagher's use of the term 'social cognition' is in line with the current conventions in the cognitive sciences. But in this context it may be a misleading term for a number of reasons (see next section for details).

form in the case of artistic group activities, such as collective jazz improvisation. In relatively simple versions of joint improvised playing, two or more musicians may agree a basic framework (e.g., chord sequence, tempo) but such a framework is by no means inevitable. One or other player may take the 'lead' while others 'follow' but roles may be swapped rapidly – or perhaps there is no clear lead-follower differentiation. What typically results is a set of unrehearsed and unplanned developments in the musical production which may take off in risky directions that are completely unanticipated by all participants, often radically departing from the set melodic and chordal structure, tempo, and so on. In such explorations there will be a continual and subtle cross-play between what occurs intentionally and what occurs by happenstance, between what is the result of individual agency and what emerges as a group product, and between what is spontaneously co-created in the moment and what is derived from a longstanding heritage of musical tradition. The example of jazz improvisation therefore provides a very useful phenomenon for clarifying how different individual, interactional and socio-cultural factors can shape individual and group behavior.

We currently do not know of any agent-based models which specifically investigate the relationship between the autonomous dynamics of the inter-individual interaction process and the pre-existing normative order that is determined by socio-cultural context in which the interaction process is situated, although there are some promising leads. It may be useful for future Evolutionary Robotics work in this area to take a closer look at some of the models inspired by duet interactions (e.g., Di Paolo 2000, Ikegami and Iizuka 2007) and models of spontaneous goal switching (e.g., Iizuka and Di Paolo 2007b). It is possible that an integration of these two approaches could provide a first step toward a better dynamical understanding of how individual behavior, an ongoing interaction process, and a pre-existing history of interactions together can lead to changes of an agent's goals. At least one thing is clear already: since the enactive approach to agency is going to draw on cognitive science, interaction science, and social science in one unified framework, it is essential to be clear about the term 'social', which perhaps has different connotations in each of these areas of research.

4. Inter-Enaction and 'Sociality'

In the preceding discussion we have sometimes referred to 'interaction' (or 'inter-enaction', our preferred term for a certain enactive view of the latter), and sometimes to 'social interaction'. We act and cognize with others and about others in our world in a variety of ways – are all of those ways to be included in a blanket way within the terms of the account of 'participatory sense-making' (PSM) sketched here and in other works cited? In what follows we will consider a view which is, in many ways, critical of the PSM or inter-enactive account. This discussion will enable us to clarify what we see as a correct evaluation of the scope of PSM theory, and also to put right certain possible mistaken assumptions about the PSM approach.

In a recent paper, Pierre Steiner and John Stewart (2009) claim that the PSM account put forward by De Jaegher and Di Paolo, and endorsed by others (including ourselves) is, at worst, radically flawed, and at best, much more limited in the extent of its application than its proponents are claiming.[12] This is for two interconnected reasons. First, the PSM view fails to take account of the fundamental role played by social norms, or (as they put it) 'normative order', in setting the context for our inter-individual interactions. These social norms include communicative, moral, legal, economic, religious, etc. rules, expectations, forms of life, and so on. As they see it, these normative structures constitute the very fabric of the *social* environment in which humans live and interact on a day-to-day basis.

Second, far from being a field of autonomy, the realm of social normativity imposes important constraints (they claim) on how the fine-grained interactions of our day-to-day life unfold: the existence and ubiquity of such constraints make it appropriate to talk of this field of inter-individual interactions as one of *heteronomy*, rather than – as the PSM account suggests – one of *autonomy*.

The authors argue that the notion of 'sociality' – and related terms such as 'social cognition', 'social interaction' – can be understood in at least two importantly different ways. On their own view, which makes strong appeals to a tradition of social theory stemming from Émile Durkheim, Talcott Parsons and many others, sociality is largely constituted by this pre-existing, culturally inherited, normative order that each social agent (human) finds him/herself

[12] Their account is couched in terms of a discussion of 'social cognition' but it equally applies to 'social interaction', and indeed to the nature of the 'social' in general.

embedded in throughout daily life. The norms in this pre-existing structure

> actually constitute the possibility of enacting worlds that would just not exist without them. Interactions between two or more agents are never properly social unless they take place in the context of an environment of social structures or norms which give meaning to the interactions. (Steiner and Stewart 2009, p. 528)

Let us call Steiner and Stewart's account the 'social normative order' approach (SNO for short).

On the contrasting view of sociality, which they identify with the PSM account, sociality emerges from the dynamics of the inter-individual interactions as they unfold in the here-and-now. The relatively small-scale interactions that are the major focus of the PSM account are actually 'heteronomous' with respect to these large-scale pre-existing structures, rather than autonomous processes that are constitutive of sociality.

We believe that the SNO account makes some crucially important points, and does indeed highlight gaps or inadequacies in the original PSM account. Nevertheless we will argue that it is possible to resolve the apparent disparities between the PSM and SNO accounts, by making some conceptual clarifications, and by delineating different terms of reference or scopes of application for the different accounts. The result will be a fuller picture of interactive agency and of sociality than is presented in either account as they stand.

Consider again the situation where two people are walking towards each other along a confined passageway. The PSM account will refer to this situation as involving an independent dynamic of interaction, which has its own *autonomy,* which in turn constrains the activities of the individual participants in the situation. Yet clearly, to the extent to which the individual participants in such a corridor scene are 'subject to' this dynamic, they are 'heteronomous' with respect to the dynamic itself. So heteronomy could be seen as being equally a feature of the PSM account as provided by De Jaegher and Di Paolo (although their account happens not to employ that term). Of course any actual corridor scene will include a host of other features which are not specified in the bare description 'two people rapidly walking towards each other and attempting to adjust their position within the narrow space of the passageway' – where it is more or less treated as a physical interaction. There will be rules of etiquette, for example, that prescribe ways of dealing with the situation that are and aren't 'socially acceptable' (one person shouting at or shoving past, the

other will be considered rude or even an assault; laying on the ground and inviting the other to walk over you would be considered impossibly obsequious; and so on).[13] These will be part of a vast array of culturally prescribed social norms – sometimes explicitly codified, and sometimes implicitly understood and even unconscious to participants – that govern the way that people are expected or allowed to behave in public spaces. These do indeed shape the situation that often unfolds in the way described in the canonical 'corridor scene'. And indeed, in relation to these pre-existing normative structures, the dynamic of the interaction of the two passing figures, as they alternately move to one side, then to the other, of the passageway, will indeed, qua interactive dynamics, be describable as heteronomous rather than autonomous. But at the same time, in relation to the individual participants themselves, this interactive process does occupy a degree of autonomy, as described in the PSM account.

For a similar reason, the pre-existing normative orders that are referred to in the SNO account can perhaps equally be described as 'autonomous' (independent; transcendent) with respect to the participants. Steiner and Stewart choose not to use the word 'autonomous' in this connection (2009, p. 530) because they want to stress the idea of heteronomy (when focusing on the participants). But of course 'autonomy' and 'heteronomy' are (certainly in this context) point-of-view-relative terms. In the case of both PSM and SNO there are individual agents and a supra-individual structure. In each case the supra-individual structure (interaction-dynamic in the PSM account; historically-given normative order in the SNO account) has 'autonomy' in the broad sense of being 'independent', having its own 'life'. Also, in both accounts this structure constrains and enables actions by the individuals. Conversely, in the case of both accounts, the individual agents are heteronomous with respect to the over-arching structure, because of the constitutive, enabling role each structure has on their activity.

Once pointed out, this should seem obvious, but perhaps it needs to be clarified, so as to forestall any further confusion. Thus Steiner and Stewart are perhaps wrong in saying that heteronomy plays no role in the PSM account (because it is there, even though not named as such). Nevertheless they are correct in saying that the kind of heteronomy imposed on (or better, implied

[13] See Colombetti and Torrance 2009, for an elaboration of this point, and for a discussion of the richly *ethical* nature of such apparently simple interactions.

for) individual agents by the normative order which provides the medium for their interactions (and makes them 'fully human agents') has complex, wide-ranging and subtle characteristics, which are not recognized (or not stressed fully enough) in the PSM account, and which are elaborated at length within Steiner and Stewart's paper. Conversely, the PSM account in turn involves subtle features – for example those to do with the dynamics of interaction which we have sought to stress in the descriptions of experimental investigations earlier in the paper – which are not taken up in Steiner and Stewart's SNO account. Thus each paper contains important elements that have to be brought together in order to have a properly filled-out picture of social inter-(en)action.

Another, related, point that needs to be made concerns the 'sense-making' aspect of the PSM account. In the above discussion we have mostly concentrated on the autonomy of the interaction between participants, relative to those individual agents themselves. But of course, as the term 'participatory sense-making' is intended to convey, the interaction between two or more agents (in the face-to-face, real-time situations which were of primary interest to the authors of the PSM account) typically involves a continual exploratory unfolding of the situation.

Consider, as an example, the interaction that might typically occur between two motorists who find themselves in a collision: as they encounter one another each may have a pre-planned culturally determined 'script' which they may aspire to follow in a way that will (they hope) remain relatively impervious to the way the other may seek to influence the interaction. Yet what often happens is that the actual development of the interaction involves a path which is mutually influenced by the two actors, and which often follows a trajectory that conforms to the prior expectations of neither of them.

Talking of the 'autonomy' of the interaction process helps to evoke the way that this trajectory seems to take on a 'life' of its own, to a greater or lesser degree independent of the individual participants. But equally, one can talk of this unfolding as a mutual exploration of the relation-space, where significances are jointly created (indeed, 'enacted') by the participants. For example there will be a negotiation over the affective tone that this encounter will take – will the course it follows be on the whole friendly or hostile? Sometimes such joint meaning-making will be primarily cooperative or collaborative, sometimes it will have a primarily combatitive or aggressive character; more often than not it will have elements of both.

There are many other examples of encounters that facilitate an ongoing exploration that has an exploratory, creative character on the part of the actors, where meanings are constantly 'enacted', 'challenged', 'reinforced', and so on but where this exploratory, enactive process may also be seen as having its own independent dynamic. The example of jazz improvisation was mentioned earlier. (Even in this sphere of artistic collaboration there may be both cooperative and confrontational elements). To get a feel for other kinds of example think of the kinds of interactions that commonly take place between people, whether in buses or underground trains or lifts, etc., people playing sports like football and squash; or again people in various kinds of sexual encounters, whether they be courtship scenes, blocked or reluctantly-borne come-ons, full-blooded passion, or any of the other myriad variants of sexual interaction.

How, then, should we relate these two accounts or these two levels of description? How does the exploratory, enactive, and immediate character of the meaning-making dynamic in real-time interactions, as characterized within the PSM story, cohere with the vast edifice of inherited, culturally-accreted norms which is the dominant *motif* of the SNO account? There may seem to be a conflict: surely, it might be said, both cannot be true. Yet that is just what, on a more reflective examination, can be agreed to be indeed the case. We construct the shared meanings in our ongoing, real-time interactions, within the context of a vast array of social 'givens', which have a solidity for individual participants – a social solidity, one might say. These social 'givens' (both informal and codified) will both facilitate and constrain the individual interactive encounters that occur at the face-to-face level. Thus, for the disputants in the automobile collision these norms include legal regulations, financial constraints, bounds of moral acceptability in word and action, instructions or recommendations in documents on how to conduct oneself at an accident scene, as well, of course, as the physical and technological conditions of the situation itself and the perceptions and memories of the sequence of relevant events.[14] But while these social givens set prescriptive

[14] Of course there are many other features of social encounters besides the interactional dynamics highlighted by PSM and the historic normative structures highlighted by SNO. It should be obvious that physical, biological, psychological conditions of different sorts play important roles, of both a primary or supportive kind. The roles of different kinds of artefacts, including texts and other symbolic media, and technological devices of many kinds, should also be stressed (e.g., Clark 2003). PSM and SNO mark out important necessary features of social action: they are in no way to be considered as jointly sufficient.

and/or permissive conditions for the interactions that occur on a given occasion, the interactions themselves will involve creative reinterpretation and modification of the very norms which are the framework within which the interaction takes place. As often as not these reinterpretations are trivial. Sometimes they can be of major cultural or political significance – as, for example, was the occasion on December 1st 1955 in Montgomery Alabama when Mrs. Rosa Parks, a black passenger on a bus, refused to move from a her seat to enable a white person entering the bus to sit in a whites-only row, in accordance with racial segregation practices in operation at the time.

Moreover, it is worth asking how these apparently impersonal social norms that are emphasized by Steiner and Stewart actually maintain their continued existence. They don't just exist in a special normative realm independently of the actual lives of people: they are embedded in the ways people conduct those lives – their continued existence requires that they be continually (inter-) enacted, in either word or deed. As pointed out above, more often than not norms are written down in various forms (or are repeated in various kinds of confirmatory speech-act). But this is true only of some kinds of norms, and even those will actively maintain their force in the social order only as a result of compliant patterns of action and interaction, and through acts of positive and negative sanction. Thus what made the whites-only norm a norm that was in force in buses in the Alabama of 1955 was the fact that it was regularly adhered to in action by both white and black travelers, and that non-compliance was met with fines or other punishments. So, while Steiner and Stewart are right that interactions of the face-to-face sort take on the character that they do because of constitutive role played by the background of historic social norms, those historic norms themselves are perpetuated through continuing compliant interactions by the members of the population for whom those norms have force.[15]

What these considerations strongly suggest is that the PSM account and the

[15] Indeed it is important to see that the term 'participatory sense-making' should be interpreted to cover, not just the kind of case where new interpretative directions are taken for a given rule or set of rules, but also the kind of case where an existing way of doing things is reaffirmed by faithful repetition. Thus taking a moment to say Grace before starting a family meal will be as much a case of participatory sense-making, as breaking with tradition by missing out on Grace. In the latter case the participants are creating a new 'sense' to their joint meal-taking activity; in the former case the participants are re-affirming their recognition of an old 'sense' – that of their traditional way of starting a meal-time. In each case the participants are *enacting* a continuation into the future of what they perceive as the way the past demands or permits them to act in the here and now.

SNO accounts are both necessary to a full understanding of inter-individual relationships and larger scale social relationships as well, of course, of individual agency. Not merely are they both necessary, but they are complementary processes, in that each process is partially constitutive of the other process. As Steiner and Stewart have emphasized in their account, the interactions that take place in real time, at a face-to-face level are constitutively governed by countless historically accreted social norms that exist as an impersonal background to the real-time interactions. However, as we have argued, the PSM account of face-to-face interactions[16] gives an account of the social reality of those social norms, by explaining that the existence of the historic force of those social norms is itself constituted by countless interactions, sayings and collaborations in the past; and that their continued existence is constituted by further interactions, sayings and collaborations into the future.

5. Conclusions

In this paper we have discussed three kinds of view: individualism; PSM; SNO. These three views suggest three different levels of analysis: one focusing on individual 'in-the-head' cognitive processes; one on the dynamics of inter-individual interactions; and on the historical structures of large- (and small-) scale social norms. Individualism interprets the inter-individual and the social in terms of individual acts and internal processes, more often than not couched in terms of some variant of the cognitivist (sense-model-plan-act) story, whose odd solipsist character only becomes evident when critics of the story, such as enactivists and others, bring it to attention. The enactive approach to agency, with its emphasis on the relational nature of life and mind, provides a different kind of departure point for a consideration of the role of sociality.

We have considered two variants here. PSM concentrates on the inter-individual level, the level at which people participate with each other in a shared moving present, and a shared presence, in which the dynamic of the interaction can be seen as having its own relative autonomy, both arising out of the agents' moves and as continually restructuring them. We have shown how

[16] The term 'face-to-face' should be used with some caution. Some interactions, for example via Facebook or Twitter, are hardly face-to-face in any literal sense. Nor are they necessary small-scale or intimate: a given announcement on a social networking site may have an audience of millions!

theoretical claims about the dynamics of these interactions can be grounded in experimental models based on minimalist scenarios using artificial agents. SNO sees action primarily in terms of the historic social norms which have created the background of expectations and rules that act as the fundamental enabling and constraining factors of the unfolding shared present. PSM and SNO can be seen as offering two contrasting responses to classical individualism, each of which stresses a crucial aspect of the supra-individual nature of human action.

However these two views are not in competition. Clearly they offer necessary complements to each other. PSM needs SNO to explain the sense in which present-tense interactions are truly social, rather than just 'inter-agential'. But SNO needs PSM to explain how the vast edifice of historical normativity left by dead people and dead time, retains its liveness in the present and into the future by countless collaborative acts of reinterpretation, revision and reaffirmation. A considered version of inter-enactivism has to stress both these levels as offering important constitutive conditions for human action.

Thus it is important, as social normative order theory insists, to see every action as taking place within a historical context – which includes the high-level accreted norms at various scales of globality and locality – broadly universal rules to do with economy, morality, prevailing technical conditions, etc., as well as community-specific and family-specific normative environments; but, it must be stressed, much else besides social norms: the physical and biological conditions, the phylogenetic and ontogenetic inheritances, and so on. However, at the moment of action or interaction itself there is also the dynamic of how the actors in a situation both are shaped by these normative conditions and reshape them in their interaction, and how the actions of each individual agent in the situation both shape and are shaped by the actions of the others present in that situation. This is the domain of participatory sense-making, but for a more complete enactivist picture we need to combine this domain of inter-individual dynamic presence with the past social conditions which have brought those individuals to this presence.

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