Perceiving at a distance: enaction, exteriority and possibility–a tribute to John Stewart

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Abstract

The aim of this article is to offer a new approach of perception regarding the position of a distant object. It is also a tribute to John Stewart who accompanied the first stages of this research. Having already examined the difficulties surrounding questions of the perception of exteriority within the framework of enactive approaches, we will proceed in two stages. The first stage will consist of an attempt to explain distal perception in terms of individual sensorimotor invariants. This poses the problem but fails to solve it. The second stage will propose a new pathway to account for spatial perception; a pathway that does not deny the initial intuitions of the autopoietic enactive approaches, but one which radically changes the conception of cognition by considering, from the perceptual stage, the need to take into account interindividual interactions. The protocol of an original experimental study will characterize this new approach considering the perceptual experience of objects at a distance, in exteriority, in a space of possibilities without parting from the domain of interaction. To do this, we have to work at the limits of the perceptual crossing, that is, at the moment when the perceptual reciprocity between different subjects begins to disappear.

1. Introduction - Exteriority

We propose a theoretical and methodological discussion of the conditions for a naturalization of the experience of spatial exteriority. This text is also a tribute to John Stewart who accompanied the theoretical approach and the minimalist experimental method that we will mobilize.[1] The core of John Stewart's work is marked by the conviction of a fundamental equivalence between cognition and life, between the activities of perception or knowledge, and the know-how of the living being who manages to maintain his existence in a variable and dangerous environment (Stewart, 1992). At the same time, for the sake of consistency, it is a matter of applying the results of the research to the observer, that is, to ourselves. The naturalization process must therefore have a first-person respondent to reflect our phenomenological experience of a meaningful world (Petitot, et al., 2000). We want to examine here whether such an approach makes it possible to account for spatial perception. This will

[1] John Stewart recently passed away (09/09/1941-01/31/2021). His work was marked by a constant effort to re-enchant scientific research in biology as in cognitive sciences. In both cases, it is a question of allying the effort of naturalization with the refusal of an eliminative reductionism. In biology, it is about finding alternatives to theories of living things that claim to reduce morphogenesis and evolution to only information from the genetic code (Stewart, 2019). In cognitive science, it is about proposing alternatives to the computational theories of the mind which claim to reduce cognition to information processing. Two great struggles that he brings together in one through the equation "life = cognition" (Stewart, 1992; Stewart, 1995). Methodologically, this program is characterized by the effort to always consider the observer's point of view, which must be understood both as an epistemological critique accompanying scientific research and as a personal commitment.

lead us to the criticism of an explanation that focuses too heavily on the individual instead of promoting the constitutive role of interactions between organisms.

How do we explain the perceptual experience of a distant object in space? How do we account for the perception of a separation between our point of view *over here* and the position of an object *over there*? (Siegle & Warren, 2010). This fundamental question has been widely discussed in philosophy from Berkeley to Husserl, Heidegger or Merleau-Ponty (Declerck & Lenay, 2018; Pacherie, 1997). Here we want to address it from the point of view of naturalization efforts in cognitive science (Epstein et al., 1986). Our goal is not only to explain the ability to determine distances, but also to account for the lived experience of the exteriority of things in a space that separates us.

The distance from the predator or to the prey finds sense in the present multiplicity of their possible positions and routes. This phenomenological experience is charged with its own issues and values, dangers and desires which only have meaning through what can happen and which depend on proximity (spatial or temporal). This is certainly the essential, ecological reason for this type of perception. The question of the perception of the exteriority of the object is therefore also that of the experience of the space before us as a phenomenal field of a simultaneous multiplicity of various possibilities. The visual perception of an object at a distance is particularly revealing. If *over there* I perceive this table as a three-dimensional object, my current perception of one of its faces, as to be associated, with all its other faces that could exist for other possible points of view. This is what Husserl calls the internal horizon of the object. Likewise, it seems to us that the space which separates us from the object, or which separates it from other objects, is also present as a set of places where we could be, of routes that we could follow (Husserl, 2013).

In the context of enactive approaches, the "sense making", the way in which the organism brings forth a world loaded with value, would take place in the coupling between the living organism and an environment to which it gives meaning according to the conditions for maintaining its own existence. Now, for the events or objects of such a world to be able to take on the meaning of positive or negative values for the organism itself, it is necessary to explain the presence of a simultaneous multiplicity of various alternatives, good or bad, not yet realized for her. For sense-making theories to respond to the claim of explaining lived experience, they must therefore be able to account for the experience of objects and events at a distance, in exteriority in a space of possibilities.

2. Enaction and Exteriority

As stated, we will adopt as our starting point, the reflections of John Stewart who, following the work of Francisco Varela and Humberto Maturana, places autopoiesis of the living as a fundamental principle of cognition. But does this theory of autopoiesis offer sufficient resources to account for the experience of separation from the object of perception? This seems to present some difficulties since precisely, as opposed to representationalism, the enactive approach posits that "object" and "subject" are intrinsically inseparable (Stewart, 1992; Varela & Poerksen, 2006). Let us quickly recall how this essential question for enactive approaches has already been discussed.

The starting point is the idea of the autonomy of a system. A system is autonomous if it is the cause of maintaining its own existence. This autonomy is achieved in the case of the living

organism by an autopoietic organization, that is to say, an organization of physico-chemical processes such that they reproduce the organization itself (Varela, 1979).[2] At each moment the organization is concretely carried out by a particularly structural state (the present state of the processes). This structural state is susceptible to perturbations that cause structural changes. Either these changes continue to achieve auopoietic unity, or the perturbations are destructive, producing the irreversible disappearance of this unity. As long as the autopoietic organization is maintained, there is an operational closure: any change in a structural state produces a new structural state.

For each structural state we can define the set of possible non-destructive perturbations that would cause viable structural changes. These structural changes themselves produce new perturbations depending on the state of the environment. The sequence of perturbations and structural changes create a structural coupling with the environment. We then define the coupling domain or interaction domain, as being the set of possible coupling states, which preserve the existence of the system.[3] The same logic of an operational closure of an autonomous system works for all levels of organization, and in particular the dynamics of the nervous system of multicellular organisms in sensorimotor coupling with their environment. Depending on the possibilities of action (structural changes) and sensation (perturbations) offered by the system, a specific interaction domain will arise.

By its autonomy, the system is distinguished from its environment, a distinction which is not reduced to the membrane, but which corresponds more fundamentally to the operational closure of its organization (Di Paolo & Thompson, 2014; Virgo et al., 2009). An external observer can recognize, on the one hand, the autonomous unit which is achieved by the sequence of structural states that preserve its organization, and on the other hand, the environment which determines the perturbations of the unit as a function of its structural changes. This environment is defined in relation to the unit as anything that is likely to produce perturbations compatible with the continuation of its existence. It is an ecological niche defined by the organism that inhabits it and which is at the same time, a condition of its existence. There is thus a "point of view" being established in the world (Froese & Stewart, 2010).[4] One thought there were enough elements to account for a world specific to the organism, that is to say of an Umwelt in the sense of (Von Uexküll, 1992) which would be distinguished from the simple physical environment (Varela & Bourgine, 1992) …

> *"…the important distinction between the environment of the living system as it appears to an observer and without reference to the autonomous unity—which we shall call hereafter simply the environment—and the environment for the system, which is defined in the same movement that gave rise to its identity and that only exists in that mutual definition—hereinafter the system's world." (Varela, 1997)*

[2] " an autopoietic system is organized (defined as a unity) as a network of processes of production (synthesis and destruction) of components such that these components: - continuously regenerate and realize the network that produces them, and - constitute the system as a distinguishable unity in the domain in which they exist." (Varela, 1997) "The living organization is a circular organization which secures the production or maintenance of the components that specify it in such a manner that the product of their functioning is the very same organization that produces them. Accordingly, a living system is an homeostatic system whose homeostatic organization has its own organization as the variable that it maintains constant through the production and functioning of the components that specify it, and is defined as a unit of interactions by this very organization (Maturana, 1970).

[3] "A living system defines through its organization the domain of all interactions into which it can possibly enter without losing its identity, and it maintains its identity only as long as the basic circularity that defines it as a unit of interactions remains unbroken." (Maturana, 1970) "Accordingly, any system which fulfils the criteria for autopoiesis also generates its own domain of possible interactions in the same movement in which it gives rise to its emergent identity " (Thompson, 2007).

[4] "the autopoietic unity creates a perspective from which the exterior is one, which cannot be confused with the physical surroundings as they appear to us as observers, the land of physical and chemical laws simpliciter, devoid of such perspectivism." (Varela, 1997).

However, is it possible to speak so quickly of a "world" of autonomous unity if we have not accounted of a field of possibilities for it? Certainly, we can consider that perception is not an internal state of the organism but that it is enacted as a state of its coupling with the environment.[5] However, we can only take this into consideration for the system that can produce or modify invariants of the dynamic that ensure the reproduction of its autonomous organization. These invariants are fully specified from within its organizational closure. Each perturbation only selects a change in the repertoire of possible structural changes (Maturana & Varela, 1987: 122). One cannot leave the domain of interaction to access causes of perturbations other than the preceding coupling states: "there is no other "object" of knowledge than the subject's own dynamic existence" (Stewart, 1992).This poses significant difficulties for the equivalence of life and cognition.

From the point of view of living things, we can no longer speak of adaptation to an external environment since it is the organism that defines the world that allows its existence. Either the structural coupling is viable, or it breaks the operational closure and the organism disappears. As long as the organism is maintained, the domain of interaction it defines remains conducive to its existence. There is no range of suitability; there is no range of proximity with the limits of the domain of viability, "there is no room for accounting for the different shades of meaning which are constitutive of any organism's lived Umwelt." (Froese & Di Paolo, 2011). There is only a factual, precarious coupling, without feedback of this precariousness, towards the dynamics of autopoiesis.[6] Adaptation is a tautology and evolution is only a drift (Maturana & Varela, 1987).

From the point of view of cognition, we do not see how to account for sense-making without stakes, without finality. As Tom Froese and John Stewart note, the definition of autopoiesis given by Maturana and Varela "is insufficient for grounding a lived perspective of concern (eg, Di Paolo, 2005), desire (eg, Barbaras, 2002), and thus of lived experience more generally" (Froese & Stewart, 2010). Similarly, this definition of autopoiesis does not allow us to account for normative activity such as adaptivity and the orientation of action towards goals (Barandiaran & Moreno, 2008; Bourgine & Stewart, 2004; Froese & Stewart, 2010).[7]

In its original form, the theory of autopoiesis is mechanistic and anti-teleological,[8] but to address this problem of an explanation of value, Varela and Weber proposed in 2002 to re-establish a form of "natural purpose" (Thompson, 2004). From a reading of Emmanuel Kant (Critique of the Power of Judgment, §64-65) (Kant, 2000) and Hans Jonas (Jonas & Jonas, 2001), they state:

> *"In other words by putting at the center the autonomy of even the minimal cellular organism we inescapably find an intrinsic teleology in two complementary modes. First, a basic purpose in the maintenance of its own identity, an affirmation of life. Second, directly*

[5] Cognition "is not the representation of a pre-given world, but is, rather, the enactment or bringing forth of a world on the basis of history and the variety of effective actions that a being can perform" (Dupuy & Varela, 1992, p.20).

[6] "There is no room for concepts such as lacks, minor or major breakdowns in autopoiesis: either organization is conserved or it isn't – being partially autopoietic is senseless and any notion of the system being at risk of disintegrating would be a remark made by the external observer and plays no operational role." (Di Paolo, 2005, p.436)

[7] " the concept of autopoiesis (or constitutive autonomy more generally) by itself allows no gradation — either a system belongs to the class of such systems or it does not (Froese & Di Paolo, 2011, p.8).

[8] "Our approach will be mechanistic: no forces or principles will be adduced which are not found in the physical universe" (Maturana & Varela, 1980) "We maintain that living systems are machines … and, hence, that [their organization] can be explained as any organization is explained, that is, in terms of relations, not of component properties." (Maturana & Varela, 1980). As is well recognized by Di Paolo: "Central to the theory of autopoiesis is the axiom of structural determinism: changes of state in a system always operate in the present as a result of its current structure and are not determined by external agents or contextual conditions." (Di Paolo, 2005, p.434) "Living systems, as physical autopoietic machines, are purposeless systems" (Maturana & Varela, 1980, p.86).

> *emerging from the aspect of concern to affirm life, a sense-creation purpose whence meaning comes to its surrounding, introducing a difference between environment (the physical impacts it receives), and world (how that environment is evaluated from the point of view established by maintaining an identity).”*
> *“The perspective of a challenged and self-affirming organism lays a new grid over the world: a ubiquitous scale of value. To have a world for an organism thus first and foremost means to have value which it brings forth by the very process of its identity” (Weber & Varela, 2002, p.117).*

But it seems to us that they go without explanation from "being a stake" to "having a stake." Certainly, the existence of the organism is an issue which makes a difference in the physical environment between what preserves it and what would make it disappear.[9] But that is not having an issue for the organism itself. We cannot account for a world charged with values for the organism until we explain how the different possibilities at play would be present for it. We can well admit that the circular causality of the autopoietic organization defines an internal end (the maintenance of its existence), but the fact that the world is defined by the domain of interaction is not sufficient for enacting external ends to pursue. At every moment the organism is in a unique structural state, carried along in a particular trajectory in its domain of interaction. We can describe finalized behaviours of a deterministic system via a regulatory mechanism (this is the great contribution of cybernetics (Rosenblueth et al., 1943)), but this finality is only visible from the point of view of an external observer who recognizes a final state (an attractor) in the space of possible states of the dynamic system. If we want to have a finality from the point of view of the organism, there must be a background of possibilities present from which goals could be detached. Proposing an explanation of this field of possibility for the organism is a necessary condition for claiming a naturalization of perceptual experience, or at least for proposing objective respondents of phenomenological experience. Therefore, if we do not want to abandon the equivalence of life and cognition, we can either modify the definition of autopoiesis, or add other properties to define living things.

Thus Bourgine & Stewart (2004) modified the definition of autopoiesis to add that structural changes must help to maintain the viability of the organism. The organization “will not be cognitive unless the consequences for the internal state of the system are employed to trigger specific actions that promote the viability of the system.” (Bitbol & Luisi, 2004; Bourgine & Stewart, 2004).[10] The dynamics of autopoiesis would be an individuation process like that of the dissipative structures of thermodynamics far from equilibrium (vortex, candle flame), but organized in such a way that the living organism exercises control over the conditions to the limit so that its individuation process can continue indefinitely (Froese & Stewart, 2010; Stewart et al., 2010).

Or, as Di Paolo, 2005) we can add to autopoiesis a complementary mechanism, in this case, adaptivity: “However, in order for an autopoietic system to actively improve its current situation, it must (i) be capable of determining how the ongoing structural changes are shaping its trajectory within the viability set, and (ii) have the capacity to regulate the conditions of this

[9] “This is because only mortal beings can be concerned about their existence and therefore value its continuation and realization.” (Tom Froese & Stewart, 2012). “This process of meaning generation in relation to the concerned perspective of the autonomous system is what is meant by the notion of *sense-making*.” (Froese & Di Paolo, 2011)
[10] “An autopoietic system is a network of processes that produces the components that reproduce the network, and that also regulates the boundary conditions necessary for its ongoing existence as a network.” (Bourgine & Stewart, 2004)

trajectory appropriately. These two criteria are provided by the property of adaptivity." (Froese & Di Paolo, 2011, p.8).

This addition of adaptivity would be necessary so that we can begin to talk about cognition and sense-making.[11] However, before resolving the question regarding origin of the criteria for such an evaluation, it is necessary to explain the capacity for evaluation itself, that is to say, to account for a form of separation between the instance who is evaluating, and the possibilities that might be realized. If not, if structural changes were simply directly determined in the coupling trajectory, adaptivity would only make sense to an outside observer who would have access to other trajectories that would have been possible. It could not be mobilized for individual sense-making.

It therefore seems to us that finality, adaptivity and sense-making presuppose an account of a form of exteriority of objects and events in a field of possibilities: there is no finality without the possibility that the goal is or not reached; there is no adaptivity without anticipation of possible dangers that are not realized; there is no value and meaning without these possible stakes. We must therefore try to account for the constitution of a distance, whether it be a spatial or temporal distance, or in a more abstract field of possibilities. We will stick here to the exemplary case of spatial distance.

We want to propose here another way out, without modifying the original definition of autopoiesis or adding additional mechanisms, but by considering the interactions between individuals. We claim that there is then a way to understand the constitution of an exteriority while remaining within the framework of the organizational closure and the domain of individual interaction. We will do this in two stages. In the first we will show the interest and the limits of an individual sensorimotor approach to the perception of distance. In the second, we will be able to present a new interactionist approach starting from a perceptual crossing and continuing on with the rupture of reciprocity.

3. An Individualistic Sensorimotor Solution of Distal Perception

To describe the perception of the position of an object at a distance, we conventionally speak of distal attribution, the ability to attribute the cause of our proximal sensations to a distant external object.[12] However, to pose the question in these terms seems awkward to us because they assume first to have representations of sensory data and external objects and in a second order, to discover a causal relationship between them. The experience of exteriority, of distance or of proximity, seems to us rather to be realized through perception and not in reasoning from perceptual knowledge. Rather than explaining perception to be the internal representation of the external world, we subscribe to an enactive approach for which the objects of perception should correspond to invariants in the coupling between the organism and its environment. Kevin O'Regan and Alva Noe called these rules of interactions "law of sensorimotor contingency" (O'Regan & Noë, 2001).[13] To provide a precise empirical basis for this explanation of distance perception, so-called sensory substitution systems seem to offer an

[11] "Cognition is the regulated sensorimotor coupling between a cognitive agent and its environment, where the regulation is aimed at aspects of the coupling itself so that it constitutes an emergent autonomous organization in the domains of internal and relational dynamics, without destroying in the process the agency of that agent (though the latter's scope can be augmented or reduced)." (Froese & Di Paolo, 2011a, p.18).
[12] "…"externalisation" or "distal attribution," is this-that most of our perceptual experience, though originating with stimulation of our sense organs, is referred to external space beyond the limits of the sensory organs. (Loomis, 1992)
[13] "Experience derives not from sensation itself, but from the rules that govern action-related changes in sensory input," (O'Regan & Noë, 2001)

excellent opportunity. In fact, these systems, developed to help people suffering from a sensory impairment, make it possible to monitor, in adults, the learning of a new perceptual capacity (Auvray & Myin, 2009; Lenay et al., 2003). For example, the Tactile Vision Substitution System (TVSS) by Paul Bach y Rita aims to give blind people access to the visual world through the tactile sense. The images captured by a camera are converted into tactile stimuli on a matrix of 400 electronic pins. When learning to use this device, we can follow the passage from the first usage where there is only the perception of proximal stimuli on the skin, to a mastery of the device which allows the perception of objects from a distance (White et al., 1970). To analyze this passage, we developed an experimental device, the Distal Glove, the objective of which was to achieve the simplest possible system that allowed the perception of an object from a distance (Lenay et al., 1997). This device consists of a simple photosensitive cell placed on the finger connected to a single tactile stimulator (a small vibrator) held in the other hand. When the light captured by the cell passes a threshold, the tactile stimulator is activated (Fig. 1 a).

To understand how perceptual content can be constituted in the coupling between the organism and its environment, it is necessary to build a well-controlled domain of interaction. This is how we describe the Distal Glove within the framework of the enactive approach. Here, the mediation of a technical device makes it possible to precisely define the repertoires of sensations (perturbations) and actions (structural changes) in order to observe the coupling dynamics which can then later take place. Human subjects are equipped by reducing their other possibilities of action and sensation as much as possible (they are blindfolded, and wear headphones that provide instructions and reinforce isolation). We can then on the one hand, observe and analyse in the third person, the strategies that they propose in order to link their actions to their sensations, and on the other hand, describe in first person, their lived experience through the use of the device (C. Lenay & Sebbah, 2001).

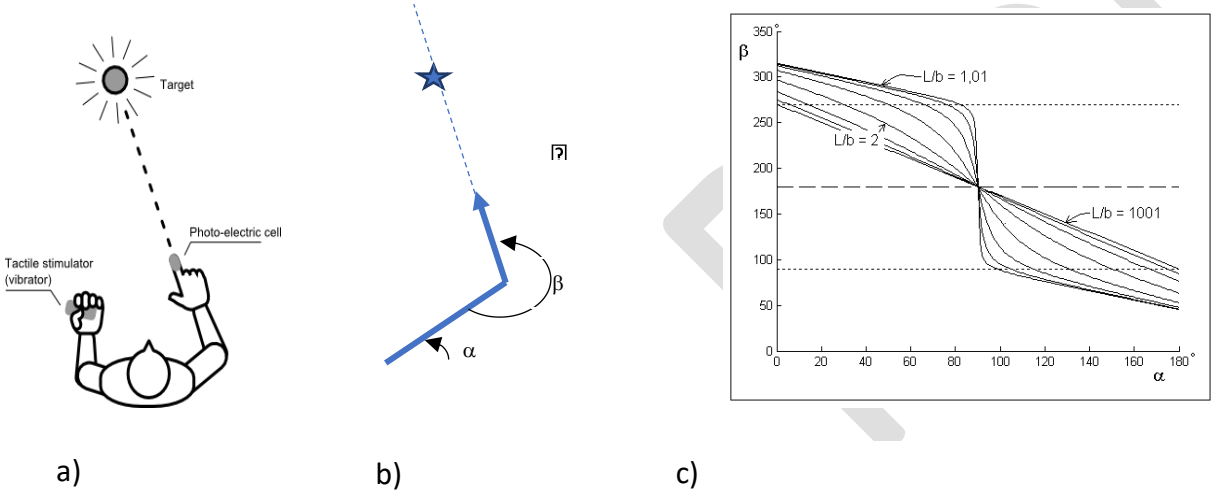

Fig. 1. a) Visual Glove: a photoelectric cell placed on the index finger controls the activation of a tactile stimulator (piezoelectric cell) placed in the other hand. 2 b) Direction and distance can be assessed by triangulation. 2 c) By simplifying the repertoire of actions to a rotation α of the arm around the shoulder, and a rotation α of the hand at the end of the arm, we can precisely give the law of sensorimotor contingency, that is to say here the law of aiming on the target for different distances L (and an arm length b).

Here, the experimental set-up aims to reduce the subject's domain of interaction to its simplest expression: there are only two possible perturbations, the absence or the presence of tactile stimulation, all or nothing, and the repertoire of actions is that of the movements of the sensor. These movements correspond to displacements by translation and rotation of a receptor field which has the shape of an infinite tube (or cone) in front of the sensor placed on the index finger. When this receptor field crosses a luminous target, a sensory stimulation is triggered. Initially, the blindfolded subject only perceives a succession of tactile stimuli related to their movements. But, after a few minutes of use they manage to perceive the direction and distance of a target. They no longer notice these sensations which are replaced by the perception of a target *at a certain distance* in front of them.

What we want to understand, then, is this sort of 'switch' in perceptual experience, which started out as a series of proximal events - the tactile stimulations - and becomes centered on objects which are separate from the body in a distal space. One of the keys to this transition seems to be *the activity* of the perceiving subject. One must advance the point of view in space in order to be able to achieve the triangulation that determines the distance from the object. We have called "Enactive externalism" this conception of perception through bodily engagement in the space of action and perception (C. Lenay & Steiner, 2010). By their action the subject seeks and masters a constant rule relating the movements of the receptor and sensory feedback. The actions correspond to the rotations and translations of the receptor field in the very space where the target is located. The perception of the position of an object at a distance is realized when there is mastery of a law of pointing, that is to say, a 'law of sensorimotor contingency' which makes it possible to target this object from an infinity of different points of view. The perception of the different directions and distances of the target is constituted by the mastery of the corresponding different sensorimotor laws

As for visual perception, the point of view, the position from which the object is perceived, is then spatially distinct from the distal position of the object. Similarly, in natural vision, when we perceive a stable object at a certain distance in front of us, by using our eyes and their movements, we have no consciousness either of the saccadic movements of our eyes, or of the variable sensory stimulations at the level of the retina. What we are perceptually aware of is where the object is relative to us and where we are, as a point of view, relative to the object. Similarly here, there is only distal perception when one perceives the position of the object without paying attention either to the tactile stimulations, or to the variations in viewpoint which make it possible to determine this position.

The switch from proximal to distal can therefore be understood as a change in the type of rule linking actions and sensory feedback. For the proximal perception of touch, the rule is that of a spatial coincidence between the point of action (the position of the sensor) and the position of the object perceived. On the contrary, in the case of distal perception, the rule associates an infinite number of possible positions (sensor positions) for the same position of the object. The duality between the general rule and the particular facts which obey it corresponds to the duality between the position of the object and the positions of the point of perception. Each distal position is determined by a rule that specifies the set of possible views on it. However, different empirical studies and a general theoretical argument show that this sensorimotor approach is not enough to account for the detachment of an object in a perceptual space.

Empirically, several experiments have been carried out to find out whether blindfolded subjects, having no information about the device they were using (a TVSS) succeeded in understanding that it gave them access to distal perception. The most striking result of the experience of Epstein et al. (1986) is that subjects succeeded in discovering and mastering an invariant relationship between their actions and the sensory feedback they provoke, without, however, considering that this relationship corresponds to the perception of an object at a distance (Epstein et al., 1986). The perception remains that of variations in proximal data, without a switch to the perception of a distal object. Auvray et al. repeated this study with a visual-to-auditory substitution device and obtained similar results (Auvray et al., 2005). The only experimental condition that allows a significant increase in the understanding of distal perception to be observed is the situation where the subject is given a cardboard that he can move in front of him, which allows sensory stimuli to be interrupted. But this is to give the subject an important clue in advance regarding a separation of the cause from sensory stimuli. If the switch of perception from the proximal to the distal works well with the classic uses of TVSS, it is because the subjects already know that perceptible objects are present at a distance and they are informed that the device is dedicated to this perception. Likewise, Siegle and Warren took up the minimalist experiment of the Distal Glove, to show that the perception of an object at a distance was only realized correctly if the subject's attention was directed towards a distal object and not towards the proprioception of its movements (Siegle & Warren, 2010).

On the theoretical level, nothing in a law which links action and sensation forces its interpretation as distal perception. We understood this when we noticed that the mathematical explanation we gave above precisely refuted what it claimed to show! Indeed, if the determination of distance is explained by a law of sensorimotor contingency, it should be represented by a curve in the mathematical space of possible actions. This is precisely what we did in Figure 1c with the space (α, β) of the arm and hand rotations. At each moment the position and orientation of the sensor is defined by a point and its movements correspond to a trajectory in this space. When this trajectory crosses the curve there is a sensory feedback. We know that the curve corresponds to the set of possible views on the distal object. But now that we read this curve, it is a shape in the two-dimensional space of this page. We can well consider that we explore it in a tactile way, as a blind person would do with a finger on a thermoformed paper, or again as if we were exploring this space by the movements (x, y) of a computer mouse controlling a cursor such that it returns a sensory stimuli each time it crosses the curve. Mastery of the law of sensorimotor contingency of a distal perception can just as well be mastery of a form explored proximally. The perception of distance can always be replaced by the perception of the shape of a curve in the space of a description of actions.

There is therefore no functional difference between the distal space where a point of view moves away from a target, and the proximal space of the trajectory of touch of the shape of a curve. They are simply two interpretations of the same mathematical law. And so, conversely, there is no assignable mathematical difference among the functions that describe individual behaviour that might force the proximal interpretation (the perception of the shape of a curve) or the distal interpretation (the perception of the position of a target). There is no mathematical difference ... and yet all the difference that interests us is there! There is a gulf between proximal tactile exploration with a finite receptive field, allowing the perception of shape, and distal visual exploration with an infinite receptive field, allowing a target to be located at a distance.

To account for the perception of distance, something must therefore be added to the determination of a law of sensorimotor contingency, another ingredient which should relate to

the ecological value of distance. However, it seems to us that what gives meaning to an experience of distance supposes a field of possibilities in which the subject can advance (Poincaré, 1913); in which, depending on this distance, there is more or less danger, more or less a chance of success. The threat is greater the closer it is, or the more difficult it is to seize the object, the more distant the object is. Without risk and without possibility, there would be only the current simple coupling, without fear and without hope, just what is. However, the existence of a threat means that the things I perceive can have an interest in me in return, perceive me and affect me. The model of this relationship is similar to the game of hunting: fear of being seen without seeing, seeking to see without being seen, seeing that one is not seen, etc.

However, there is an important difference between proximal or distal interactions, a difference which does not stem from a difference in individual sensorimotor function: it is the reciprocity or not of perceptions in an interindividual encounter. A proximal (tactile) perception is necessarily reciprocal. I cannot perceive without being perceived. On the contrary, a distal (visual) perception is only possibly reciprocal: I can perceive someone who perceives me, but I can also perceive someone who does not perceive me, or I can be perceived without perceiving. Our hypothesis is therefore that the separation that makes it possible to construct exteriority stems from a difference between seeing and being seen; between paying attention and being the object of the attention of another perceiving body. Note that this issue of non-reciprocity is particularly important in child development (Moll & Khalulyan, 2017; Reddy, 2003; Reddy, 2000). In fact, to understand non-reciprocal perception is to understand that others may not pay attention to me even if I pay attention to them. It is a form of *originary* separation; the separation from others. Here we hypothesize that separation as loss of others' attention is more fundamental than spatial separation and that it should be used to understand the constitution of the experience of distance.

But how do we account for the lived experience of perceptual non-reciprocity? Also, for the enactive approach that we have adopted, how can we respond without involving a level of cognitive representation?

4. Interindividual Interactionist Approach

To study the constitution of the difference between perceiving and being perceived, we adopt an interactionist approach reduced to the interactions between two subjects. First, we will recall the results of a study of reciprocal perceptual crossing. We will then be able to present some first results of a new experimental situation where this reciprocity is called into question.

4.1. Reciprocal Perceptual Crossing

We call “perceptual crossings” all those situations where two perceptual activities meet, as for example in mutual touching, or when we “catch each other’s eyes”. To study this in its simplest form possible, we have established along with John Stewart and Malika Auvray, the perceptual crossing paradigm (Lenay & Stewart, 2012). Two blindfolded participants are placed in different rooms and can only interact via a device. Each person explores their domain of interaction with a computer mouse and receives tactile stimulation on the index finger of their free hand. The repertoire of their actions is reduced to left / right movements of a receptor field in a one-dimensional space, and the repertoire of sensory input is reduced to a single all-or-nothing tactile stimulation. When this receptor field crosses an object (a black pixel), a tactile stimulus is delivered (by activating the pins of a piezoelectric cell placed under the index finger

of the free hand). All objects have the same shape (a segment 4 pixels wide) and return the same sensory feedback when the receptor field crosses them (receptor field is 4 pixels wide).

To achieve a meeting between the two participants, it is necessary to establish a crossing of their domain of interaction. For this we must endow each participant with a body-object, that is to say, a body that other participants can perceive (a body for others). The intuition that guided the design of this experimental protocol was that the presence of the partner should be recognized as the experience of "seeing the other seeing me" (Gallagher, 2014). The body-object of each participant therefore had to be linked to its perceptual activity so that it could be recognized as such by the other units.
Ici, nous définissons le corps objet comme un disque aussi large que le champ récepteur.
Here, we define a body-object as a segment which exactly covers the receptor field (4 pixels wide). The participants share the same one-dimensional space for the displacement of their receptor field. When the receptor fields of one participant touch the body-object of his partner, the receptor fields of this second participant touch the body-object of the first. This is a situation of a perfect “perceptual crossing” (Auvray et al., 2009; Lenay et al., 2006).

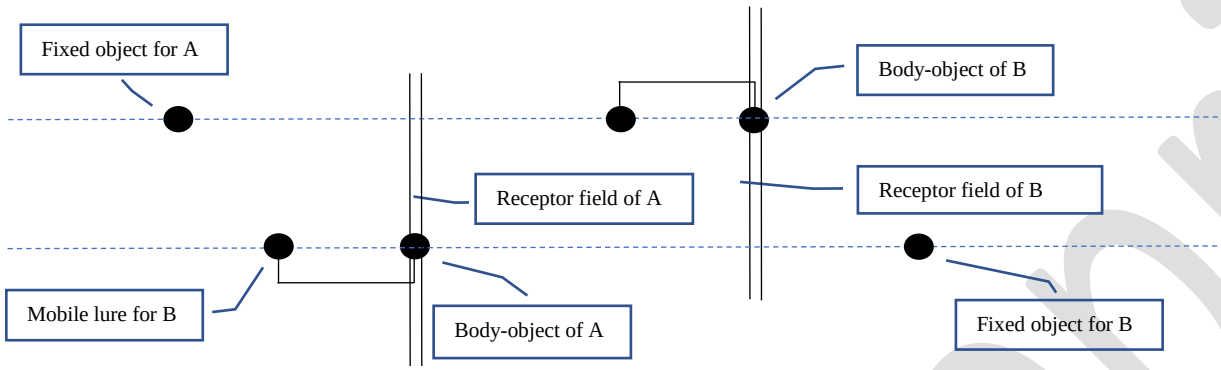

Fig. 2. Perceptual crossing paradigm: the shiftings of the subjects' receptive fields are captured in a one-dimensional space that loops around itself (it arrives at one end and reappears at the other). For each one, three objects are present: a fixed object, the partner's body object and a mobile object.

For each participant, there are three types of objects in the environment: either a fixed object, or a moving object, or the partner's body-object. The objective here is knowing whether the participants can recognize the situation of reciprocal perception by discriminating it from the perception of a simple object. So that the task is not deemed too easy, the mobile object must have a behaviour as rich as that of the body-object of the partner. For this, we established that the object is in constant distance from the receptor field of the partner (50 pixels). By construction, this moving object (called moving lure or shadow) has the same behaviour as the body-object of the partner. Thus, under these experimental conditions which eliminate any other possible clues, *my partner can only be differentiated by his ability to perceive me*. To check if the participants were able to recognize this perceptual activity turned towards them, that is, to recognize the situation of perceptual crossing, we asked them to click each time they thought they “met” their partner.

The interesting result of this experiment is that the participants first collectively succeeded in this task. There are more clicks when identifying a partner (63%) than the fixed object (15%) or the mobile lure (33%). However, it seems that each participant does not make the distinction between the partner and the mobile lure! At the individual level, there is no significant difference in the probability of clicking after stimulation from someone else perceiving the participant at the same time (0.40) or after stimulation from the mobile lure (0.48). The collective success can be explained simply by noting that the "meeting" of the partner is much more frequent (52%) than that of the mobile object (15%) or the fixed object (33%) (Auvray et al., 2009). For each participant, it seems easy but not very important to maintain a stable interaction with the fixed object. It is almost impossible to maintain the interaction with the mobile lure, but the situation of mutual perception is intermediate. Participants find themselves engaged in a sufficiently stable dynamic of interaction since they seek to perceive each other. We thus observe *a hook* between the perceptual activities of the participants when they meet (Di Paolo, 2016). For the fixed object, determining an invariant that links actions and sensations is easy. Subjects hover around this object and eventually pause on it for a moment. But in the case of the encounter of the body-object of the partner, the search for such an invariant is constantly thwarted since it causes a displacement of the object that it tries to determine. Indeed, reciprocally, my partner is also trying to establish a perceptual invariant thus pursuing my own body-object. This brings about the emergence of a second-order collective dynamic which leads everyone into a *hook* with their respective partner but unintentionally since they do not have the ability to distinguish the stimuli from their partner to those from the moving lure. Clicking on an object that is not fixed is sufficient to solve the task since the encounter of the partner's body-object is more frequent than that of the mobile lure. The resolution of the task is therefore first and foremost an emerging property of the collective dynamic and not the product of an individual recognition of others (Di Paolo et al., 2008; Froese & Di Paolo, 2011b; Iizuka & Paolo, 2007; Lenay et al., 2011; Michael & Overgaard, 2012).

However, (Froese et al., 2014) have shown that this individual recognition of the partner can be obtained if the subjects are engaged in collaborating in order to succeed in the task, and if they are asked to perform only one click at the end of each session. The individual probability of clicking following a stimulus from the partner becomes significantly higher than that of clicking after a stimulus from the moving lure. Indeed, the participants prove to be able to use the *hook* of their perceptual activity to develop joint action strategies: the interactions are structured to give rise to an alternation between moments of passivity and activity of the one or the other in turn-taking. It seems that the most important clue to eliciting a subject's click is to receive a series of stimuli while remaining passive, i.e. immobile in relation to the partner (Kojima et al., 2017). Note that this supposes the individual capacity to distinguish activity and passivity, that is to say, to distinguish the sensory variations which depend on oneself and the variations which depend on external changes that they can then attribute to the perceptual attention of others (Froese et al., 2014b). For this, subjects must know that they are not the source of sensory variations that they undergo, that is, they must know how to present themselves as an immobile object relative to their environment and in particular relative to the partner.

The experimental conditions of this classic paradigm of perceptual crossing do not provide the elements for constituting the difference between seeing and being seen since, on the contrary, by construction, reciprocity is necessary. You cannot touch your partner without being touched by him. We therefore propose to introduce a minimal bias which will make it possible to get out of this reciprocity.

4.2. Biased Perceptual Crossing

Our general hypothesis is that the experience of spatial exteriority can only takes its meaning through the difference between perceiving an object and being an object of perception, that is, by the absence of reciprocity between different perceptual activities. Particular attention must therefore be paid to the difference between the domains of interaction of different autonomous units. As recalled, the autonomous unit is not spatially enclosed in itself. It is an open system that can only be maintained by the flows of matter and energy that pass through it. But each autonomous unit is carried out by a different operational closure that defines a specific domain of interaction. And yet it is possible that these domains intersect.

To study this situation, we propose an experimental study of which we will present some preliminary results. We have taken the minimalist conditions explained above but have introduced a bias in the meeting space. It is important to clearly distinguish between the domain of individual interaction and the domain of inter-individual encounter. For each, as above, the domain of interaction remains formed of a one-dimensional space of action. But this time, for the outside observer, the coordinates of the domain of interaction of the two subjects are no longer aligned but form a fixed angle between them (15 degrees). We will call the Center of the Encounter Space (CES) the point of intersection of the two axes. So that the meeting between the subjects can take place at a distance, it is considered that their receptor field is an infinite band perpendicular to their axis of displacement. This change is invisible for each subject that is still moving right / left on their axis. Except for this bias, the experimental conditions are the same as for the classical perceptual crossing. However, as we will see, interaction dynamics have changed.

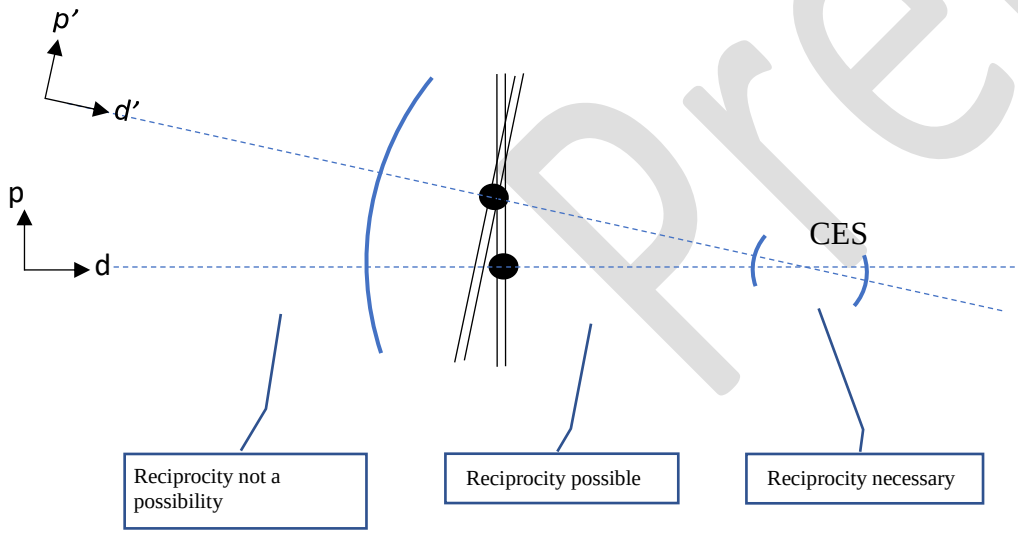

Fig. 3. Biased Perceptual Crossing
Each participant can only move on their horizontal axis. For the outside observer, these axes of movement form an angle of 15 ° between them in a meeting space. Each participant is defined by a body-object and an infinite receptor field perpendicular to the axe of movement. The outside observer

can define a distance in depth, on the p (respectively p ") axis which is a direct function of the distance in relation to the CES on the d axis (d'). There is no fixed object, no other moving object than the body-object of the partner.

By introducing this simple bias into the meeting space, three different regions appear, depending on the distance from the point of intersection of the action spaces (CES).

- First, in the central region of the meeting space (CES), reciprocity is necessary: if a participant meets their partner, the participant is necessarily perceived by her partner. It is a mode of proximal interaction similar to touch where one cannot touch without being touched.
- Then, further on both sides of the CES, non-reciprocity becomes possible and therefore also reciprocity is only *possible*: if a participant meets their partner, it is possible that they will not be perceived by him. It is a mode of distal interaction similar to vision where it is both possible that our eyes meet or that we see without being seen.
- And finally, far enough from the CES, reciprocity becomes impossible: if a participant meets his partner, it is impossible for the participant to be perceived by his partner. If I perceive you, it is impossible for you to perceive me and if you perceive me, it is impossible for me to perceive you.

The possibility of reciprocal sensations, that is, the probability that participants will simultaneously receive a sensation, decreases linearly with distance from CES. It is easy to geometrically determine this probability for a given distance from the partner relative to the CES: we measure the proportion of the positions where the participant would be perceived by his partner among the positions where he could perceive him.

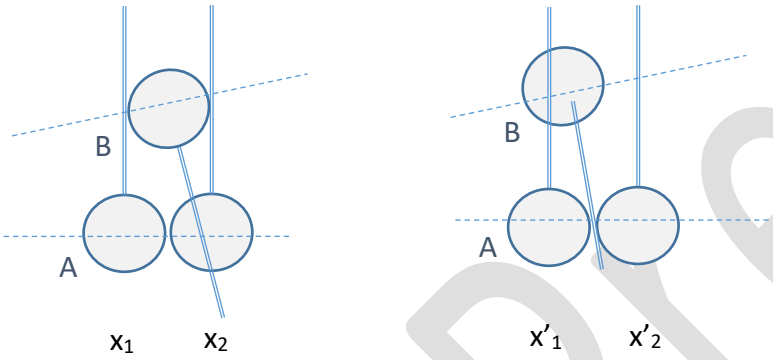

Fig 4: In this particularly simple situation, for a given distance of participant B relative to the CES, the external observer can measure:
- the possible positions of participant A for which he receives a sensation: x2 - x1
- the possible positions of participant A for which participant B receives a sensation: x'2 - x'1

If the external observer admits a uniformity (spatial equiprobability of the positions) he can then determine the probability of reciprocity of a sensation of the participant A for a distance of B with respect to the CES (or, what is equivalent, for a distance between participants in depth p). This is the portion of the positions where A is perceived in the set of positions where she perceives B:
(x2 - x'1) / (x2 - x1)

The possibility of reciprocity thus defined belongs to the description space of the external observer and corresponds to the geometric ratio of an objective probability. We can thus

determine the border of the visual region when the possibility of motionless reciprocity becomes zero. For example, for a receptor field 4 pixels wide, a body-object 40 pixels in diameter, and a bias of 15 °, we find that this border is at 645 pixels on either side of the CES, that is to say, a distance in depth between participants of 173 pixels. Beyond that, there can no longer be any motionless reciprocal perceptual crossing. Thus, the distances of the partners in the meeting space correspond to a greater or lesser possibility of reciprocity. We will keep the term possibility rather than probability because the reciprocity of the attention of others obeys a multitude of other conditions independent of the computable distance which interests us here. We hypothesize that this distance, inaccessible from a solitary individual point of view, will nevertheless influence individual dynamics through inter-individual interaction.

Experiment and Results:

Eight pairs of participants are placed in two separate rooms and can only interact through the device. They are asked to meet and move together over the greatest possible distance (the only object present is the body-object of the partner). They are told that they can change direction as long as they stay together (it will be considered that they are no longer together if there is a difference of more than two seconds between two sensory stimuli). We will only present here the results of the first and last sessions of this preliminary experiment. The first session consists of 4 trials of 90 seconds. Then, after 25 minutes of interaction, participants complete a final session of four 90-second trials. At no time is there any feedback given to the subjects regarding their performance

The most interesting result to remember here is the existence of a point of attraction for the movements of the two subjects which is located at the point of intersection of their individual interaction spaces (CES). To highlight this, we look at the average speed of the participants (for the periods when they manage to move together) as a function of their distance from the CES.

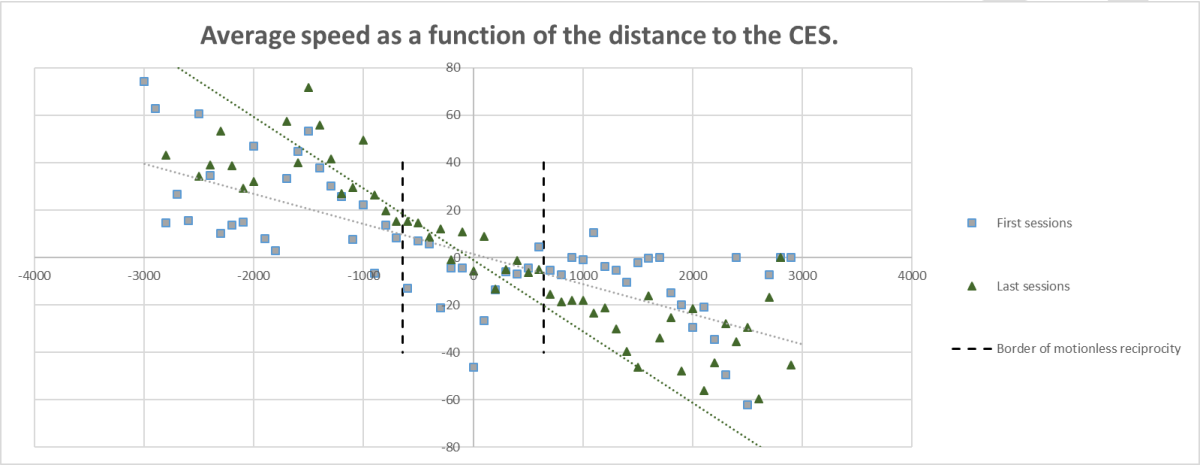

Fig. 5. We look at the average speeds of the participants for different distances to the CES when they are in interaction sequence: we consider that there is an interaction sequence if less than 2 seconds elapse between two stimuli (the speeds are calculated over two second intervals).

We see that the average speed varies according to the distance from the CES. When participants are on the left of the CES, they tend to move to the right (positive speed), and when they are on the right, they tend to move to the left (negative speed). There is a very clear correlation between average speeds and deviation from CES, a correlation that disappears beyond the

boundary of the region of possible reciprocity. This is verified by looking at the evolution of the correlation as a function of the distance to the CES.

Correlations	First session	Last session
On the left of the CES: [-3000; -700] reciprocity not possible	-0,34	-0,17
Around CES: [-700; +700] reciprocity possible	-0,10	-0,84
To the right of the CES: [+700; + 3000] reciprocity not possible	-0,71	-0,51

Discussion

The mutual search for a perceptual crossing leads the participant to get closer to the Center of the Encounter Space (CES). If the participants try to move away from it, we see that the collective movement becomes more and more difficult until it becomes quite impossible. They therefore tend to move from a region where reciprocity is difficult to a region where it is more and more likely until they reach the point of attraction where reciprocity is necessary (Fig. 6).[14] This emerging dynamic is essentially collective since it depends on a variable, the distance between the participants, which cannot be constituted in their individual space of interaction. However, following this distance, there is an orientation of the movements of the participants in their individual interaction space. And in return, these displacements produce a modification of this distance.

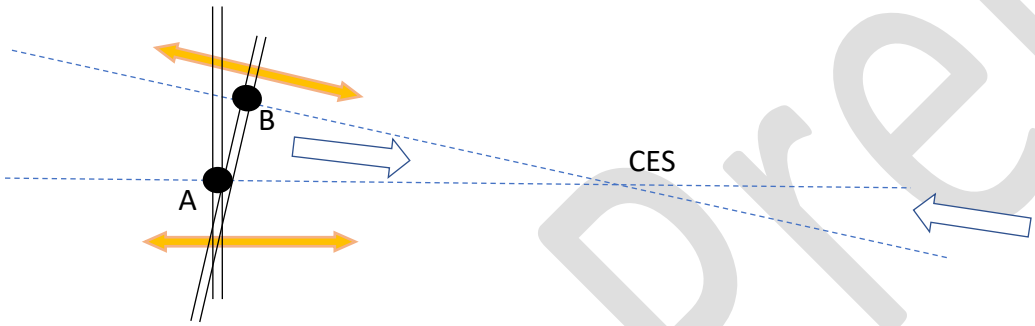

Fig. 6: If participant A seeks to perceive the body-object of participant B, they will have to carry out a sweep (orange double arrow) which will lead them to the right. Likewise, participant B will also have to move to the right to perform a sweep around the body-object of participant A. The participants are therefore drawn into a common movement towards the point of intersection of their axis of movement (CES). After this point the same logic is reversed, and the participants will rather be drawn into a movement to the left. Thus, the CES is a point of attraction of the interaction dynamic.

We have posited that separation is constituted by non-reciprocity. The experimental study seems to show a situation where an emerging collective dynamic depends on the possibility of

[14] The question of knowing if this can be considered as an "attractor" in the precise sense it has in the dynamics of complex systems remains to be decided according to the models of collective dynamics that one could propose.

non-reciprocity. Let us observe whether this is enough to account for the experience of separation.

For each subject, the difference in distance of the body-object of the partner cannot cause any sensorial distinction. They cannot be differentiated according to the laws of individual sensorimotor dynamics. However, in the meeting space (description space of the external observer) this distance influences the possibility of reciprocity between the perceptions of the participants. And this possibility of reciprocity influences individual dynamics. As above for the reciprocal perceptual crossing (4.1.), the collective dynamic involves each participant in movement, but unintentionally since they do not have the ability to distinguish distances. This effect of distance between subjects is also not the result of an individual recognition of non-reciprocity as such. It would also be very difficult for a subject to recognize this non-reciprocity if the body-object of his partner was recognized precisely by the reciprocity of the perceptual crossing. However, to the extent that each participant seeks to meet the body-object of their partner, the participant succeeds even more so if the partner perceives him, that is to say, if there is reciprocity. The possibility of reciprocity drives the subjects towards strengthening this possibility until the point where they come together, that is, until they find the proximal contact where reciprocity is necessary. It is the fact that this reciprocity is not assured that causes this tendency to move in the direction that increases its possibility. This point must be emphasized here. The observed effect cannot be explained by factual reciprocity or its absence. Rather, it is produced precisely by the *possibility* of reciprocity (the probability of being perceived by one's partner when one perceives it). What explains attraction is not reciprocity, it is only variations in the possibility of reciprocity. Note that the size of the body-object (or the width of the receptor field) is necessary for this dynamic of interaction: if the other were only a point (and the receptor field a line), there would be no visual region (where immobile reciprocity would only be possible), but only either the necessity or the impossibility of reciprocity. Body-objects with their spatiality allow not only a perceptual crossing, but also a gradation of the possibility of reciprocity.

On the collective level, we therefore observe the emergence of a relationship between the possibility of reciprocity and the movements which modify this possibility. From the point of view of the external observer, we see that the collective dynamic depends on distance and produces individual actions that tend to reduce this distance (if their objective is to find each other). For the outside observer, it is the distance between the participants that makes it possible to calculate the probability of reciprocity of their sensations. But if we take the point of view of a participant, we must rather reverse this inference and start from the possibility of reciprocity in order to try to construct a distance understood as separation in a field of possibilities.

For each subject, separation from their partner corresponds to a loss of control over their attention. At the center of the meeting space, the interaction is proximal: if I pay attention to the other participant, they are obliged to pay attention to me. But when I move away from the CES, the interaction begins to become distal. When I pay attention to the other participant, nothing ensures me that they pay attention to me. To move forward into the space of encounter is to move forward into "depth" if we take depth to mean the dimension in which the specific separation of a distal space is achieved (M. Merleau-Ponty, 1996). A separation that is defined here as a loss of grip on the attention of others (before designating a spatial quantity). Even if the subjects cannot know the bias and the distance, they may recognize variation in the difficultly to follow each other. Non-reciprocity would first be experienced as a difficulty of the task, a form of resistance, for example a reluctance of others to follow me. In this situation

the experience of separation becomes possible, it is a loss of control over other people's attention.

With the attention that they give or don't give to me, the other reveals to me that I have a body that affects them (Reddy, 2003). A distinction between the perceiving body (Leib) and the perceived body-object (Körper) can therefore be realized, even if they are linked in the concrete realization of autonomous unit. It corresponds to the distinction for the subject between the body-object of the partner that he perceives when he is not perceived by his perceiving body, while distinguishing between his own perceiving body which allows him to perceive and his body-object that his partner can possibly perceive without his knowledge. In a proximal interaction, as here near the point of attraction, Leib and Körper are confused. When we move away from the point of attraction they tend to differentiate. This distinction makes possible an attentive passivity like that which we have seen at work in the reciprocal perceptual crossing: it is a question of presenting his Körper as an immobile object relative to his partner in order to recognize sensory variations of which we are not the origin.

However, before being able to speak of the awareness of distal exteriority from the position of an already given subject, it would be necessary to be able to propose an ontology in which a space of possible positions can be defined for both objects and the subjects that perceive them.

5. Theoretical and Ontological Proposition

To account for perception at a distance, we need to have an ontology that gives full room to the possible. Here is not the place to take up this question in all its difficulties (Armstrong, 1997; Hintikka, 1979). We will only offer a sketch of such an ontology of the possible and we will limit ourselves to the very simple environments of the experimental studies that we have proposed. Indeed, our minimalist experimental method can be accompanied by a form of theoretical minimalism. It is about practicing a conceptual parsimony to check whether the elements put in place in the experimental situations are sufficient to propose an explanatory scheme of the perception of distance in a space of possibilities.

To construct this space we propose to start from the possibility of reciprocity in order to define the distance. The sense of exteriority, as the experience of the independence of a world, would find its origin in the possibility of non-reciprocity. Any perception of the distance of an object would be the perception of a possibility of reciprocity. We must then verify that we have sufficient conditions to build an ontology in which the notions of spatial position, point of view, action and sensation in a space of possibilities could be defined.

But to follow this path, the possibility of reciprocity must first be defined for any separate object, be it an inert object or the body-object of another unit. The reciprocity of a perception means that the perceiving unit is not only affected by the object it perceives (its perturbations depend on this object) but also that it affects this object (it is a source of perturbation for this object) which in turn modifies his perceptual activity. It is through its body-object that the unit can affect the object of its perception, that is, to be perceived by it. The generalization of the question of reciprocity for any object consist in recognizing that the body-object is not just an object for other sentient unities, but an object for all things it might affect.

We can therefore define reciprocity in a very general way: it is the reaction of the perceived object (inert or not) to the body-object of the unit that perceives it, this has in turn, the

consequence of modifying the perceptual activity. For the perceiving subject, the question of reciprocity can therefore arise for any object depending on its capacity to react to the fact of being perceived. The passivity of an inert object simply means that it has no sensitivity at a distance. In this case, there is reciprocity only during the proximal encounter. An object like a cup placed on a table is also possibly in reciprocal relation to my point of view. But, there will be "reciprocity" only at the time of proximal contact, that is, at the time of necessary reciprocity. For example, the tangible object that I encounter transforms my perceptual activity by blocking or reorienting my possibilities to act. However, following the approach we have adopted here, we posit that the encounter with another sensitive instance at a distance is necessary for the constitution of a perception of this distance. The inert object will then take place in a space that will have been opened by these interactions between perceiving subjects. Here we are adopting a form of animism like that which Jean Piaget attributed to the early stages of development. Here, any object is first taken as an intentional object (in this very restricted sense of a possibility of responding to my activity), and it is only later that it can be reduced to the reactional poverty of a thing (Piaget, 1929).

Ontology of Space as a Field of Possibilities

To begin, one can define the position of the perceived object for a point of view as the place where reciprocity would be necessary if that point of view were there. All the other positions of the point of view relative to this object are those of only possible reciprocities. The value of these possibilities can vary depending on the distance: the closer you are, the more you can attract attention or risk being noticed. The exteriority is that of the reciprocity that would be necessary *over there*, perceived from the point of view, *over here*, of only possible reciprocity.

The *space of positions* in which the object is perceived is a space of possibilities of reciprocity. Each position seen from one point of view is another possible point of view.

This *point of view* is situated where the body-object is since the possibility of interaction with other unities depends on it.

The *action* is a structural change insofar as it causes a change of position of the point of view, that is to say, a change of the possibility of reciprocity in relation to the perceived objects. It is therefore a displacement of the body-object. The action remains the product of a structural change defined from the point of view of the operational closure of the autonomous unit, but different structural changes can correspond to the same action since only the changes that could affect the perceived objects count.

The sensation is a perturbation in that it always may or may not be reciprocal. In the case of distal perception, the same sensation can occur for an infinity of different possibilities of reciprocity, that is, an infinity of possible distances (in our experimental device, this is illustrated by a receptor field which has the shape of an infinite band). The sensation is indifferent to the distance from the object that causes it. In other words, for a sensation, all possible distances from the object are present at the same time. Sensation still corresponds to a perturbation, but it is no longer understood from within the autonomous unit as a sign or effect of a difference in the environment but rather only as a possibly reciprocal event.

Now, sensorimotor coupling takes on new meaning. It is no longer simply a coupling between perturbations and structural changes, but a coupling between sensations and actions as we have

just defined them: each sensation corresponds to a possible reciprocity, each action corresponds to a variation of this possibility.

Distal Perception

In the experimental study of biased perceptual crossing, we made sure that there wasn't individual access to distance in depth. This allowed the distal separation to be well characterized as a possibility of non-reciprocity. But now if we accept this ontology of distance, we can return to a little more complex situations where, as in the experience of the Visual Glove, we grant the subjects repertoires of actions and sensations that allow them to determine specific sensorimotor coupling laws for specific distances. We can then propose an explanation of the shift from a proximal to a distal interpretation of such laws. There is distal perception if the law of sensorimotor contingency is understood as linking *actions* of displacement of the point of view, that is to say changes in the possibility of reciprocity, to *sensations* understood as the possibility of reciprocity. The determination of the law of contingency for a position of the object gives all the possibilities of reciprocity of this object, that is, the multiple possible positions of the point of view of an object whose unique position is where reciprocity would be necessary.

Distinction of the Subject of Perception

If we follow this path, we must abandon the presupposition of a pre-existing subject of perception, given from the outset by the autopoietic organization. The instance perceiving a distance is not the autonomous unit as such, but this unit associated with a body-object situated for others and separated from them. For this "enactive externalism" (Lenay & Steiner, 2010), there is a co-definition of the point of view of the perceiving instance, and of the distance that separates it from the object that it perceives. Perceptual contents correspond to states of coupling concretely realized in the relation between the unit endowed with an object body and the objects of its environment. All the possible determinations of objects for a unit belong well to its domain of interaction since they ultimately correspond to invariants of the coupling between perturbations and structural changes; but at the same time, each of these invariants is positioned into a field of multiple possible invariants.

Field of Possibilities

Indeed, the interest of such an approach is to make it possible to better understand how the perception of the position of an object at a distance can go with the presence of the field of possibilities which surrounds it and in which it separates. For a point of view of the object, the possible reciprocities all exist at the same time and among them exist the position of the object which is that of necessary reciprocity. This possibility is detached from the others by the process of determining a law of contingency, but the other possibilities remain present considering each sensation retains the multiplicity of its possible causes. Between the point of view of the unit and the object at a distance there are endless other possible positions. Each of these positions can either be the necessary reciprocity of a proximal relation (the unit could touch the object), or another possibility of reciprocity of a distal relation (the unit could perceive the object) at a distance from another point of view).

For example, in the case of the Visual Glove presented above, during the progressive determination of the position of the object at a distance, each part of the corresponding pointing curve designates its general reason (its generating principle) from among an infinity other

possible reasons. The reason for the pointing curve is simply the position of the target (the position of the necessity of reciprocity). A few points on this curve (a few sighting points of the target) are sufficient to define all the points of the aiming curve. But, in the temporal process of determining the invariant of the coupling, at any moment an infinite number of other invariants always remain possible.

Possibility and necessity allow us to understand how the law of contingency can describe the aim of a single object through the multiplicity of actions and sensations: the multiplicity of points of view for the same object is explained as a multiplicity of possibilities for the same necessity. For an object that I perceive in a given position in relation to my point of view, there is also the field of other possible positions where the object could be and where I could be. By its body-object which allows a meeting and a separation with the body-objects of other perceiving units, the unit is situated as a point of view and its invariants are those of laws linking actions and sensations as variations of possibility of reciprocity. A world opens in the domain of interaction by a kind of "possibilization" of the states of the coupling.

Many works in enactive approaches as in phenomenology have defended the idea that agency and subjectivity can only be constituted by an interweaving between perceiving body and body-object, Leib and Körper (Stapleton & Froese, 2016). Here we also defend this imbrication by noting that the body-object is necessary for the perception of distance. In this, it is part of the perceiving body. However, it always remains partly outside the world proper to the perceiving unit since, precisely, there is no separation for it between its perceiving body and its object-body which would make it possible to constitute the latter as an object. It is only others who, through our interactions, endow me with the body-object that opens the space of possibilities for me.

Even if the field of possibilities of each unit remains contained in its domain of interaction, it must be understood as a space of possibilities shared with others since it is built, not in a solitary way, but by the encounter of their body-objects. Everyone in their own “world” recognizes the presence of others through their body-object. It is the presence of the possibility of attention, an attention that escapes me insofar as it comes from another “world” of its own, but which intersects with mine since my own body-object can exist for it. What we share is our separation. A separation that allows us the constitution of a space of possible reciprocities.

6. Conclusion

It will be another endeavor to check whether this conceptual scheme is generalizable to the whole of perceptual experience. Here we only want to insist on the contribution of a theory of the perception of the object at a distance in exteriority, in a space of possibilities.

This helps us to understand that the perception of distance can be done at a distance from the object. The determination of the sensorimotor invariant is indeed done from the displacement of a point of view separate from the perceived object. The need for reciprocity *over there*, is seen from the variations of the possibility of reciprocity for a point of view *over here*. I can perceive positions defined in my domain of interaction but which are outside my domain of viability, positions where I have never been and never would go, i.e. in the middle of a fire, beyond the precipice, inside the mouth of a wolf, on the moon… Indeed, the perception of distance as a possibility of reciprocity does not need the necessity of reciprocity to ever be realized: it simply remains possible for me. Thus, the distance from the object makes it possible

to endow positions with values, to flee or pursue them, fear them, or desire them. The existence of external ends and norms becomes conceivable, including for targeted positions that are outside the realm of sustainability. With the opening of the possible, the domain of interaction can become a "world" for an autonomous unit. There can be sense-making as the capacity to enact this world of meaning.

In the context of enactive approaches to social cognition, sense-making is enriched by participatory sense-making. The idea is that the dynamics of inter-individual interaction have a relative autonomy that largely escapes the intentional actions of the participants. In turn, these emerging properties affect individual activities. Participatory sense-making describes the way in which autonomous agents engaged in social interactions modify or make possible some of their individual sense-making activities (De Jaegher et al., 2010; De Jaegher & Di Paolo, 2007). The research and the hypotheses proposed here radicalize this role of social interactions by posing that even individual sense-making does not exist before them[15].

We can then consider a primitive subpersonal level, an intercorporeality (Maurice Merleau-Ponty, 1968) made up of interactions between organisms in a "cross modal sensorimotor system" (Gallagher, 2013; Gallagher & Meltzoff, 1996). Agency and full individual cognitive autonomy would be secondarily constituted from this shared substrate. This original intercorporeality would explain the existence of a mutual understanding that would precede and make possible the so-called "social cognition" phenomena such as the recognition of others, joint attention, imitation, or emotional contagion. In a classical perceptual crossing as in a biased perceptual crossing, we have indeed seen at work a form of intercorporeality produced by the dynamic of interaction between body-objects relatively independent of individual perceptual activity. It is this intercorporeality that then makes the recognition of others and the constitution of the field of possibilities of reciprocity possible.

However, in the perspective we have adopted here intercorporeity is produced by the *separation* of organisms and the crossing of their domains of interaction which are irreducibly heterogeneous. The meeting of different operational boundaries does not produce a homogeneous common world but, on the contrary, allows the construction of gaps and distances in a field of possible relationships between organisms. It is not of course a question of returning to a cognitivist approach posing the interiority of already constituted subjects who then meet and whose hidden internal states should be inferred. On the contrary, interiority can only take on meaning if we first recognize the constitution of the space in which interior and exterior can be defined (Lenay & Steiner, 2010). This is why we tried to understand how the meeting of the body-object of one unit with the body-objects of other unit allowed the very constitution of the subject of perception as a point of view situated in relation to other points of view.

John Stewart also proposed to go through the social to account for the broad cognitive categories and in particular the general category of an isotropic Euclidean space. By taking up the work of Durkheim and Sohn-Rethel, the aim is to show how the normativity of actions and the *à priori* of categories come from their institution in the social structures that precede them (Stewart, 2015). In a general theoretical positioning article with Pierre Steiner, they show the importance of taking into account social structures strictly speaking (and not simple

[15] This perspective is close to the constituting intersubjectivity that Zahavi defends (Zahavi, 1997). For him, the Other plays a necessary role in perception by the realisability of his point of view with regards to the other faces of the tridimensional object. But here we defend the notion that it is the Other that allows *me* to constitute space itself as a system of possible point of views. This should be sufficient to justify the general possibility of other points of views on the object. (Declerck, 2018)

interactions between individuals) in order to account for human cognition. The social structures which form our living environment and which always precede us, provide us with the norms which constrain and make possible all our activities. The heteronomy of these social structures that we inherit contributes to the regulation and the very meaning of each of our actions (Steiner & Stewart, 2009). However, to explain the functioning and effectiveness of social forms as norms for subjects, it is necessary to explain how their actions may or may not obey these norms. They must be posed sufficiently in exteriority so that their obedience can even be possible. We have tried to explain this by also mobilizing the collective (although not the social in the sense of Steiner and Stewart) and the otherness of the subjects that compose it.

The operational closure of autonomous unity has not served us to defend its self-sufficiency in the constitution of its experience - we have endeavoured to show the contrary - but it has served us to give an empirical meaning to otherness through plurality of operational closures of different autonomous units. Indeed, the idea of an operational closure makes it possible to justify the irreducibility of the differences between domains of interaction that constitute the fields of possibilities in which subjectivities can be realized. It is the radicality of otherness that opens up the space of possibility. In this world, otherness is revealed by the meeting of other organisms which, by escaping the determination of their attention, lead the coupling in unmanageable directions. From a phenomenological point of view, rather than appealing to a homogeneous anonymous common world preceding the constitution of subjectivities (Merleau-Ponty, 1996; Merleau-Ponty, 1968), we have adopted a perspective close to that of Emmanuel Levinas (Levinas, 1979; Métais & Villalobos, 2021). For each, there is an encounter; not that of resemblance of the alter-ego, but rather the encounter of otherness. The body-object, the face of another, is the presence in the perceptual world of an absence, understood in our text as the impossibility of full determination or mastery of the attention of others (but with the power to injure or kill which opens an ethical relationship).

With John Stewart, we have therefore maintained the essential link between life and cognition, but by granting an essential role to the plurality of living beings. Certainly, cognition proceeds from the living, but with other living beings.

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