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MIND MEETS THE BODY SEARCHING FOR ITSELF – EMBODIED, SOCIAL, PERCEPTUAL, ETHICAL, LINGUISTIC AND TEMPORAL ASPECTS OF CONSCIOUSNESS

São Leopoldo.
2022

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Abstract

Consciousness is a vague concept. The thesis goal is to elucidate why. We will argue for the possibility of analyzing the complex concept of consciousness into its main basic aspects, following Damasio's distinction of core consciousness and extended consciousness. The method chosen for performing such analysis is provided by the Tononi's Integrated Information Theory, as it allows for the analysis, while accounting for the integration between the parts arranged as a whole. Consciousness was thus analyzed into the aspects of: embodied core consciousness; and five aspects of extended consciousness; Social; Perceptual; Ethical; Linguistic; and Temporal. While impairment of core consciousness extinguishes the expression of consciousness as a whole. The aspects of extended consciousness, on the contrary, can be selectively knocked down, yet preserving the remaining aspects. The thesis presents a demonstration that the Reductive Analytical Method can be derived, as a particular case, from Integrated Information Theory, thus justifying our choice. The aspects of core consciousness and extended consciousness received a transdisciplinar review of the literature. The evidence thus gathered replicated previous findings, suggesting core consciousness to be localized, extended consciousness to be decentralized and the integration between the parts to constrain the possibilities of consciousness as a whole.

Keywords: mind-body problem, social, perceptual, ethical, linguistic, temporal, consciousness.

Resumo

Consciência é um conceito vago. O objetivo da tese é elucidar o porquê. Argumentaremos pela possibilidade de analisar o conceito complexo da consciência em seus principais aspectos básicos, seguindo a distinção usada por Damásio entre consciência central e consciência ampliada. O método escolhido para tal análise é fornecido pela Teoria da Informação Integrada de Tononi, pois ela permite analisar as partes arranjadas como um todo. Consciência foi assim analisada nos aspectos da: consciência central corporificada; e cinco aspectos da consciência ampliada; Social; Perceptual; Ética; Linguística; e Temporal. Enquanto a perda da consciência central extingue a expressão da consciência como um todo. Os aspectos da consciência ampliada, ao contrário, podem sofrer perda seletiva e, ainda assim, preservar os demais aspectos. A tese apresenta uma demonstração, que o Método Redutivo Analítico pode ser derivado, como um caso particular, partindo da Teoria da Informação Integrada, justificando assim nossa escolha. Os aspectos da consciência central e ampliada receberam uma revisão bibliográfica transdisciplinar. As evidências assim reunidas, replicando achados anteriores, sugerem que a consciência central é localizada, a consciência ampliada é descentralizada e que a integração entre as partes constrange as possibilidades da consciência como um todo. Palavras-chave: problema mente corpo, consciência, social, perceptual, ética, linguística e temporal

Contents

1 Introduction

In order to provide some insight to the mind-body reduction, we should first make explicit what it means for something to be reducible to another. Reductive Analytical Method have algebraic roots. “To reduce” translates, in a Cartesian sense, to the action of isolating independent variables. If Reductive Analytical Method were dismissed, multiple variable problems would either: require greater time and resources to be solved; be prohibitively difficult or unsolvable. Most hard science’s solutions rely upon the reductive method at some point. Reducing mental phenomena to body phenomena, in this mathematical sense, basically means that mental phenomena can be fully described from within a description of body phenomena.

No body is a floating island, scientific methodology may isolate the human body from its environment for the sake of simplicity. Does it mean that the human body can live in the absence of the environment? Obviously not.

We will suggest that a similar reasoning can be applied to the case of the human mind. Given the mind can receive stimulus from the environment. By isolating the human mind from the environment are we not hindering the possibility for an exhaustive description of the mental phenomena? We are not denying that the internal activity within the body is the direct cause for triggering a thought, what we are implying is that in addition to the body influences, many other contextual elements are at play.

Let us suppose a thought happened and some neural circuitry fired up inside my skull. The neural activity in my brain is the immediate cause to the thought I just had. However, other influences may also be considered: the physical environment I am currently at; my timeline context; previous ideas and culture I was exposed to in the past; people, tools and materials I have access to and so on. Let us say the thought I had was the thought of a red apple. Let us say a little scientist was living inside my skull having access to the firings of my “red apple” neural circuitry, but no access to anything outside my skull. The hypothetical little scientist may have all the information about my inner mechanisms, but only indirect access to why those mechanisms are being triggered. If the little scientist could only peek with his little head out of my ear, would not he learn much about what was really going on?

Learning about the real context I am inserted at would probably point out to many clues unbeknownst to the little scientist until he gets to look with his own eyes, instead of mine. It makes sense to distinguish between mind and body, not because the mind is made out of something other than the matter, but because the abstract concept of mind encompasses the material components it is made out of *and* the imaterial relations between its parts.

Recent cognitive studies and neuro imagery techniques included mental phenomena to the scope of objective science, defying the notion that the subjective nature of mental phenomena remains outside the scope of objective science. Integrated Informa-

tion Theory provides quantitative methods for the information contained: in the whole; in the sum of its parts; and in the relation between the parts. The framework of Information Theory seems more comprehensive than Reductive Analytical Method when it comes to describe the relation between the whole and the parts. The statement "the whole is equal to the sum of its parts" is true for the particular case of null integration in the values of the equation of Integrated Information Theory, otherwise the whole contains less information as its possibilities are constrained by the interdependence between the parts.

According to Integrated Information Theory: no set's information can be greater than the information in the sum of its parts; Reductive Analytical Method only provides a partial account of neuronal dynamics. Quantifying the whole as "greater than the sum of the parts" contradicts Integrated Information Theory. If our interpretation of Integrated Information Theory is correct, there is also no mathematical ground to claim for the whole to be *always* equal to the sum of the parts. Novel and Traditional research methods struggle in the attempt to untangle consciousness. Methods accounting for consciousness' tangled nature may contribute to debate as well. While the reductive method is fit for describing equations with multiple independent variables, Information Theory contribution allows for recollecting the pieces collected through Reductive Method into a more comprehensive picture.

Divergent versions of concept of consciousness are recurrent in history. Before the 20th century, the theme belonged to the theoretical field. Experimental psychology, animal studies, innovative neuroimaging techniques and a more accurate profile for the neurochemistry of behavior allowed for a more objective research regarding the subjective aspects of consciousness. The philosophical implications of such scientific endeavors have not been yet fully discussed nor understood. Our thesis intends to share our considerations about the confrontation between some recent empirical evidence gathered through reductive analysis applied in the study of the human nervous system and the philosophical concept of consciousness.

Core consciousness is a sine qua non condition for more complex aspects of extended consciousness. Wakefulness and sleep is controlled by the brain stem, injuries to this area, specifically in the upper bridge, are correlated to the loss of consciousness in vegetative coma. The extended consciousness, however, depends on the neocortex, which is fed corporeal information from subcortical areas. Different modules add relatively independent subjacent layers of information analysis. Areas specialized in processing different aspects form a composed unit of modules and their connections. Our proposal analyzes consciousness into *Embodied* Core Consciousness and: Extended *Social* Consciousness; *Perceptual*; *Ethical*; *Linguistic* and *Temporal*.

Embodied core consciousness links bodily functions, such as heartbeat, breathing, circadian rhythm, metabolic and sexual hormones to a self-image. Male and female human brain share similar structures, nonetheless, the Central Nervous System regulates

and gets feedback from the shaping of our bodies. Natural selection has access to a lot more genetic variation on sexual reproduction compared to asexual reproduction. The selection during courtship rituals, mating activities, pregnancy and labor exerts constraints to mammal behavior. Sex has been a constitutive part of who we are, since our evolutionary and individual birth. Perceptual consciousness allows partial conscious access to external information through the peripheral senses. Lack of affectional bonds causes pain, inclining us toward socialization. Other people's minds are not directly open to inspection. The Mentalizing Network – a cluster of cortical areas responsible for creating hypothesis about internal and external mental states – is a constitutive part of social consciousness. A neuronal wiring pushing us away from solipsism. Temporal consciousness projects itself to past, present and future times. Ethical consciousness inclines us to empathy, predisposing us to experience appropriate emotions when evaluating courses of action that may violate or preserve cultural tradition and moral principles. Linguistic consciousness is responsible for using words and symbols. This expression, not unique in humans, allows for externalizing information to peers and internalizing information vocalized from others. The loss of one, or more than one, aspect of the extended consciousness does not necessarily impair the other aspects. The five aspects of extended consciousness are relatively independent, each one not requiring simultaneous activation of the others. Our hypothesis must be contextualized within evolutionary theory. The referred brain structures enabling extended consciousness, including its subjective aspects, must be understood through the lenses of natural selection.

The cortical areas responsible for extended consciousness have appeared at some point of the evolution of our common ancestors. Was extended consciousness a byproduct of this process, or did the selective pressures favored this capacity? A broad, yet superficial, bibliographic review may contribute to the definition of the consciousness concept. Broad because no single research field specializes in the study of consciousness, superficial because we have no competence to a more throughout analysis.

Major breakthroughs in the last few decades have established for the first time the possibility for objective research about the inner mechanisms at play regarding human conscious states. The aim of this thesis is to paint a conceptual picture of how human consciousness may be structured, inspired on neuroscientific evidence.

Antônio Damasio presented relevant findings on subcortical contributions to consciousness. This area is crucial for core consciousness. All vital bodily functions are controlled in the subcortical areas. It seems counter-intuitive that consciousness depends on an area of the brain that plays a relative role in the autonomic nervous system. The point is that information necessary for the maintenance of life, even if processed at a non-conscious level, will be relevant to the levels of processing that can become conscious [1]. In the subsequent moment, part of the information coming from the sub-

[1] After a fear stimuli, for instance, prefrontal areas may become activate in order to suppress firings from

cortical regions that map and control the most basic bodily processes is accessed by areas of the neocortex. Virtually all animals with a Central Nervous System are capable of waking states. The subcortex appeared first along the evolution of the Central Nervous System. Human consciousness does more than keep us awake for much of the day, but being awake is a necessary condition for the expression of extended human consciousness. Evidence from coma patients suggests that being awake is impossible without brainstem activation [PARVIZI and DAMASIO 2003].

"That the organism, as a unit, is mapped in the organism's brain, within structures that regulate the organism's life and signal its internal states continuously" [PARVIZI and DAMASIO 2001]. This map of the body is available from a subcortical level to the insula lobe, as the processes of breathing, swallowing, heart rate, etc. rely upon these representations for their proper functioning. This region gathers bodily feelings and feelings of emotions, being able to pass on the information to feed cognitive processing modules. As the subcortical processes are responsible for basal metabolism, usually this basic/elementary aspect of consciousness does not receive much attention from philosophers.

Core consciousness is a concept intrinsically connected with protoself. "Protoself is a coherent collection of neural patterns that map, moment by moment, the state of the physical structure of the organism in its many dimensions." [PARVIZI and DAMASIO 2001]. Our theoretical proposal, developed further along the chapters of the thesis, distinguishes Damasio's concept of extended consciousness into five different aspects. This distinction should explicit how certain areas of the brain contribute to consciousness, not homogeneously, but through specialized modules. We suggest that the complex neural networks, whose contributions are intersecting, are responsible for subjective experience of self-recognition. While core consciousness is very localized, extended consciousness spreads throughout the neocortex, with slight emphasis on prefrontal areas. We suggest that the subjective conscious experience is the product of a multifaceted analysis processed by distinct modules that are self sufficient to the extent that they are still able of some cooperation with the other modules.

The human being is extremely complex, but it seems to us wrong to deduce that, because of this complexity, there would be something beyond basic physical, chemical and biological processes taking place under consciousness hood. If we take reduction in the Cartesian sense, the linear analysis is unfit for describing a non-linear system of dependent variables. The countermeasure for making sense of the reductive approach

amygdala [GIUSTINO and MAREN 2015]. However, route from prefrontal areas to amygdala takes: much a longer time compared to the hormonal and physiological changes in the body that are already happening as an answer, short after the frightening stimuli; has intrinsic limitations. Information such as increased heart rate and flutter in the stomach (when threatening stimuli force blood to migrate from the viscera toward the peripheral limbs) may be consciously accessed. The neural pathways required for the access from subcortical to neocortical areas takes a toll on brain's limited resources, the economic principle can help describe why homeostatic processes remain unconscious most of the time. When the access path is not being actively requested, it will stand by.

from most scientific research regarding consciousness is to keep in mind that each field can only hold partial answers. Convergent support from, at least, more than one research area is required for more general claims about consciousness to hold. Even when multiple groups of scientists from different areas get into an agreement, the chance for error is not null.

We may decide to ask ourselves the question: "What is it that we know that we know?". How the external objects in the world can be consciously accessed. The literature review carried out so far points out that no single brain region gives conscious first-person full access to all the information available to the Central Nervous System. In order not to just verify the obvious (i.e. that we know nothing) we analyze consciousness in different aspects. Such a demarcation is necessary to explain brain functioning. We intuitively perceive consciousness as a continuous and indivisible flow and not as a disconnected jumble of pieces of a jigsaw puzzle. The combination of the modules responsible for extended consciousness can result in a composite unit, it only shows itself to be fragmented when the modules are not working properly.

Our research suggests that this unified perception of conscious states is due to the connections between the different modules involved in the whole process. Evidence supports the notion that superior performance is achieved with refined and simplified cerebral cortical processing, therefore supporting the modularization hypothesis can achieve better efficiency [DEENY et al. 2003, WU et al. 2007]. Suggesting that highly connected neuronal areas require greater energy expenditure. However, the complete isolation of the regions would make it impossible to pass information from the location where it was gathered, toward the areas to be processed. Metaphorically, the processing "islands" are linked by an ocean of connections that integrates information when and where the information is needed. In some cases, like the insula lobe, many connections with other islands come together and there is enough local processing to form a "continent".

The neocortical aspects of extended consciousness are built upon the information received from core consciousness subcortical areas. The aspects of extended consciousness can be separated into five aspects: social, perceptual, ethical, linguistic and temporal. The aspects are divided according to their respective brain areas, however to draw the line distinguishing the aspects is never an easy task, as the areas often overlap each other. The cortical connections can establish a link between two or more networks that can be correlated with the different aspects of consciousness. Even though the division in different aspects is illusory, the description serves its purpose because it simplifies the matter.

Dysmorphisms are observed in the corpus callosum in comparing men's to women's bodies. The splenium of the corpus callosum is proportionately more voluminous in women [DELACOSTE-UTAMSING and HOLLOWAY 1982]. A greater bulbosity is related to better cognitive performance in women, but this characteristic does not con-

tribute to the performance of men [DAVATZIKOS and RESNICK 1991]. These bodily differences indicate that, on average, the female brain tends to exchange more information across hemispheres compared to the male brain. Women, on average, have greater empathic capacity compared to men [TOUSSAINT and WEBB 2005,RUECKERT and NAYBAR 2008].

Evidence suggests that testosterone inhibits binding to the oxytocin receptor [2]. Oxytocin influences the establishment and strengthening of affective bonds (whether through receiving a hug, exchanging marriage vows or having an orgasm). In autism, serum oxytocin levels are significantly lower [MODAHL 1998], while intranasal administration of synthetic oxytocin reduces psychotic symptoms and improves ToM and social perception in autism and schizophrenia [PEDERSEN 2011, JOHNSON et al. 1991, INSEL et al. 1993, ARSENIJEVIC and TRIBOLLET 1998].

The cerebellum, amygdala, hypothalamus and gonads are components that appear early in our evolution and are oriented to controlling and getting feedback from the internal bodily functions. To underestimate the balancing contribution from brainstem areas and evolutionary older components of the human brain can prove deceitful to our interpretation of human consciousness. In the most basic sense of the word, "consciousness" means the consciousness of the body. This level consciousness in not unique to humans, in fact, rudimentary core consciousness may probably be found in most living organisms.

The embodied core consciousness is linked to the higher brain aspects, basically through the insula lobe, gathering subcortical information that can be accessed by the neocortex. Abstract information depends on concrete information. Information from the body furnishes consciousness with sensitive stimuli (bottom-up) that will later furnish ideas about the outside world (top-down). Some defenders of embodied cognition are aligned with anti-representationalism, insisting that the skull or skin should not be treated as a line dividing where the mind ends [NOË 2009], for life operates in a circular process closed within itself in its constant adaptation to the environment [MATURANA 2002].

Often we will find different theories competing over an answer for the mind-body problem. It is plausible to believe that each theory has its own strengths and weaknesses. Our research suggests that the mind-body problem is not a single monolithic problem, but a composite problem that can be taken apart into many smaller problems. Many questions can be derived from the mind-body problem and no single theoretical perspective is fit to answer all the questions derived from the mind-body problem. Our hypothesis holds that there is no single answer for the mind-body problem, but a plurality of answers coming from many different angles, depending on which particular question regarding the mind-body problem is asked. Hopefully we may be able to

[2]Oxytocin hormone main function (whether in natural or synthetic form) is the induction of labor in pregnant females and during breastfeeding. [SOLOFF, ALEXANDROVA and FERNSTROM 1979].

recognize where all those perspectives converge towards.

This conciliatory answer may seem to be an easy way out, but it is actually the hard way out. The simplistic approach would be to hold a single viewpoint and to close our eyes to the different schools of thought about the subject. In our opinion, no single scientist nor a single branch of science can afford to see all the aspects of consciousness. This is why we chose our bibliographic review to cover a broad range of different perspectives and to offer some possible interpretation for how all the branches may be taken together into a whole picture.

Indeed some theories have been more compelling than others, by providing more solid evidence, displaying more consistent theoretical framework, or both. However, no single theory seems fit for describing all the aspects of the mind-body problem. For instance, in chapter 5 when comparing empiricism and rationalism we will respectively argue that: (empiricism) [rationalism] is (better fit) [unfit] to describe knowledge acquisition regarding the external world, but (unfit) [fit] for describing knowledge acquisition regarding abstract concepts.

Mind's existence depends on the body. Being inherent to the human being to have bodily characteristics such as gender, ethnicity, height, age. These are questions that naturally come to mind when answering the question: "Who am I?" Thos accidental features are ubiquitous during our lives, disguising their salience, rarely standing out from its background. The pervading influences from the body to the mind are thus easily overlooked.

Men enjoy many privileges in our society, simply because of the sex they happen to have been born with. For instance, I never experienced what it feels like to be a woman in the context of a misogynistic society, therefore I may easily underestimate the magnitude of the daily difficulties imposed to the opposite sex. To understand this influence may not only be difficult for any man, but for woman as well, as she may have grown desensitized over the constant diminishing, even more troubling, she may have internalized the lie repeatedly told to her that she is less of a person because of her sex.

Analogous reasoning could be drawn about other accidental bodily features. During Apartheid, racial segregation was openly institutionalized. Fortunately Nelson Mandela led the anti-apartheid political movement that has ended this abject political period, yet this should serve us as a warning to the sociopolitical influences forced upon us because of the tone of our skin. The law may have changed, but have the mentality changed as well?

The social environment predispose stereotypical prejudices to invade self-image. Another example: during the process of sexual discovery, for the mind to identify itself to a different gender from the body one was born to often becomes a cause for anxiety [WILLIAMS 2008].

The mind's eye not only looks inward, but it reaches to beyond the limits of the

body. Perceptual consciousness focuses on the external world. The dorsolateral prefrontal cortex is involved in visual attention [ROUNIS et al. 2010, DEHAENE and CHANGEUX 2011, PANERI and GREGORIOU 2017]. This aspect of consciousness enables one to gain a subjective perspective of the world.

If the structure of the mind were different, the external world would be distinctively perceived [NAGEL 1974]. All the information arriving from the perceptual channels can be made available to the perceptual consciousness. Part of the information is filtered, given that the access memory (also known as working memory) constrains the amount of information that can be accessed, due to our biologic limitations. Most of the remaining sensory information, collected from the senses, remains non-conscious. Would the means to collect information change, the outcome would probably change as well. As we don't share the same perceptual means of a bat, for instance, we probably can't conceive how it would be like to be a bat.

An action can be performed according to the visual stimulus, even in the absence of the ability to accurately report the received stimulus. An effect demonstrated in studies with the patient D.F. According to Schenk, Patient D.F. was able to correctly insert the letter inside a slot no matter what direction the slot was, but unable to correctly report what was the slot's direction asked the letter was inserted to (the probability for the reported direction to match with the actual slot's direction was as good as random). D.F.'s hand movement required access to information that could not be consciously reached [SCHENK 2006].

The central executive network has an important contribution to enable conscious access to the external world [BADDELEY 1993, BADDELEY 1993]. The Central Executive Network is activated when any cognitive demanding task is presented to the subject. Activation of the Central Executive Network suppresses activation of the Default Mode Network [BRESSLER and MENON 2010]. Prefrontal areas are responsible for particular contribution to attention and consciousness such as: the dorsolateral prefrontal, and parietal areas. Sensory information, gathered from the senses, can thus be accessed, interpreted and manipulated. A common assumption is that specific signals for each channel from external objects are the main causes for activation of sensory neurons [3]. The Sapir-Whorf hypothesis argues that language and culture constrain perception. The hypothesis may be extended to the backward direction: that perceptual experiences, or their absence, may also constrain and influence language and culture. This two-way path (language $\leftrightarrow$ perception) may explain why different cultures struggle so much trouble to understand each other, analogous to the bat in the Nagel example, different cultures perceive different worlds.

Attention self-control (and the continuous exercise to bring it back, after some dis-

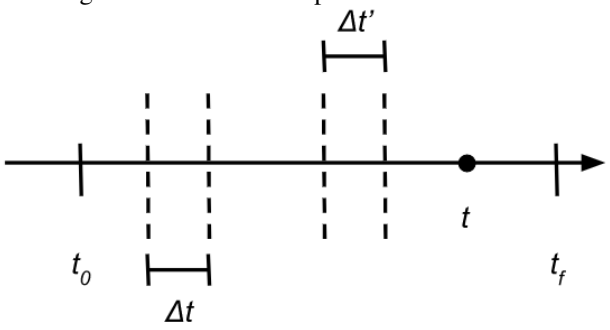
[3] This may not be the case, as in the unusual synesthestic perception, where a stimulus from one sensory modality evokes involuntary experiences to another modality channel. Moreover, evidence from primary sensory cortices suggests the occurrence of cross-modal interactions [ZHOU and FUSTER 2000, COHEN et al. 1997].

traction) is one more factor to account for in any consciousness theory. The ability to focus on a particular target, or patiently delay an immediate pleasure are symptoms of the good functioning of the Central Executive Network. While the multitasking capability requires the "boss" network to redirect attention, the Salience Network is responsible for switching control between either activating the Central Executive Network, deactivating the Default Mode Network, or doing the opposite: deactivating Central Executive Network, activating the Default Mode Network.

Temporal consciousness includes accessing memories from the past and autonoetic awareness [4]. Human beings exist, from birth to death, constrained to the dimensions of time. Classical mechanics is fit for describing phenomena involving negligible speeds when compared to the speed of light, within the macroscopic scale. Ordinary human beings (of a size many times the Planck length, traveling at ordinary speeds) can have their timeline described in terms of classical physics with acceptable precision.

In the classical mechanics formulation, the body of a living human being is temporally located in the interval between two points: birth (time = t_0) and death (time = t_f) in a continuous line in which the passage of time is a constant, i.e. intervals of equal length (Δt and $\Delta t'$) represent two linear passages of time with equivalent duration.

Figure 1: A Cartesian representation of a timeline



A point on the line (time = t) is a non-dimensional (zero-dimensional) projection of the one-dimensional line segment that represents a lifespan of an individual, on the mathematical description. In one-dimensional coordinates, the point projection t is contained in the line segment that starts at t_0 and ends at t_f. The opposite is not true: the point t does not contain such a line segment. Part of the information is lost after a projecting the one-dimensional line segment into a non-dimensional point. This projection transformation produces a loss in information, when attempting the inverse transformation applied to the result – from the point back to the line segment – there is no sufficient information left in the point to recover the initial parameters for rebuilding the original line segment.

[4] Briefly put, the capacity for mental traveling to past or future scenarios

Patient K.C., after a motorcycle accident, suffered extensive brain injuries, including bilateral loss in the hippocampus [ROSENBAUM et al. 2009, ROSENBAUM and MOSCOVITCH 2019]. After the accident, K.C.'s memory was stuck at the moment, confined to a small portion, just a shadow from the rich temporal experience he once had. Patient K.C. had lost the capacity to recall what he was doing just a few minutes ago. Forgetting his last thoughts as soon as his attention were directed elsewhere. The accident caused a significant loss on his temporal consciousness, without harming his semantic memory and knowledge acquired before the accident.

The classical physical description for time passage is useful for us to visualize what happened to the temporal consciousness of the patient K.C. A healthy temporal consciousness of an individual with a working hippocampus over a lifetime, capable of creating new memories, retaining old memories and projecting themselves into the future, resembles the analogy of the line segment between t_0 and t_f. K.C.'s memory, on the other hand, resembles the point projection t. Both the healthy individual and K.C. Memory have access to the more immediately present information, but only the former has access to information from longer ranges. In the mathematical analogy, the K.C.'s capacity for memory is a subset of the capacity for memory of a healthy memory.

Arguably the most famous brain lesion is the Phineas Gage case. This pioneer study was the earliest to suggest the role of the brain in shaping personality. From the reconstruction of his accident, it became known that his medial prefrontal cortex (mPFC) was injured. His memory and general intelligence seemed unharmed, but his behavior had changed dramatically when compared to what he used to be before the accident. "After the accident, he no longer showed respect for social convention; ethics in the broad sense of the term, were violated; the decisions he made did not take into account his best interest." [DAMASIO 2006, p. 11]. Studying patients with similar conditions, Damasio describes changes in their experiences of consciousness. The ethical consciousness aspect is compromised in the case of mPFC injury.

The prefrontal areas first got the attention of neuroscientists, but speaking in terms of evolution and development those areas appeared only recently in human kind. Naomi Eisenberg and Matthew Lieberman have brought new attention to a much older area in our brains: the areas for detecting pain. In humans, as in other mammals, the dorsal anterior cingulate cortex (dACC or brodmann area 32) is associated with social pain [EISENBERGER, LIEBERMAN and WILLIAMS 2003]. The same region is responsible for physical pain. Analgesics reduce both social pain and physical pain [EISENBERGER 2011]. Social pain is a biologic alarm that makes the moments when they are disconnected from their peers unpleasant for mammals. Being alone is one of the great evolutionary risks to mammalian survival, from early childhood to old age. Avoiding social pain was crucial to mammalian fitness in the past and is still relevant today. We will argue that the social nature of the human mind plays an important role to our social consciousness.

Peter Carruthers elaborates a representationalist theory of mind. According to him, consciousness is a high-order representation directed to the low-order representational system. Carruthers proposes a theory – called high-order representational theory – establishing a hierarchical structure, where lower levels are responsible for non-conscious processing while higher levels are responsible for conscious processing, i.e. the subjective experiences of the organism. Carruthers postulates that this hierarchy is only possible through the presence of a structure capable of mentalizing [CARRUTHERS 2007].

According to Sartre, not knowing what is behind the gaze of another person cause us to anguish as we do not have direct access to the mind behind the gaze. This anguish would fuel human consciousness [SARTRE 1943]. The default mode network recruits areas of the mentalizing network, [MOLNAR-SZAKACS and UDDIN 2013, HYATT et al. 2015, SPUNT, MEYER and LIEBERMAN 2015, LIEBERMAN 2013, MARS et al. 2012]. Mentalizing network is responsible for the social consciousness, making it possible to guess what might be going on in the mind of others and in one's own mind. Introspection is related to the areas of Theory of Mind (ToM), i.e. the generation of hypotheses about internal processes of one's own mind and the mind of others as well. The "mind reading" circuits share the same regions of the Default Mode Network, by far the most active network throughout our lives and even our dreams [DOMHOFF and FOX 2015]. This network spends more resources than any other network. Evidence suggests in favor for human social needs comes from activation of pain-related areas (dACC) along with social rejection.

The circuitry needed to perform extended consciousness in humans requires longer brain formation. Furthermore, among all animals, humans have the highest ratio of metabolic consumption [5] of the Central Nervous System / metabolic consumption of the whole body [MINK, BLUMENSCHINE and ADAMS 1981].

Another drawback is that few non-human animal species display significant numbers of individuals with same-sex partner preferences [NAGASAKO, OAKLANDER and DWORKIN 2003] and asexual behavior [CLARK and JR 2000]. Such behaviors, from an evolutionary point of view, are maladaptive. Wasting the opportunity to generate offspring reduces the chances of transmission of genetic material. Studies show biologic bases for the variation and diversity of sexual behavior in animals [CLARK, TUCKER and JR 1992].

A maladaptive behavior, from an evolutionary point of view, is not correct or incorrect, has neutral moral value. Inferring about the morality of an action solely on the basis of the evolutionary aspect does not seem at all a satisfactory criterion.

Humans have no natural predator and can subjugate any plant or animal to his will, an exception among the animal kingdom. This is not because we are the strongest and fastest animal (we are not), but because humans cooperate in a much more flexible

[5] Measure in cm/min

fashion than any other animals. Some animals are more cooperative than humans, bees and ants for instance, but each bee and each ant has a very rigid role in the colony. The role of each human can change over the course of one's life. We suggest that the evolutionary adaptations that brought the maladaptive behaviors (celibacy and suicide) so specific to our species came along with the adaptations that allow us to reevaluate our purpose in society and life.

Significant rates of self-extermination are mainly observed in humans. Even though there is evidence of deliberate self-endangering behavior among non-human animal species [PRETI 2011, CRAWLEY, SUTTON and PICKAR 1985], no animal model of suicide, or self-aggression was proposed. In humans, main causes reported by adolescents who have experienced suicidal thoughts include seeking relief from terrible mental states or escaping impossible situations [BOERGERS, SPIRITO and DONALDSON 1998]. Suggesting a correlation between suicide and the suffering brought about with the human enhanced capacity to express self-oriented emotions.

What those mentioned studies suggest is that an increased capacity for self consciousness might be associated with an increase of maladaptive behaviors, decreasing human evolutionary fitness. In this case, in addition to the aforementioned disadvantages, evolutionary theory indicates that one must find other evolutionary advantages, if that turns up not to be the case, the rise of human extended consciousness is to be considered an evolutionary aberration. The evolutionary case of the human being would face us before an evidence that would not be in accordance with the theory of evolution of the species (the selection would have occurred and propagation of genes with lower fitness, disfavoring others that are fitter).

"It's overhelmingly acknowledged by the scientific community that evolution [...] [is] undeniably supported by physical evidence." [CARTER and WILES 2014]. Extended consciousness must have brought along evolutionary benefits that outweigh the disadvantages encountered. Each aspect of human extended consciousness contributes to increasing the chances of reproduction and survival.

The social aspect of extended consciousness inclines toward prosocial behavior. The perceptual aspect, predisposes greater accuracy in learning information from external stimuli. The ethical aspect, discourage violent behavior. The temporal aspect, enhances storage capacity for the learned information and organizes it in a chronological fashion. The linguistic aspect, increases the range of information to be expressed; facilitate social exchange; influence perception; its symbols are likely substitutes for the objects they refer to. From an evolutionary framework, the possible advantages from human extended consciousness should balance out the energy spent in developing and maintaining big neocortical areas, as well as the maladaptive behavior it predisposes. We suggest that the subjective quality of human experience have biological causes and, as such, must have biological explanations.

Environmental pressures demanded, in our ancestors, the formation of larger and

more organized groups. Natural selection favored genes carrying mutations throughout human evolution related to the increase in neocortex volume. We work with the hypothesis that the ability to express extended consciousness was strengthened by the volume increase of the neocortex. Other factors also play relevant roles in the development of each organism: the adequacy of the diet; sleep quality; diversity of stimuli; interaction, care and learning in family and society; just as injuries or abuse suffered, especially during the early stages of life, impose a requirement for cells to express or suppress the action of genes.

Extended body consciousness includes sexual, ethnic and non-verbal expression aspects. The body is situated halfway between the internal and the external. The organism has a self-regulation condition that enables itself to keep its structure adapted to the environment [MATURANA 2002]. Like a rubber wheel that shapes itself according to the terrain, but does not become necessarily part of the terrain.

Sex differences in animals are not homogeneous. Tournament species males breed during annual tournaments. They compete fiercely with each other. Aggressive males produce many offspring. The gentle ones produce few. The males are larger than the females. Females do all the parenting.

Pair-bonding species live in better balance. Male and female share parenting. They are close to the same size. They are monogamous. One male produces roughly as many offspring as the next.

No species is purely one or the other.

> Gender is the most important variable in the prediction of criminal behavior. Crime and delinquency rates for males are in excess of the rates for females in all nations, for all communities within a nation, for all age groups, for all periods of history for which organized statistics are available. [JANEKSELA 1997]

Such statistics reveal a male predisposition to aggression. Elevated testosterone levels are related to increased crime and violence [DABBS JR 1995]

Adopting behaviors compatible with one's own body is adaptive, from a reproductive point of view, even if it may be morally incorrect. The ethology of many non-human animals points to the role of testosterone in the male as important for stimulating aggression, violence and competitiveness to intimidate other competing males during mating rituals [WINGFIELD 1987, GOULD and ZIEGLER 2007]. The female does not need to compete for the partner, on the contrary, she can choose the one with the best characteristics, according to her criteria. For her, creating bonds is more important than destroying them. Most females in the animal kingdom have low levels of testosterone and low levels of aggression.

In some species the same male fertilizes different females during the same season, this strategy maximizes the male's chances of passing on his genes. The female needs

to invest much more in her offspring than the male, if the male has fertilized many females, he can neglect his offspring without much harm to his chances of passing on her genetic material. The female is in a very different situation, if she neglects her young her chances for breeding in that season will be jeopardized. Ethology shows that, in mammals, females are only more aggressive than males when it comes to protecting their young [HUGHTO and REISNER 2016].

The perceptual consciousness aspect reveals clues to dangers or opportunities. Focusing on what one is observing enables to capture vital information that would otherwise go unnoticed.

The temporal consciousness aspect is relevant to understand the patterns of recurrent risks and opportunities. With such information one is able to plan for the future. E.g. building a shelter for protection. There is no immediate advantage during the construction of the shelter, but the ability to project about the future may guarantee benefits to be reaped later on. Saving provisions for the winter by remembering that there is scarcity at that time will increase the chances of seeing the arrival of spring. Such behavior is not unique to our species.

The ethical consciousness aspect of the individuals in the group enables for greater trust and stability. If everyone acts in accordance to ethical rules, the whole group benefits. On the other hand, being surrounded by rapists, murderers and thieves will drastically reduce the survival chances. The human inclination to reject antisocial behavior is adaptive, by individually refraining from these bad habits, the whole group is benefited. Social animals are more likely to reject antisocial individuals, while they are predisposed to accept individuals who act in accordance to the rules of conduct.

The ability to assign intentional states to others is a skill is an extension of the social consciousness. Although there is a predisposition to moral behavior, we know that we and others do not always act morally. The ability to estimate the emotions of others makes it possible to foresee risks or opportunities. Activation of the mentalizing network, probes the other, raising hypotheses about their hidden motivations, enabling an approximate assessment of their beliefs and desires. Trusting the enemy is often risky, and distrusting the friend, too. The social world produces strong demands on emotional intelligence. We suggest that, throughout evolution, the challenges of navigating the social world exerted pressure on our species to. The rise of the social consciousness coincide with the increase of the encephalization quotient [6] in our species. In order to understand the others, we had to understand ourselves.

Language is an important asset of the human's toolbox. Language is adaptive to the human being for innumerable reasons, it enables: to alert the other about dangers that he he may be unaware of; share more efficient techniques; coordinate complex actions in partnership; increased capacity for analysis and reasoning; new forms of creative expression, bringing people together in cultural activities that strengthen the

[6] Encephalization quotient stands for the ratio between brain volume and body volume.

social bonds.

Natural selection has endowed us with heightened consciousness. The only way to make evolutionary sense of this mutation is to consider the balance of advantages and disadvantages to be positive. Accepting this line of argument would enable us to say that, in Darwinian terms,perceiving the world from a subjective point of view brought an overall advantageous behavior to our species. We suggest that our ancestors with greater self-reflection probably had greater fitness than its counterparts others and, as a result, were more successful in passing on their genes.

If we are endowed with the capacity for consciousness, it probably was adaptive to our species to invest much of its available energy resources in high-demand neural processes – which is too costly to other nonhuman animals. Such processes enable us to consider a wide range of possible actions for ourselves. This self-perception seems to reshape our way of acting in response to external stimuli which, so far, has been a successful adaptation. Other species are threatened by our actions, but only the human being can perceive himself capable of threatening and realizing its extinction. Perhaps we are too adapted for our own good.

1.1 Problem

If, on the one hand, the investigation of core consciousness already presents enormous challenges, the same can be said, if the challenge is not even greater, in relation to extended consciousness. We analyze consciousness into Embodied Core Consciousness and five aspects of Extended Consciousness: Social; Perceptual; Ethical; Linguistic and Temporal. Stitched together by the fabric of the connections between the modules.

We will focus on the phenomenon of core consciousness and extended consciousness. Chapter 3 discusses a methodology to integrate the different aspects of consciousness. The integrated information theory should allow us to proceed in the reductive analysis of the different aspects of consciousness, studying each one in isolation from the others, but for the synthesis (and here comes the innovation) we will not simply add the components, but we will pay attention to the structure between the parts and how each part constrains the behavior of the other parts. For the role of neurons is not merely to stimulate the others, but to inhibit them as well.

> When we see, for example, we experience visual sensations: the felt quality of redness, the experience of dark and light, the quality of depth in a visual field. Other experiences go along with perception in different modalities: the sound of a clarinet, the smell of mothballs. Then there are bodily sensations, from pains to orgasms; mental images that are conjured up internally; the felt quality of emotion, and the experience of a stream of conscious thought. What unites all of these states is that there is something it

> is like to be in them. All of them are states of experience. [CHALMERS 1995].

We regard the hard problem of consciousness as presented by Chalmers as, in fact, a genuine problem that has not yet received a satisfactory answer.

"Chalmer's attempt to sort the 'easy' problems of consciousness from the 'really hard' problem is not, I think, a useful contribution to research, but a major misdirector of attention, an illusion-generator." [DENNETT 2000] Dennett's counterargument to Chalmers' paper is not an answer to the hard problem, but an attempt to discredit the problem altogether. But the distinction proposed by Chalmers seems useful. The "easy problem" of describing **how** observable and quantifiable physicochemical mechanisms in the brain enables for the expression of consciousness is a different problem from the "hard problem" of explaining **why** being conscious has a particular subjective character that gives rise to the experience of being conscious.

We suggest the possibility to outline an argumentative line that can direct us on our path to describe **how** natural selection favored the capacity for consciousness on our ancestors. The reductionist approach to consciousness gives no complete answer neither to the hard problem nor the easy problem, but it can suggest what the pieces of the puzzle may be. According to an evolutionary account, analyzing the aspects of extended consciousness may provide some tools that may contribute in grasping how biology shaped conscious experience. For example, the aversive subjective experience associated with physical pain, or the rewarding subjective experience associated with orgasmic experience, we suggest, play a crucial role in our chances for, respectively, the survival and the reproduction of our genes. In other words, it makes sense that having an orgasm feels good because it predispose us to have sex. The "feel good" is a subjective feature associated with the conscious experience and there may be a perfectly reasonable biological explanation for it.

The present thesis suggests that the subjective experience associated with different events in human life may be consistently described through evolutionary lenses. For example, feeling pain as unpleasant predispose us to avoid any threat to physical integrity or social relations. This aversive character promotes the avoidance behavior, increasing chances for survival.

Unfortunate people with a rare condition of congenital insensitivity to pain, also called congenital analgesia, are in much greater risk, especially during childhood. As they can easily injure themselves without realizing it, people suffering from this condition rarely reach adulthood [NAGASAKO, OAKLANDER and DWORKIN 2003]. The genetic mutation responsible to the subjective aversive experience associated with pain was adaptive because individuals with this characteristic were more likely to reach the reproductive stage of life. Babies born without this ability require greater attention and care to protect their physical integrity, which, from an evolutionary point of view, is maladaptive. Which makes it likely that the characteristic of insensitivity to pain

should disappear or be greatly reduced over generations. Natural selection certainly contributed to the condition of congenital insensitivity to pain being an extremely uncommon condition [REFERENCE and VASEY 2002].

This serves as an example of how we may describe the underlying mechanisms for the subjective nature of human experience and behavior. Looking for clues suggesting the adaptive or male adaptive change in human behavior under the influence of conscious processes, is not a not a straightforward process. The relevant factors shaping human experience and behavior do not evolve independently. A certain gene may or may not be expressed depending on the presence of certain environmental factors, on the other hand, environmental factors may or may not be as relevant depending on the respective gene presence.

> Genes are rarely about inevitability, especially when it comes to humans, the brain, or behavior. They're about vulnerability, propensities, tendencies. [...] It's not the gene that causes it. It's that the gene interacts with a certain environment. [SAPOLSKY 2004, p. 151]

The two variables at hand are mutually dependent, rendering unfit the reductive approach, as a crucial information is lost when one isolates gene from environment.

One approach we suggest that might mitigate this issue is the integrated information theory. If subjective first-person experience was an inherited capacity in humans, as it seems to be the case, one may look into the results collected through the use of multiple research fields applying reductive methodology, but taking one step back in the interpretation of the results, by asking the question: how consistent are the different results, when taken together?

Conscious processes seem to play an underlying influence in the observable human behavior. When I say "I am conscious", among other things, I am implying that I have some control of my behavior. Even though I may not be aware of everything happening inside my body when I move my arm, it clearly seems to me that it was me who made the decision to move the arm. As if my consciousness set the right conditions in my body for my arm to move. If I were willing to move my arm and my arm refused to move, I would certainly fear that something went completely wrong inside me. We seem to have control over how our body moves.

As with other animal characteristics, "behind every successful genetic mutation there is always a natural and biological explanation" [GRIFFITHS 2005, p.629]. Suggesting that, if human consciousness resulted from a sequence of mutations over our genetic makeup, there probably is a natural and biological explanation for human consciousness.

The alternative would be to look for unorthodox explanations. An extra ingredient that science cannot measure. Consciousness is such a complex problem, why should we limit ourselves to orthodox methods of research?

> We might add some entirely new nonphysical feature, from which experience can be derived, but it is hard to see what such a feature would be like. More likely, we will experience itself as a fundamental feature of the world, alongside mass, charge, and space-time. If we take experience as fundamental, then we can go about the business of constructing a theory of experience. [CHALMERS 1995]

Adding extra ingredients is usually a strategy frown upon in scientific community. The added non-physical entity cannot fit into an analytic description. In this case, to include a non-physical entity constitutes an irrefutable claim. Mass is a fundamental physical property of matter and can be measured in kilograms in the International System of Units, as well as charge, measured in Coulombs. Mass and charge are fundamental properties. To be a fundamental property of physics means to be a property that cannot be further divided into simpler components. For example, a particle can have charge without having mass, an example is the photon. In the same way, a particle can contain mass without having an electric charge, an example is the neutrino. If we were to include experience as a physical property of matter then not only would we be able to measure it, it should be independent of the other fundamental properties. In other words, for experience to be considered a new fundamental property would require the possibility of observing an "extra particle" that has experience, without neither having mass nor charge. A subterfuge to avoid this burden is to place this new concept outside of physics, the shortcoming of this strategy is that it should come along with the onus of coming up with a measuring tool to measure something that, by its definition, is immeasurable.

Can we accept that there are entities carrying experience, without mass or charge? Arguably, physics can be called a "fundamental science" because all branches of natural science, such as chemistry, biology, geology, are constrained by the laws of physics [FEYNMAN 1995]. A geology that refutes the laws of physics is only to be accepted in the academy in case it satisfactorily demonstrates the flaws in the current physical theories.

If we take experience "as a fundamental feature of the world" it entails the existence of a feature of the world that the laws of physics have dismissed completely. If this turns out to be true, dramatic changes would be required in order to accommodate this new fundamental feature to the laws of physics. By taking experience to be as a fundamental property, new laws of physics would derive, such changes would have to reshape not only physics, but chemistry, biology, geology. Extraordinary claims require extraordinary proof. Have Chalmers provided any proof for his extraordinary claims?

We believe that both the easy and the hard problem of consciousness deserves our attention, but we are dissatisfied with the approach suggested by Chalmers. Without some strong evidence, adding new fundamental entities should be inadvisable, to say the least. The logical principle of Occam's razor holds its essence in the statement:

"entities must not be multiplied beyond necessity". The onus from rejecting experience as a fundamental property is to explain the phenomena of consciousness according to the fundamental properties in current laws of physics and other branches of natural sciences.

Therefore the problems of consciousness our thesis will be concerned with are not restricted to the objective aspects of consciousness, but the subjective aspects as well. The concept of consciousness focused here is not a monolithic concept, but a plural one, composed of many different branches.

Our consciousness concept considers two main division in consciousness. Namely, core consciousness and extended consciousness. Core consciousness is limited to a very basic aspect of consciousness. The most fundamental body regulation and feedback required for the proper functioning of consciousness and physical health. Extended consciousness, on the other hand, covers a much broader range of processes. Extended consciousness is much less vital than core consciousness. We distinguish extended consciousness in five aspects: social, perceptual, ethical, linguistic and temporal. One aspect of extended consciousness may be knocked down, without necessarily impairing consciousness as a whole. But if core consciousness is harmed, the other aspects of consciousness can no longer be expressed.

1.2 Methodology

In order to discuss the plurality of consciousness, first we will introduce our main methodological tool for our analysis. Namely, we will apply Integrated Information Theory. This framework suggests the reductive method unfit for studying complex phenomena such as human consciousness. We may proceed to study the different aspects of consciousness in isolation, but the main difference between reductive method and Integrated Information Theory relies on the synthesis step. According to the reductive approach a simple linear sum of the isolated components would suffice to understand the behavior of the whole. Applying Integrated Information Theory the synthesis not only acknowledges the sum of the isolated components, but subtract the integration between the parts, accounting for the constraints in the system due to how the parts are structured.

After introducing our methodology, the next task is to gather up all the main aspects of core consciousness and extended consciousness. During this listing it is important to take notice that in breaking down the aspects in order to its study one is forcefully ignoring how the parts are related to each other. Missing the integration between the parts will hinder our research to be fragmentary.

Focusing the problem of consciousness, papers from different areas of knowledge are reviewed. Aligned with methodological naturalism, the approach emphasizes the natural sciences. The reading and interpretation of a large range of multidisciplinary

papers and books are crucial for the research on human consciousness. This requires a careful look at the technical and scientific details of brain research, otherwise we would have to rely blindly on the accuracy of the analysis of our sources.

We have selected a wide range of studies that we believe are capable of contributing to a little elucidation of the many components that are working in cooperation for the rise of consciousness. Some neuropathological cases are interesting for the study of consciousness in assessing how consciousness is compromised due to damage to a specific area. The theoretical hypotheses raised can now be compared to real evidence. Images of brain activation in humans performing different activities are available today, due to the discovery of new imaging research techniques. With the help of the results obtained with the use of these new tools, we will try to design a theoretical framework that is minimally satisfactory and coherent with the experimental data of one of the oldest and most difficult enigmas in the history of philosophy: human consciousness.

Empirical evidence may support or refute philosophical theories about human consciousness. For such an ambitious research, failure is always a possibility. The paradoxical circularity in the human mind's attempt to explain itself can be formalized as follow:

- P1. A mind is more complex than the objects it can explain.

  If,

- P2. The human mind satisfactorily explains the human mind.

  From P1 and P2 it can be concluded that:

- C. The human mind is more complex than itself.

Conclusion C is a paradox. If something is more complex than itself, then it must be simpler, which in turn means that it must be more complex... The argument goes on indefinitely. As conclusion follows from the premises, in order to avoid the paradox, one of two premises should be considered wrong, the premise more likely to be wrong is P2. If the mind could explain itself, then it would have to be simple enough for a theory to be able to describe and explain it; if human mind were that simple, it would be incapable of formulating such a complex theory about itself.

Perhaps there may be a way to avoid the paradox: the combined efforts of two or more minds could result in something more complex than one mind. If we share the research results of a large enough number of intelligent people, treating the aspects shared between human minds, under compatible paradigms, it may be possible to reach some common understanding that a single person would not be unable to. To reconcile such a number of different contributions is a difficult task, yet possible in theory. This combination of minds is not intended to explain itself, but to explain only a simpler set of features that human minds have in common. The capacity for consciousness is something that most human beings have in common. Our methodology consists in bringing

together different authors and areas of knowledge to superficially describe consciousness. The present thesis considers an horizontal view of the problem of consciousness. It may not solve the paradox altogether, but do we have any better alternative?

Please consider the following thought experiment: during the 16th century a team is organized to map the seas and territories around the World. For this purpose, several students from different schools of cartography were sent to the explore the World. In the end, the students were brought together and the regions of the World they mapped is gathered. The scales and cartographic techniques would hardly be compatible from one student to the other. It may not even possible to understand in which regions the maps are superposed or not even mapped. Any attempt to adapt, or reescale the maps to unify the results would likely produce aberrations, discrepancies, deformities and errors. The effort would probably result in a distorted and unreliable representation of world's geography.

One may argue consciousness remain uncharted territory. The thought experiment suggests that, in order to draw a somewhat reliable representation of consciousness, it would be helpful to have: a general theoretical framework, from a far away perspective, about consciousness as a whole; and the particular empirical studies regarding the main aspects of consciousness, from a closer perspective, about the constituent parts of consciousness. At the very least, it would be helpful to have a sketch of consciousness. Even if it is only a superficial understanding, this may provide us a glimpse of what the horizon of consciousness may look like from a global view. Not only the reductive description of each component of consciousness is important, but also we have to figure out how the pieces fit together. This panorama is still under construction at the time the thesis is being written. Imagine that we chose to study a small aspect of consciousness in great depth, committed to our own theories and approaches, without some common denominator for how to present our results and discuss them among other researchers, without some common paradigm. Would we be much better than the player in "pin the tail on the donkey" game?

If each research program is committed to a different picture of consciousness, their results may be accurate, but incompatible between different research groups. As in the thought experiment mapping example just described, each map would be represented through distinctive methods and scales. The different descriptions may be accurate in themselves, but translating them into an unified profile produces errors.

Consciousness is complex. It involves more than one discipline. Some common sets of rules and assumptions must be worked out in order to enable a translation between the different research being done. Thus the researcher would be able to share the small increments obtained from their results with the academic community. Some concessions may be necessary, in our case we chose to work on a large and comprehensive scale, which should help representing the whole constellation of consciousness, the compromise in making such choice is its inaccuracy in the details portrayed. Fu-

ture research may apply the general integrated approach, but with a narrower scope, refining the individual aspects with greater texture and precision. Consciousness encompasses multiple brain areas, many variables can alter human behavior. Apparently unconnected when seen from the local approach, the interplay between different brain areas may become more apparent from a greater distance.

1.3 Hypotheses

Human consciousness is plural, it encompasses a collection of different aspects. The complexity of consciousness cannot be exhaustively studied through a single scientific discipline. Much of the scientific research rely upon the reductive method, indeed, the reductive method is fit for describing the parts of consciousness in isolation, but unfit for integrating its parts back to the complexity it displays as a whole.

Our hypothesis is that phenomena of extended consciousness relies upon a distributed system instead of a centralized system. Therefore, our best hope to ever describe the phenomena of consciousness is through the combination of many branches scientific research regarding the different aspects of consciousness, taking complexity into account.

1.4 Results and future research

The literature review carried out so far suggests that different areas of the human brain spread over the neocortex are specialized in enabling the expression of different aspects of extended consciousness.

Core consciousness, on the other hand, is centralized. According to studies on comatose patients, the core consciousness to have its nucleus in the superior pons and posterior midbrain, all cases of vegetative coma present specific damage in the superior pons region, in some cases including the posterior midbrain [PARVIZI and DAMASIO 2001]. The other aspects of extended consciousness can only manifest along along the support of core consciousness.

Aspects of extended consciousness are portrayed as relatively independent branches, one or more than one aspect may be altered or impaired without necessarily directly affecting the other aspects. In evolutionary terms, core embodied consciousness precedes extended consciousness. The primitive aspects of extended consciousness can be seen in some non-human animals. For example, the mentalizing network is shared with primates. Chimpanzees and great apes are able to pass the false belief test [7] [CONNELL

[7] In the false belief test paradigm the following situation is presented: there is Sally and Anne in a room; Sally leaves her ball in the basket and leaves the room; Anne switches the ball from the basket to the box without Sally seeing it and returns to where she has been; when Sally returns, where will she look? Anyone who has seen the whole scene knows that the ball is in the box, but from Sally's point of view the ball would be where she left it and the fact that Sally looks in the box should surprise anyone who correctly attributes a false belief in Sally's mind.

and DUNBAR 2003, CALL and TOMASELLO 1999].

A caveat to be noted: the association of each aspect of consciousness to its respective brain areas is an oversimplification of the actual processes at play. If we were to commit ourselves to a more technical description of the shaping of human behavior, more attention should be given in accounting for different levels: of genetic influence; hormonal balance and neuroreceptors presence; environmental and societal influences; priming factors and so forth [SAPOLSKY 2017].

Each aspect of consciousness encompasses different functions, modularization brings together in a single area the processing of a certain type of information. For example, in the extended ethical consciousness, two areas are both involved when analyzing ethical dilemmas, but with orthogonal functions: the mPFC, with a more emotional and automatic character; the more utilitarian dlPFC, which performs rational and deliberate calculations. Regarding the search for a moral center, Greene counters:

> "Where is the brain's moral center?" Apparently, people find the idea of a "moral center" in the brain very compelling. There may be many reasons for this, but I think it has something to do with the fact that a center, unlike a distributed system, need not have parts. The moral center of popular conception, I'm guessing, is not a computational system housing an array of dissociable subsystems that perform relatively simple, complementary functions. It is instead more like a portal, out of which fully formed moral thoughts emerge. [GREENE 2011, p. 263].

We can speak more generally and say that the idea of "a center of consciousness" is appealing for similar reasons. Consciousness does not seem to be fragmented, but it appears to flow continuously. Which makes it seem counter-intuitive to present the extended consciousness as the product of several parts combined, as a mosaic in which each part not only has its own information.

However, the research carried out so far suggests that the separation of extended consciousness into five aspects is compatible with neuroscientific data enables for a better demarcation of the complex concept of consciousness into more basic components. The investigation with new imaging techniques of the activation of the structures of the living human brain is a recent and promising field. Consciousness is a broad term, so the use of the term can end up being somewhat vague and imprecise. By adhering to the distinctions regarding the aspects of consciousness it may be possible to disambiguate and clarify what one means by "consciousness". When referring to a more particular aspect of consciousness we advise for naming which aspect one is referring to. The term "consciousness" should be reserved to talking about consciousness in general, as a whole, for clarity sake.

Guiding ourselves through the eyes of our predecessors and peers seems to be the natural path for anyone who wishes to look beyond the horizon of current research.

The concept of human consciousness fosters a rich debate in philosophy and psychology. We believe to live in a special moment, when the opportunity presents itself to improve our theoretical framework of reflection on the mind in contrast to the hard sciences enabling us to model the material processes taking place in the brain, during its functioning. Past thinkers who really looked into the subject of consciousness would probably have had taken great advantage of the recent discoveries in order to revise their notes.

A question for future research presents itself. the integration concept seems to be relevant to the discussion about consciousness. If that is the case, some conceptual consequences may follow from Tononi's Integrated Information Theory. Consciousness should thus be regarded not as a monolithic concept, but as a compound concept that includes the aspects of consciousness integrated into a single whole. Five modules of extended consciousness plus the core consciousness would not contribute homogeneously to consciousness, but each part to be specialized in representing a different aspect of human experience.

The *embodied* core consciousness would be related to the matters immediately related to the physical body. The remaining aspects belong to the extended consciousness, that can be further divided into: *social* consciousness, to experience ostracism and healthy relationships as, respectively, painful and pleasurable; *perceptual* consciousness, piecing together representations of the information available to the senses; *ethical* consciousness, a sense of empathy for others, the capacity to develop feelings for other sentient beings; *linguistic* consciousness is capable of symbolic reasoning, internally creating and manipulating language; and *temporal* consciousness, storing the information and hypothesizing about possible future scenarios, conjectures inspired upon past experiences

We are not suggesting that there is no interference between the aspects, only that there is a greater specialization and modularization that locates the efforts of each aspect of consciousness preferentially predisposing it to process certain type of information to the detriment of others. Modularization is more energy efficient than a holistic activation, simply because activating the whole brain costs more energy than activating an area of the brain. Regardless of the type of information to be processed, the brain runs on limited resources and selective pressures favored brains with better energy management. These ideas are just germinating, future works may better assess the description presented. Whether it is theoretically well grounded and empirically corroborated.

1.5 Conclusion

Describing human consciousness is a challenge, a mere scratch on its surface is more than we can hope for. We have found little evidence supporting that a single brain

region may be responsible for all aspects of consciousness. Although core consciousness is indeed very localized. In the case of extended consciousness, evidence suggests the contribution of many areas spread throughout the neocortex.

There are many theories about consciousness, some are self-contradictory if taken to the last consequences. Rather than wanting to prove what is the best theory of consciousness, the contrast between many theories seems to be much more promising than to focus on a single universal theory. The balance between opposing theories turns out to be beneficial to the advance of scientific research. Criticism can be destructive if ignored, but fruitful if acknowledged and properly dealt with. The plurality of opinions and studies enhances the chances for finding mistakes and improving the ideas. We are not advocating for a single theory of consciousness, quiet the contrary, multiple scientific fields and philosophical theories can complement each other, the philosopher job should be to search for the subtle equilibrium between different theories in contrast with the empirical evidence in order to properly develop a complex and rich concept of consciousness. A recurrent theme in this thesis is to pay attention to the parts **and** how the parts fit together, in order to be consistent with this standpoint, we have to broaden our horizons and look into many different scientific disciplines.

The academic training prepares the student to focus on a very narrow scope and it is only natural for things to be so, but this strategy may prove insufficient when it comes to describe human consciousness. If there is any hope of elucidating consciousness, it probably lies in the alliance of philosophy, neuroscience, experimental psychology, anthropology, sociology, etc. When the expertise of many different, scientists, focused on the subtle details, are combined into the greater picture, we may find it to share promising insights. A self-explaining mind produces a circularity, perhaps the way out of the circularity lies in the combined efforts from many minds complementing each other, studying the shared aspects of human consciousness and how each aspect interacts with the other aspects.

2 Integrated consciousness

2.1 Introduction

The motto:"The whole is greater than the sum of its parts" synthesizes a contrasting alternative to reductionism [POYNTON 1987, HEALEY 2016]. Information theory [SHANNON 1948] states integration constrains the information hold by the whole below the limit of the information of the sum of its parts [EDELMAN and TONONI 2003]. We will argue that the analysis of both approaches, reductive and non-reductive, can be benefited from the mathematical concept of information.[8]

Following the reductionist stance, taking for granted that Cartesian Analysis is applicable, all the components and mechanisms of the Central Nervous System would yield an exhaustive description of any phenomena it is responsible for. Considering, for example, coupled L-C electric circuit oscillators [HANIAS, KARRAS and MOBARAK 2009, YAREN, KIZIR and YILDIZ 2019], a very simplified system and yet, it impinges already the Cartesian Analysis' scope, given such oscillators are demonstrated to give rise to chaotic behavior [CAPRA 1996, PRIGOGINE and LEFEVER 1974, GLEICK 2011]. Resembling two neurons closed in a loop, the coupled oscillator pair analogy display wave patterns that approximate, to some extent and adequate parameters, the empirically measured electrical signals produced from the human scalp due to brain activity [LUCK 2014].

Consistently, a two neuron simplified model forming a feedback loop would display sensitivity to initial conditions. If we were to increase the complexity of our model by including: a number of neurons greater than two; neurotransmitter's and hormonal chemistry; gene/environment interactions [SAPOLSKY 2017], would only strain the reductionist approach even further. Not to mention (at risk of overshooting the target) early development stimuli, parental support, cultural group influence [DUNBAR, MACDONALD and BARRETT 2007]. Reductive analysis is tailored for systems composed by independent parts, but it suffers from relevant limitations when it comes to analyzing equations with dependent variables. Up to now, information theory has been deemed reliable in research regarding complex systems by providing first base principles accounting for the interdependence between parts, not just the isolated parts. Maybe there is hope for an acceptable framework guiding conceptual analysis on the puzzle brought by connecting neurons together. Integrated Information Theory may yield another reading key for making sense of the mind-body problem.

A long-lasting philosophical dissent has been recently reignited, influenced by the advent of cognitive studies: whether the mind may or may not be reducible to the activity in the body. In broader terms: whether mental life can be taken as independent of matter [JUNIOR 2020, HATCHER and TOFTS 2004]. Our brief text cannot com-

[8] A previous version of the chapter 2 was submitted and published as a paper [PAULY 2022].

promise itself to an exhaustive explanation of Integrated Information Theory and its relation to mental life. Yet, two considerations can be drawn: **first**, by considering the whole modeled as a set of bits, the interrelation between the bits subtracts information instead of adding it; **second**, the equations model for a single neuron cell spiking activity give us little reason to expect for any deterministic behavior, quite the opposite, its precise dynamics becomes highly unpredictable as time goes by. The causal chain of events is probably there, the problem is when we try to exactly pinpoint which cause brought up which effect.

A few words of caution: Mathematicians, physicists and computer scientists may find the mathematical prose not up to standard. Yet, philosophers and psychologists should indulge some license for the shallow literature review on the mind-body problem. The chapter is not supposed to be read as a treatise, merely as the schematics for a plausible transdisciplinary interpretation regarding the interface between the subjective mental experience and the objective measurable observable neuronal activity. The rhetorical maze between humanities and hard sciences is not to be underestimated. Our limited knowledge in both areas may hinder our ambitious goals.

Section 2.2 regards the ongoing disagreement over the mind-body reduction. Some arguments for holding the information contained by the whole to be equal to or lower than the information contained in the sum of its parts are presented in section 2.3 and section 2.4. Section 2.5 highlights why even the most simplistic "two neuron cells" brain model does not display deterministic behavior. Finally, section 2.6 attempts to sew those ideas into a coherent thread.

In order to consider the mind as a whole in its relation to the sum of its parts, a solid understanding is required on basic principles. How the assembling of parts relates to the information they can contain? [EDELMAN and TONONI 2003, BAUER 2011].

According to information theory [SHANNON 1948]: **the information in the whole is less or equal to the information in the sum of its parts.** Increasing the amount of parts tends to increase the information, provided the parts have some independence. Otherwise, if there is only one rigid pattern highly integrated, no matter how many components are added, it will have the same total amount of possible combinations, namely two – exactly the same number of possible combinations in a system composed by a single bit.

2.2 Is consciousness reducible?

The mind to body bridge shows inherent complexity [BASSETT and GAZZANIGA 2011, SPORNS 2002]. Rigorous theoretical conceptualization concerning the philosophy of the mind should be compatible with the empirical observations concerning the matter. Complexity is found at many intricate levels: physical; chemical; biological; evolutionary; neurological; developmental; social; etc.

The concept of emergence defies the mind to body reduction paradigm. It may be interesting at this point to present some ways emergence was defined.

> The term emergence is a multi-faceted concept whose exact meaning depends on context and invariably the field of study. In the field of (low-energy) nuclear physics, emergent phenomena are always associated with highly complex and highly non-linear behavior. [LUU and MEISSNER 2019]

In humanities, the historical basic notion of emergence stretches back to Aristotle [O'CONNOR 1983]. Aristotle defines emergence as: "In the case of all things which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something beside the parts" [ROSS et al. 2014]. Even though Aristotelian physics is majorly outdated, Aristotle's intuitions on emergence better resisted to the test of time, still considered relevant to most contemporary philosophers.

There is something we are not completely satisfied regarding emergence. Where does the "something beside the parts" comes from? As for the writing of this text, we know of no solid evidence suggesting the mental phenomena to defy any physical laws. There may be something else in mental phenomena beyond physical, chemical and biological laws, but, as far as we know, no philosopher was able to formulate what it is. This new scientific branch remains absolutely unknown, we do not even know how it would look like nor where to search for it. There is still no evidence available besides the ones provided from the hard sciences.

Imagine, for instance, a gear watch [9] and mentally take it apart. The scattered parts no longer record the passage of time, are now free to be assembled back into a gear watch or in any other configuration. The information contained in each part comes strictly from the part itself. The context does not add any information to the system. The information was already in the parts, if the context did anything was to constrain the gear watch parts movements, subtracting the possible arrangements of the parts. Any behavior of the parts that is incompatible to the proper operation of a gear watch is excluded. Simply put, the gear watch context forces a gear watch to be nothing else but a gear watch. An assembled gear watch is exactly the same as all the parts of a gear watch, organized in a particular structure.

It is perfectly plausible to generalize, from the gear watch example, to other mechanical apparatus. A computer, a car, a microscope, a bow and arrow, or even a molecule. When taking one of such items apart, one will find the parts they are composed and nothing else because there is nothing left to be found. At least, nothing to be found in obedience to the methods available to our current scientific knowledge.

[9] In the predictability spectrum a gear watch is located closer to more predictable clocks and away from unpredictable clouds [POPPER 1965], nonetheless, the chaos theory is deemed as a promising theory for statistically evaluating the degrees of freedom in order to map different phenomena, including brain phenomena [BAŞAR 2012], along the predictability axis.

Can a system composed of multiple parts hold more information than the sum of its independent parts? Information Theory presents an equation establishing integration as the information of the sum of the parts subtracted by the information of the whole. From this framework: in the case of all things which have several parts, the whole is the sum of its parts constrained by the relation between the parts.

Is consciousness reducible? Reducible in the cartesian sense, through reductive analysis? No, we do not think so. Is consciousness reducible to the sum of the parts, constrained by the relation between the parts? Yes!

In predictable sets, such as logic gates in a well assembled computer, the parts are rigidly related to one another, the behavior of each part highly depends on the behavior of other parts. For less predictable sets, such as water molecules in a cloud, the relations between parts are much less rigid. In the cloud, as the integration is much lower compared to the computer example, the interaction between molecules display more degrees of freedom. The slightest mistake in calculation for predicting the cloud molecule behavior, due to the practical necessity of approximating the numbers, will feed back, stacking up in a loop, making future dynamics less and less predictable over time.

Max integration is dull, a brain with all neurons perfectly in sync would be as interesting as a light switch, either all neurons are on or off. Total independence, on the other hand, is noisy, similar to hearing a radio device tuned to a frequency in between radio channels. The interesting spot lies somewhere in the middle, as an example we can think of an ant bridge formed in crossing a gap between branches. Enough rigidness to enable the bridge formation, but not excessively, not to compromise the flexibility in adapting to the environment.

According to the reductionism, exhaustively providing the algebraic description of each part would suffice in providing enough data for restoring the whole system back by adding up all the parts. This approach works beautifully in the scope of linearly independent equations. Unnecessary obscure intermediary entities are avoided [QUINE 2011] because none has to be postulated when all the relevant variables of the problem are neatly isolated. In this regard, Integrated Information Theory is distinct because it takes off the blindfold on the dependence between variables in systems that can only be properly described by linearly dependent equations. No entity has to be multiplied, and that is the main reason reductionism combined with information theory seem to be so promising. The subtle tools available to Information Theory renders the analysis of complex system a possibility.

Chalmers famously argued reductionism to be unfit for describing the facets of human consciousness because such materialistic description cannot account for an essential property, namely, the property of conscious experience.

An analysis of the problem shows us that conscious experience is just not

> the kind of thing that a wholly reductive account could succeed in explaining. [CHALMERS 1995].

Cognitive studies would only face the soft problem of consciousness, i.e. the problems that objective science can explain. However, no scientific effort would be able to tackle the hard problem of consciousness, the problem involving first person qualitative experience [CHALMERS 1995, CHALMERS 1996]. Chalmers claims that in order to face up the hard problem of consciousness one is required to posit the existence of a non-physical entity. Claiming experience to be the most likely candidate for the non-physical entity that he claims we should posit.

> The really hard problem of consciousness is the problem of experience. When we think and perceive, there is a whir of information-processing, but there is also a subjective aspect. As Nagel (1974) has put it, there is something it is like to be a conscious organism. This subjective aspect is experience. When we see, for example, we experience visual sensations: the felt quality of redness, the experience of dark and light, the quality of depth in a visual field. Other experiences go along with perception in different modalities: the sound of a clarinet, the smell of mothballs. Then there are bodily sensations, from pains to orgasms; mental images that are conjured up internally; the felt quality of emotion, and the experience of a stream of conscious thought. [CHALMERS 1995]

Famous thought experiments also challenged mind-body reduction arguing through counterexamples [JACKSON 1986,NAGEL 1974,SEARLE 1980]. Pointing out the ineffable nature of consciousness, beyond scientific reach. *What* is consciousness, in the ontological sense of the thing in itself is an impossible question. By its own nature, the noumenon of consciousness will always remain beyond human sense and perception. To translate the subjective quality of the experience into words would be an impossibility. Even though it seems obvious we should have privileged access to the intrinsic nature of our own mental states when we are consciously experiencing them, we would only have access to the phenomena caused by our mental states, but no direct access to the mental states themselves. “A person blind from birth could know all about the physical and functional facts of color perception without knowing what is like to see something red” [HARMAN 1990].

When Helen Keller describes how she perceives the world, even though she cannot see nor hear, is able to provide a clear and precise report of what she can perceive to be out there in the world. Her description does not fall short, in any sense, when compared to other descriptions documented in the literature from people capable of both seeing and hearing. The Helen Keller description suggests that having the experience of seeing and hearing the world is not required in providing a report of the perceptible objects in the external world. Is the subjective quality of the first person experience of seeing or

hearing ineffable? Is a blind or deaf people in disadvantage when it comes to describing what it is like to have some conscious perceptual experience?

Hellen Keller writings demonstrate that a blind and deaf person seems to be just as capable as anybody else when she describes *what* a conscious perceptual experience feels like.

The question "*what* is consciousness?", seems to be just as hard as the question "*why* is consciousness?". Isaac Newton once wrote that he could only describe *how* an object falls toward the ground, but only God could answer *why* it falls. The Wittgensteinian spade is turned, as one simply cannot go any further after reaching the bedrock. If our efforts can ever hope to achieve some answer about consciousness it can only address the question of "*how* is consciousness?", but not the *what* nor the *why* questions.

One may argue the previous claim to hold some sort of mysticism surrounding the quality of consciousness. No words nor scientific efforts would ever be able to address the mystical experience [GELLMAN 2019]. Likewise, we could apply the same reasoning when addressing the *what* and the *why* questions about consciousness. Only a sentient creature experiencing the feeling of her own conscious experience directly in a first "creature" perspective would be able to understand what it feels like for her to feel her conscious experience. One requires a leap of faith in order to suppose that other people's conscious experience is similar to one's own.

The criticism just mentioned poses a real threat and challenge to an objective explanation of conscious experience. We cannot afford to provide a proper scientific description of what is consciousness. By the 1913 Webster definition for the word, Ineffable means: "Incapable of being expressed in words; unspeakable; unutterable; indescribable; as, the ineffable joys of heaven. Taking the criticism seriously force us to admit that the *what* and *why* questions about conscious experience cannot be addressed through the scientific method. In this sense, the qualitative aspect of consciousness distinguishes it from other phenomena. To underestimate the problem posed by explaining conscious experience or to overestimate our methods in probing it may doom our efforts to understand consciousness.

Dennett openly opposes Chalmers' soft/hard problem categories [DENNETT 2000]. According to Dennett's position, to consider the metaphysical essential inner experience as a non-physical entity in itself takes the problem of consciousness upside down. A living human body composed of orchestrated biological cells in a "gear watch like" "nanobot" operation would have its own intentionality [DENNETT 2008] little room should be left for imaginary entities (not to mention, risking heresy, free will [DENNETT 2015]). Is Dennett's outrage against Chalmers' paper justified?

The contemporary turn of events have witnessed the return of fanatical denial of scientific facts spread through some segments of our society. It has been a long time since challenging the academic secular institutions was so fashionable. At times such as ours in which the concept of truth is so diluted, Dennett's skepticism sounds very

reasonable. Delusional times require us to be more skeptical than ever.

That being said, awareness of confirmation bias effect – people's general tendency favoring their own hypothesis rather than the alternatives [KLAYMAN 1995], grants no immunity against confirmation bias. To dismiss the criticism presented against reductionism is no easy task. Although dualism seems to be a discredited view in the contemporary philosophical circles, it is still advisable to seriously consider the counterarguments that have been brought.

There is little we can offer beyond the prolific debate about the mind-body problem. Our brief contextualization cannot even hope for a scratch in the surface of the problem. The mention of the controversy should serve us as a warning to the deep problems waiting ahead. Unsurprisingly, there seems to be little agreement regarding the possibility to describe the nature of the phenomena of human consciousness. Neuroscientists are already struggling to get a glimpse of the complex mechanisms on our bodies that reflect directly on our behavior, and that is without considering the onus of explaining what lies beyond physics.

As we are no experts in neuroscience, often we relied on the lengthy and ongoing literature produced by specialized journals. Gradually, through meticulous scientific evaluation, glimpses of the relevant brain mechanisms responsible for adjusting behavior are being outlined [CHANGEUX 2006, EISENBERGER and LIEBERMAN 2004, COHEN et al. 2002, GREENE 2013, NICOLELIS 2011, PARVIZI and DAMASIO 2001, SAPOLSKY 2017, ZAK 2008, TONONI et al. 2016, HOHWY 2013].

Is it reasonable to draw connections between conceptual philosophical ideas regarding the human consciousness and the recent, but ever growing, base of knowledge being gathered about the human brain? If we ever hope to contribute to this discussion is to present a philosophical framework to define the different aspects of consciousness. Checking for the compatibility between the philosophical concepts regarding human consciousness and the recent findings regarding the mechanisms at play in the human brain is of utmost importance. Philosophical ideas about human consciousness should watch closely as the body of knowledge about the human brain grows and is constantly revised.

The golden standard research methods utilized on neuroscience heavily depends upon the reductive analysis. The reductive methodology goes through a series of steps. The **first** step consists of the analysis of a complex problem into its basic components. The **second** step consists of finding a solution for the basic components of the problem. The **third** and final step consists of the synthesis; the analyzed parts are recollected together.

Integrated Information Theory offer us some important considerations regarding the reductive analytical method. What happens when we proceed to analyze apart an equation with dependent variables? How are we to make sense between the relation between the whole, the parts and the interdependence between the parts. To contemplate

the analysis step as a reversible transformation is only true when considering linearly independent equations. This will bear a crucial importance in the synthesis step. To analyze a linearly dependent equation into its basic components is not an irreversible transformation as it forcefully dismiss the integration between the parts during the analysis. Isolating variables require one to sever any connection between the other variables as if the variables were independent from each other.

To analyze a linearly dependent equation in its basic components is not a problem *per se*. The problem presents itself if we do not account for integration during the last step, when adding the parts together into the whole. Taking the isolated variables from a linearly independent equation and proceeding with the linear sum of the parts back to the whole results in no error, because there is no dependence to be lost when analyzing independent parts.

The same cannot be said about linearly dependent equations, because, in this case, the dependence between the parts is lost when the parts are analyzed. The linear sum of the isolated parts of a linearly dependent equation is different to the original linearly dependent equation. A more formal discussion on this will be presented in section 2.3.

Now, let us discuss an example. We will often consider the most likely candidates to predict significant loss in performance in different tasks relevant to human behavior due to specific and localized damage to particular areas in the brain. This methodology serves as a practical example for how neuroscientists may proceed in analyzing apart one area of the brain, in analyzing apart one brain function.

Considering a localized brain trauma may lead to a loss to one of the cognitive function in its victim, at the absence of any other observable symptom, can often be presented as a *ceteris paribus* clause. Comparing a control group (composed of healthy subjects) to the group of interest (composed of subjects with a particular area in the brain compromised) yields the opportunity to suggest that, all other things being equal, the damage in that particular brain area was responsible for the observed differences between the control group and the group of interest.

It does not follow that any particular area can be completely insulated inside the skull. The encapsulated modularity theory [FODOR 1983] is appealing in terms of efficient energy consumption and highly automated networks [10]. But it falls short when it comes to explaining other cognitive processes such as learning a task for the first time; it falls short when explaining how the one module can stimulate or inhibit activity in other module. A null value of integration between modules, i.e. completely insulated modules, would only produce a fragmentary outcome, because the parts would not be

[10] One way to demonstrate the importance of modularity goes as following. The difference between the amateur basketball player and the professional basketball player was measured by the modular capacity each one displays when imagining to make a throw. Drilled to the limit, a very small neural network is activated in the brain of a professional basket ball player, while a much more spread out areas are fired in the amateur brain [WU et al. 2007]. There is a much greater cognitive demand for the amateur to imagine making a basketball throw because more areas have to be activated.

able to share information. Suggesting a subtle balance between freedom and cooperation between brain modules.

> When we consider the range of operation of homeostatic processes, we can objectively describe states of efficiency, states of inefficiency and states in between. Efficient regulatory states are those, for example, in which the performance of regulation is not only adequate but timely, with minimal consumption of energy, minimal impediment, ease, and smoothness.[...] [T]he notion of harmony is perfectly apt to describe such states. [DAMASIO 2005]

Integration adds no information to the whole. On the contrary, according to equation 3, the entropy for the whole is equal to the entropy for the sum of the parts minus the integration between the parts. Integration takes information away, it means that the possibilities the whole can assume are constrained by the relations between the parts.

Even though no single neuron is irreplaceable *per se*, it may require a great deal of neuroplasticity – or even clinical intervention [CRAMER et al. 2011]– to cover for the loss of a whole cluster of neurons arranged in a module,

> Although plasticity of visual connections persists in the adult brain, the range over which this plasticity occurs constricts with increasing age. Early in development, gross rearrangements of axonal arbors are possible, while in the adult, plasticity appears to be restricted to local changes in synaptic efficacy. In addition, the adequate stimulus for evoking a change also appears to be increasingly constrained as the brain matures. [BEAR, CONNORS and PARADISO 2020, p. 720]

To understand the patterns formed by the neurons fitting into the whole picture requires not only the reductive description of the phenomena (beyond the authors' grasp). Be it physical, chemical, biological, evolutionary, neurological, developmental, social, etc. One should look into each aspect **and** take a step back from each research field findings through reductive approach in order to realize no isolated field holds all the answers for all the questions at once.

Each field offers tools for finding specific answers to specific questions. When taken together, the frameworks from different fields should further constrain the possible description of the phenomena. In this sense the mind-body problem seems solipsistic. Should we not also address influences from other components, say: the mind-environment problem; the mind-social problem? This chapter focuses on the contribution from the Integrated Information Theory, suggesting a possible methodological approach for evaluating the complex relations brought from connecting the pieces that compose the human behavior.

Optimistically, this may ground, from basic premises, tools for evaluating both the holistic and reductionist approaches. Ideally, the definition of integration and the

discussion on the mathematical caveats for solving linearly dependent equations may prevent some misunderstanding whether to reduce complex systems into more basic mechanistic is possible or not.

As for our answer to the question serving as the title of this section: "Is consciousness reducible?". From the above discussion we have reached a frustrating answer: it depends on what we mean reduction to be.

If by reduction we mean that, through Cartesian reductive analysis we can reduce the mind phenomena to body phenomena: our answer is no, the Cartesian method is unfit for accounting for an exhaustive description of complex systems such as the human brain.

If by reduction we mean that we can expect the hard sciences to provide an exhaustive description answering questions about *what* is consciousness like; and *why* are we conscious: our answer is still no. Such questions will always remain beyond the scientific scope.

And finally, if by reduction we mean that we can reduce the description of how the phenomena of consciousness manifests itself to an exhaustive scientific description from integrating the perspectives from physics, chemistry, biology, psychology, social sciences, ecology and so on, concerning all the variables at play influencing our bodies: our answer is we sure hope so. Our positive answer may turn out to be falsified (it can be falsified), that was probably our best shot and only way to prove the reduction to be impossible. This combined scientific endeavor may prove to be insufficient for an exhaustive description of how the phenomena of consciousness manifests itself. We either assume the risk or admit our defeat.

2.3 Information and Integration set the upper limit for consciousness complexity

Tononi's definition of integration [EDELMAN and TONONI 2003] can provide us a starting point:

$$\phi(x) = \sum_{i=1}^{n} h(x_i) - h(x) \tag{1}$$

In equation 1 integration is on the left side of the equality sign, one can manipulate it so that the *h(x)* gets isolated on the left side of the equation, better contrasting to the holistic motto: "the whole is greater than the sum of its parts".

Adding $+h(x) - \phi(x)$ on both sides of the equation, keeps the equality sign unchanged. The simple rearrangements steps are meant for better visualizing the issue at hand, though they are not strictly necessary.

$$\phi(x) + h(x) - \phi(x) = \sum_{i=1}^{n} h(x_i) - h(x) + h(x) - \phi(x) \tag{2}$$

Table 1: Definition of the terms in the equation 1 establishing the relation between Integration and Information

Symbol	Meaning
$\phi(x)$	Integration
$\sum_{i=1}^{n} h(x_i)$	Sum of the information of all individual components considered independently
$h(x)$	Information of the system considered as a whole

Source: author.

$$h(x) = \sum_{i=1}^{n} h(x_i) - \phi(x) \tag{3}$$

Equation 4 analyzes three possible interval values for $\phi(x)$[11]. Even though there is no real case scenario represented by negative parameter values of integration – it can be either greater than or equal to zero – we considered this possibility because this would be required in order for the whole to store more information than the sum of its parts. Two parts can be either related to each other ($\phi(x) > 0$) or not ($\phi(x) = 0$); ($\phi(x) < 0$) has no counterpart in the world, it does not make sense to say the parts are less than unrelated. Two neurons, for instance, can either be in a stimulatory or inhibitory relation to each other, or no relation at all.

$$\text{if} : \phi(x) \begin{cases} > 0 & \text{then} : h(x) < \sum_{i=1}^{n} h(x_i) \\ = 0 & \text{then} : h(x) = \sum_{i=1}^{n} h(x_i) \\ < 0 & \text{then} : h(x) > \sum_{i=1}^{n} h(x_i) \end{cases} \tag{4}$$

The more positive the values for integration between the parts: less degrees of freedom, the entropy and the information. Isolating the parts (zero integration) does the opposite, increasing the degrees of freedom, the entropy and the information. There is a limit for the information of any given set of parts because there is a limit to the possible combinations the parts can assume.

We would like to add a comment about core consciousness and extended conscious-

[11] **Positive integration (first line of the equation)**: the possible patterns are constrained, restricting the degrees of freedom (physics' jargon meaning the system is more likely to be in a particular set of configurations). Positive values of integration translates into the entropy for the whole being less than the entropy for the sum of its parts.

Zero integration (second line of equation): to the particular case where integration is zero, the whole can assume the same number of possible patterns of activity as all the possible patterns of the isolated parts. Referring to the previously mentioned gear watch analogy, each component can be arranged in any possible way regardless of the structure.

Negative integration (third line of equation): negative values for integration means that all the parts are not only completely independent of each other, they are even more independent than that. This is incurs in a self-contradictory statement. According to equation 3, for the holistic motto "the whole is greater than the sum of its parts", the entropy of the whole has to be greater than the entropy of the sum of its parts. Negative values for integration do not exist in the real world. The whole system can only store as much information as the sum of its parts.

Table 2: What would be the outcomes from tossing a fair coin 3 times?

Possibility	1st	2nd	3rd	4th	5th	6th	7th	8th
Outcomes	000	001	011	010	100	101	110	111

Source: author.

ness. Consciousness as a whole is composed, according to Damásio, of core consciousness and extended consciousness. Core consciousness is, thus, one of the parts at the right side of the equation. How come the loss of core consciousness can extinguish consciousness as a whole? The explanation lies on the integration. In order for the result at the right side of the equation to to be equal to zero, when the only part lost was the part of core consciousness, integration must be maxed out. The prediction we derive from that is that: core consciousness must be connected to all parts of extended consciousness, i.e. core consciousness is responsible for feeding the aspects of extended consciousness with information coming from the rest of the body.

2.4 Biting the bullet: can one bit hold more information than one bit?

Long story short, no. The amount of information a bit can hold is limited to the bit itself (flabbergasting). The conclusion may seem obvious, but at risk of sounding repetitive, this section clarifies some ideas regarding information theory and how we may apply the mathematical tools in the analysis of the philosophical debate regarding the mind-body reduction problem.

According to the information theory framework, in order to increase the amount of information hold by the whole above the sum of its parts, integration would have to assume negative values. Demonstrating that integration is either zero or positive, never negative, suggests the holism motto to be incompatible with information theory. Relations between the system's parts do not add information, on the contrary, the more the parts are related to one another, more constrained they are and less information they can hold. I.e. integrated systems are constrained to assume particular patterns. The whole can either hold the same amount or less information than the sum of its parts. Information does not magically appear out of nowhere.

Let us consider throwing a two-sided coin in a sequence. Each throw can only assume two possible outcomes: head (0) or tail (1), i.e. Binary outcomes. We will analyze a finite sequence of, say, three throws (n=3). The total of possible combinations is equal to 2^n, replacing n for the value (n=3) yields: $2^3 = 8$. See table 2 for the list of all the eight possible outcomes.

Considering probability of event happening (p) and base [12] (b), the information (i)

[12] in information theory the logarithmic base most commonly used is binary

Table 3: Minimum vs. Maximum integration

Throws	Integration	Entropy for isolated throws	Entropy for the throws as whole
1	-	1	1
2	0	2	2
2	1	2	1
3	0	3	3
3	2	3	1
n	0	n	n
n	n-1	n	1

Source: author

is determined from the following equation [CARTER 2007]:

$$i(p) = -log_b(p) \tag{5}$$

For each throw of a fair coin there is 0.5 chance of head and 0.5 chance of tail. Therefore: $i(head) = i(tail) = -log(0.5) = 1\ bit$.

Considering the number of outcomes (n). Entropy is the average amount of information from the event.

$$h(x) = -\sum_{i=1}^{n} p(x_i) log_b(p(x_i)) \tag{6}$$

The total entropy for 1 throw equals 1 $h(1) = 1$[13]. $h(2) = 2$[14]; $h(3) = 3$; $h(n) = n$.

As a thumb role, entropy is equal to the number of bits required to express the possible combinations. Take table 2 as an example, it takes three binary digits to express the combinations from three throws because that's the necessary and sufficient number of bits to exhaustively express all the possibilities.

Let us see what happens to entropy when integration comes into the picture. Now, We have entered the realm of unfair coins, i.e. throws can now depend on previous throws. From equation 3, we can build a table for the possible values to the parameters of our coin tossing example. We considered the minimum and maximum values of integration, respectively.

Three throws ($n = 3$) can be: **a)** totally independent – producing 8 different possible outcomes (3 bits of entropy); **b)** totally dependent, producing 2 possible outcomes (1 bit of entropy) – either all heads (000) or all tails (111); or **c)** integration assumes a value in between the minimum and the maximum possible values – assuming, for instance, a rule in which the second throw will have the same result as the first, but the third may or may not be different; such rule enables for 4 different outcomes (000, 001,

[13] $h(onetoss) = p(head) \cdot log_2(1/p(head)) + p(tail) \cdot log_2(1/p(head)) = (1/2) \cdot log_2(2) + (1/2) \cdot log_2(2) = ((1/2) \cdot 1) + ((1/2) \cdot 1) = 1$.

[14] As we are considering a fair coin each throw is independent $h(twotosses) = h(onetoss) + h(onetoss) = 1 + 1 = 2$.

110, 111) resulting in 2 bits of entropy.

According to equation 3, it'd be required negative integration values for the whole system's entropy in 3 throws to be greater than the sum of its parts. First, three coin throws cannot yield more than the 8 possible combinations shown in the table 2. Second, if three bits in combination would hold together more information than they hold separately, where did this extra information came from? Third, integration is not to assume negative values because negative integration values imply the parts to have even more independence from each other than complete independence, an absurd statement.

Claiming that the whole system can store more information than the sum of its parts is in conflict with information theory [15]. The mathematical conclusion seems relevant to the mind-body problem because it stresses that the relations between neurons can never add information, instead, the opposite of that is true, the relations between the neurons constrain the information expressed by each neuron. An analogy is provided to better visualize this concept in page 61.

If were not by restricting information due to the neuronal patterns arranged during evolution and early development, the sheer number of neurons in our brain would yield a combinatorial explosion of number of possibilities growing in factorial progression. The predictive brain theory suggests our brain to judge what scenarios more or less likely [HOHWY 2013].

Considering the value of integration to be: Zero) all the different combinations of independent neurons would be as likely to be activated as any other; Maximum) The neurons are locked in two possible scenarios, either they are all firing together or no neuron will fire; Somewhere in between zero and maximum) some clusters of neurons are synced together, but others are independent, some scenarios are less, others more likely. The intermediate values of integration is where there are more interesting results. The Integrated Information Theory has predicted such values for integration to be correlated with conscious states. The theory is useful in develop new methods for assessing consciousness in non-communicative patients [TONONI et al. 2016].

The neuronal arrangements are more likely to be triggered by a limited set of specific stimuli, under an acceptable margin of predictive error. This suggests that, were neurons free to rearrange at will [16], our world perception would constantly change – any sensorial input possibly triggering an array of different action potentials –, no matter how bizarre, all scenarios would then deemed as equally probable, because the neuronal pathways are not properly integrated.

[15] The motto "the whole is greater than the sum of its parts" in itself does not specify in which sense the whole is greater than the sum of its parts. It may refer to information or something else, such as in the property/relational holism [HEALEY 2016]. Further evaluation on alternative interpretations of holism are beyond the current chapter's scope.

[16] Data suggests this not to be the actual case, as adult neuronal plasticity is quite limited. The hypothetical scenario is brought for the sake of the argument.

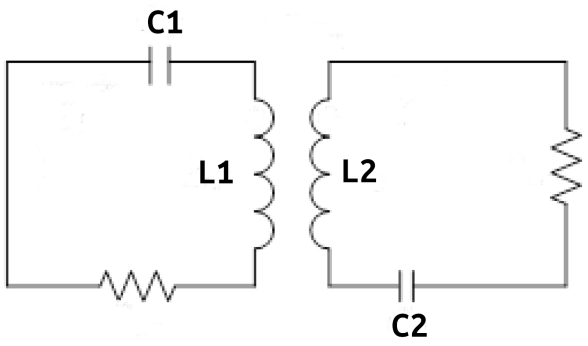
2.5 Two neurons in a loop behave chaotically. How about some billions?

As our just-so story goes, we summarize a caricature of the reductionist position as follows: Taking for granted that complex system can be reduced to more basic phenomena, neurons correspond to the basic "building blocks" of the Central Nervous System. Therefore, studying the isolated building blocks of the Central Nervous System, i.e. studying the individual neurons' behavior, holds the key for solving the mind-body problem. In order to test the reductionist hypothesis, a pretty forward approach is to go ahead and model the phenomena.

Through the L-C analogy that will follow, we suggest the reductive method to be unfit for explaining the Central Nervous System, let alone the human mind. A coupled L-C electrical circuit oscillator may be regarded as the closest physics metaphor to a two neuron cells wired in a loop. Also known as resonant circuit, the L-C circuit consists of an inductor (L) and a capacitor (C) connected in series to a power source, one L-C circuits can be coupled together with another by placing each inductor close to the other. L-C circuits oscillate. The capacitor stores energy in the form of electric field (E) between its plates; while the inductor, in its magnetic field (B). The circuit oscillates energy back and forth, from the capacitor to the inductor and vice-versa.

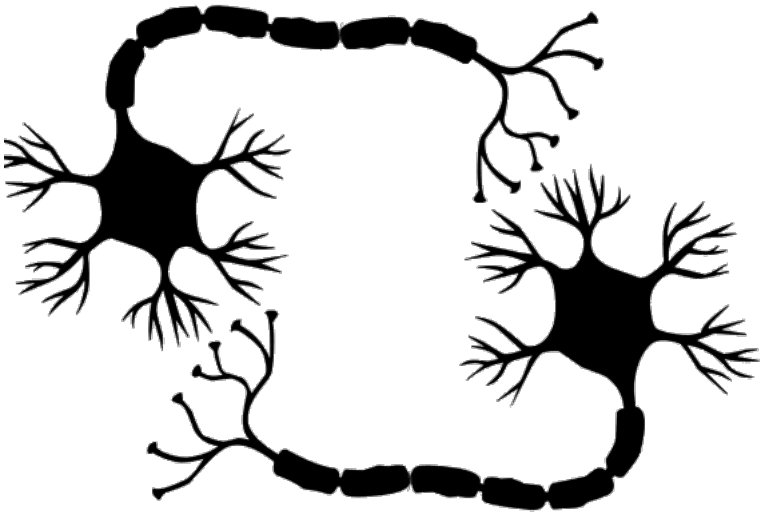
The coupled L-C circuit model is a simplified model for two neuron cells. The propagating mechanism for transmitting action potentials is thus replaced by a simple electromagnetic inductor-capacitor exchange. Figure 2 shows the electrical diagram for a generic coupled L-C circuit.

Figure 2: Coupled L-C circuit diagram



A two neuron cells model consists of two neurons, the axon from the first neuron reaching the dendrites of the second, the axon of the second neuron feeding back to the dendrites of the first neuron. In figure 3 the two neuron cells model is ilustrated. When enough stimulation comes to the dendrites – above the potential threshold – of the first neuron another signal will be sent through its axons forward to the second neuron,

Figure 3: Two neuron cells loop model



after sending the signal it returns to the resting potential baseline. As the neurons in the presented model are wired in a loop, the nerve signal will oscillate back and forth between the two neurons.

The behavior of an ideal (zero resistance) L-C circuit can mathematically be described as a harmonic oscillator. Similar to a pendulum subject to the gravitational field, swinging back and forth. Moreover, coupling two L-C circuits together results in chaotic behavior, the same goes for coupling two pendulums (the double pendulum) [HANIAS, KARRAS and MOBARAK 2009, YAREN, KIZIR and YILDIZ 2019], intuitively [17], coupling two neuron cells together is analogous to coupling two L-C circuits. It seems plausible to suggest that the "two neuron model", a higher complexity version of the coupled L-C oscillators, should also yield chaotic behavior.

The neurons' symphony plays a significant contribution to mental states, nonetheless we argue that studying them isolated is only sufficient for a partial explanation. Human behavior is influenced both from internal and external factors, the line separating brain and world is not as clearly drawn as it may seem at first sight [NOË 2009]; the gene/environment relation demonstrates at one hand that some genes only expresses themselves under certain environment conditions, if and only if said environment condition is present – at the other hand, that environment conditions can only activate those genes if and only if said genes are present [SAPOLSKY 2004, SAPOLSKY 2017].

Ideally, the philosophical conceptualization of the mind-body problem should be updated to better accommodate the scientific theoretical model and empirical observa-

[17] The formal mathematical demonstration for this is beyond this chapter's scope.

tions. The more disciplines one takes into account more it becomes clear that the mind-body problem is more than just the problem of how mind and body are connected. The mind-body problem is a problem regarding many variables: the environment external to the body; the environment internal to the body; the sociocultural environment; the genetic biological makeup.

The body influences the mind, but so does the early years of development, the environment, the social context. As if the mind-body problem was not problematic enough, development, environment and social context will add new layers of complexity to the problem of consciousness. A particular gene playing a particular role to a particular behavior gets activated if and only if some particular environment condition is met. An ethically questionable experiment serves as an example for the crucial relation between early development and perceptual capacities: healthy new born kittens were kept in a light deprived cage for a year, causing the cats to become permanently blind after being released from the cage [CYNADER, BERMAN and HEIN 1976]. On the laboratory, the environment and initial parameters can be controlled to a point where the margin for errors is residual. But outside from the laboratory, the environmental influences become quite unpredictable.

Arguably the majority of hard science research programs heavily rely on Cartesian reduction or some refined strategy tailored for isolating some particular variable of interest to be studied. This remains true when considering the multiple dependent variables involved in the complex nature of mind during the cognitive and psychological studies conducted more recently. The golden standard analysis for said studies requires quantifying the statistical significance of the findings. The methods available are reliable to some extent, not perfect. Not differently than any hard science study it comes with the caveat that there are intrinsic error sources within the data samples collected. Evidently, the major experimental error sources can be identified and remedied by improving experimental design employed, analysis, etc. However, there is no way to exclude minor variation between subjects due to the very nature of the mental phenomena being observed, as not every person will be affected in exactly the same way by the same stimuli they are exposed to. Considering this caveat, can we take the results from psychological and cognitive studies to be deterministic?

It is been a while since Laplace's demon has been thoroughly exorcised from physics [SHERMER 1995, JEDLICKA 2014], maybe it is about time to untangle 19th century's determinism from philosophy of mind [18].

[18] On a side note, a disambiguation between "physical determinism" and "theological determinism" is in due. Rest assured: no scientific evidence nor theory (deterministic or non-deterministic) has proven or refuted free-will – one finds both groups, free-will believers and deniers, whether among classical or chaotic physicists. The physical realm ends when the metaphysical realm begins. It seems important to clarify and try to set some clear boundaries in order to prevent us from mixing up the physical use from the theological use of the word. When we refer to determinism in the text, we are exclusively referring to physical determinism. We do not feel qualified, by no means, to offer any contribution to the ongoing libertarianism vs. determinism theological debate.

The current chapter suggests, at one hand, the reductive science to be unfit for an exhaustive description of mental phenomena, by isolating the parts one forcefully neglects the dependence between the parts. At the other, the holistic claim that "the whole is greater than the sum of its parts" is in contradiction with information theory. One bit cannot hold more information than one bit, adding bits together will not increase the total amount of information the bits originally hold when isolated.

A third alternative can be considered: mental phenomena results from neural activity, constrained by its integrated patterns. The neural activity, on its behalf, is also constrained within its embedded environment. This alternative considers the information in the whole as the result of sum of the information in the parts *minus* the integration between the parts.

Neglecting many aspects of neuronal dynamics, the mathematical models for describing single neuron spiking are simplified [GERSTNER 1998]. Techniques for examining the receptive fields enables for understanding the "[. . .]behaviour of individual cells, but fails to deal with the problem of the relationship of one cell to its neighbours" [HUBEL and WIESEL 1962]. This brief account on some epistemological barriers suggests the reductionist program premise that a comprehensive description of the brain, from its basic components, could exhaustively demonstrate the deterministic chains that cause mental states to critically underestimate the limits of reductive biology, regarding brain and mind studies [BARLOW 2007]. For accepting the mind to be reducible to the body through the Cartesian reductive method, one has yet to provide a proper argument explaining how isolating the inextricable networks of densely packed and highly organized system composed from a number that exceeds 10^{10} neuron cells, as found in the current mammalian brains [GERSTNER and KISTLER 2002]. The neuronal synergy and structural patterns – only observable from within the whole system's point of view – are forcefully neglected during the Cartesian analysis.

Communication between us may be possible, as we share similar cognitive apparatus and backgrounds. Even so, uttered sentences "resonate" (slightly or critically) differently for each one of us. Each person having its own unique understanding, in accordance to one's own history. This may be a source for angst, risen from the fact we can never know exactly the thoughts behind the other person's look [SARTRE 1943].

It is usual to define Theory of Mind as the capacity for attributing beliefs, intentions or desires for others [PERERA and Stein 2018, PREMACK and WOODRUFF 1978, GRIFFIN and BARON-COHEN 2002,SAXE and KANWISHER 2003]. Trying to read another person's feelings may easily put us under cognitive stress. There is simply too much information, from multimodal inputs, to compute in a short time-lapse. We can briefly present, as illustration, how an Integrated Information Theory methodology may be applied in order to provide some reading keys that will guide us in making some sense in the context of Theory of Mind.

Suppose one is to perform a lie detection task: whether another person's statement

is in accordance to said person's beliefs or not. Microexpressions, body language, tone of voice, timing, baseline deviance, etc. Many variables may or may not bear relevance to the lie detection task, in estimating the person's sincerity. In accordance to Integrated Information Theory, we should take the information from each variable and the dependence between variables. Do all the parts fit together coherently to a context, or not? Is the tone of voice (or any other variable) in harmony with the message? Etc. The variables do have meaning in themselves, but including the contrasting of how the parts fit in the context, allows for a more exhaustive analysis. When a person is telling a lie, the true beliefs will be hidden. In a good lie performance, it may be the case that no isolated component gives the lie away, but by looking to the whole picture one may realize how the different components are telling different narratives. Some contradictions will only be apparent from looking to the context.

We cannot directly reach the inner causes behind other people's behavior. What we can do is to provide educated guesses. For predicting other people's behavior, one has to infer mental states. Primate species are highly social, it has been found, for primate species, that the best predictor for greater Encephalization Quotient, is a greater maximum group size [DUNBAR, MACDONALD and BARRETT 2007]. The default mode network, which plays a major role in Theory of Mind [SPUNT, MEYER and LIEBERMAN 2015], takes up most of the human brain's available time, energy and resources in making sense of social interactions and hierarchy. This suggests an explication why humans show a natural tendency to be remarkably proficient at gossiping. As social animals, we take integration to another level. Not only our brains are made out of a collective swarm of integrated but flexible neuron cells, but as humans, we are the only species to manage to cooperate as a global population in which billions of individuals cooperate for the benefit of humanity. But we are getting ahead of ourselves, more attention will be dedicated to the issue in Chapter 4. For now, we have to recollect the ideas we developed so far.

2.6 Taking it all together

The presented discussion highlighted some limitations in classical approaches to the mind-body problem. Be it when it comes to extrapolating the whole to be greater than the sum of its parts, or taking a whole complex system of dependent variables to be reducible to the sum of its isolated parts. Our confidence on the scientific tools for measuring and probing into the material substance, should not blind us for when it comes to confronting the collected data about human subjective behavior. Our efforts can easily backfire, as humans get harder to predict as more clever they get.

It seems prudent to point out what questions no theory of consciousness will be able to tackle, before developing our model. Even the best theories will only be fit to provide answers within a limited range of questions. For the time being, the theory of

everything has yet to be disclosed and there are no signs it will be anytime soon. More plausibly, no single theory will ever provide all the answers for a range covering all the aspects of consciousness. The plurality coming from different scientific branches is probably our best hope in describing the mechanism at play in different aspects of the phenomena human consciousness. Our choice for approaching a complex system such as the human Central Nervous System came from an inspiration to our methodology from the Integrated Information Theory, yet the apparent simplicity of mathematical models is only illusory, as it should incorporate complexity. It is merely a framework to be employed in order to review and incorporate the findings from different scientific branches into a broader perspective. Restricting the scope to the mind-body problem appears to be a dangerous oversimplification. Instead, the complexity of human mind should require more sophisticated tools, due to the growing amount of scientific evidence suggesting contextual influences from development and environment are also relevant to the interactions between mind and body.

Future research may take profit into looking: **first**, how pons and midbrain connects peripheral nervous system (PNS) to neocortex; **second**, how different cortical areas filter, divide, organize and integrate the incoming information in order to share access to other areas, eventually giving rise to awareness, and **third**, taking each different basic modules studied from a reductive approach into a global perspective. The task of building a bridge between mind and body is colossal, but still, the effort seems justified.

3 Embodied Consciousness

The preceding chapter introduced a mathematical perspective on the reductionist method. The terms core consciousness and extended consciousness are borrowed from Antonio Damasio:

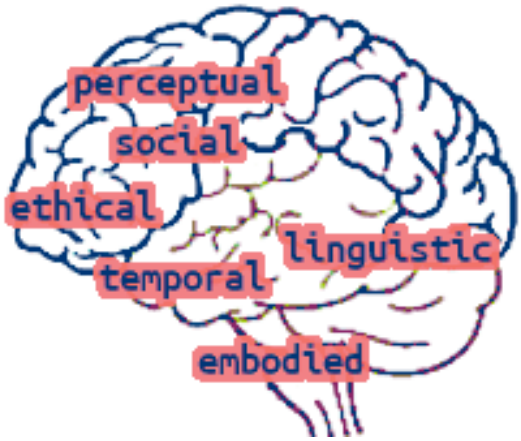
> [...] consciousness is not a monolith, at least not in humans: it can be separated into simple and complex kinds, and the neurological evidence makes the separation transparent. The simplest kind, which I call *core consciousness*, provides the organism with a sense of self about one moment – now – and about one place – here. The scope of core consciousness is the here and now. Core consciousness does not illuminate the future, and the only past it vaguely lets us glimpse is that which occurred in the instant just before. There is no elsewhere, there is no before, there is no after. On the other hand, the complex kind of consciousness, which I call extended consciousness and of which there are many levels and grades, provides the organism with an elaborate sense of self – an identity and a person, you or me, no less – and places that person at a point in individual historical time, richly aware of the lived past and of the anticipated future, and keenly cognizant of the world beside it.
>
> In short, core consciousness is a simple, biological phenomenon. [DAMASIO 1999, p. 23]

Embodied core consciousness refers to the biological foundation for consciousness. Keeping the flow of information from body to the brain and back from the brain to the body is vital for the expression of any conscious state. The influence the human body exerts over consciousness may seem obvious, yet this interdependence is often overlooked. The basic biological characteristics of our bodies predispose us to specific behavior.

Anger, for example, and any strong emotion will be exacerbated by high levels of testosterone. Testosterone does not cause violent behavior on itself, but it escalate evoked emotions, increasing the chances for aggressive behavior. For every culture and continent on Earth, the majority of crimes are statistically committed by men. This suggests one of the many influences our bodies exert over human behavior.

Damasio suggests our consciousness begins at the biological level of our bodies. Over time, the body develops, matures and grows old, but other than that, our consciousness has nowhere else to go. Being part of the background, the influence of our body on our behavior is ubiquitous and we can easily grow used to it, to forget about it, or simply to underestimate how our body shape our inner life. Yet, embodied core consciousness is, according to Damasio, the foundation of consciousness. The empirical evidence on comatose patients demonstrates that consciousness is lost whenever the bridge connecting the brain with the body is lost, suggesting in favor for the hypothesis that core consciousness is *sine qua non* condition for extended consciousness.

Figure 4: Core and extended consciousness



The ambitious goal of the thesis is to further analyze core consciousness and extended consciousness.

The sketchy drawing shown in figure 4 of how consciousness can be localized in the brain is quite inaccurate. Nonetheless, the picture may help us to visualize the conceptual map of core consciousness – limited to the older subcortical areas – and extended consciousness – spread through the younger neocortical areas. This oversimplification serves a didactic purpose.

Previous chapter introduced the reduction from a mathematical perspective. Any single research field can only cover a few aspects of a given problem. Claiming that the integration theory can explain everything about human consciousness self-contradicts a basic idea concerning integration, ignoring the intricate contributions other scientific fields may exert over the matter. In order to remain consistent with integrated theory, one is required to study how consciousness is affected by more than one perspective, many contributions can be combined and compared, gradually enhancing the description of the human consciousness phenomena. The incompleteness of the theory is as obvious as the incompleteness of science.

Current chapter goal is to focus on some mechanisms at play to describe how embodied core consciousness is manifested. Damasio has suggested two different levels of consciousness. At the most basic level, consciousness starts with a basic collection of neural patterns enabling the building of the representation of the body's internal states. This 'protoself' function automatically tracks down internal physical changes influencing homeostasis processes. "Protoself is a coherent collection of neural patterns, which map moment-by-moment the state of the physical structure of the organism" [PARVIZI and DAMASIO 2001].

For each new thing that we learn, we unveil more than one new mystery, unbeknownst to us before. Expanding the horizon of our known ignorance. The void would

remain dormant in case we never looked into it. Analogous to the Pandora's box myth, no returning point, once the box is open. The more ignorant we remain, the easier it is to ignore our own ignorance [DUNNING 2011]. The more confident we are have reached a satisfactorily description of consciousness, exhausting all of it complexity, the more it becomes clear how incompetent we are. Protoself is the entry door that opens up the path for the subsequent aspects of consciousness. The more eager we are to look for our mistakes and to recognize how little we understand about the subject, higher are the chances for us to be in the right path.

Human mind poses to itself as a puzzle. Previous chapter focused on the mathematical techniques for making sense of a system composed by many parts. In this chapter, we will focus on the constraints imposed by anatomy to our minds. From chapter 2, we argued Information Theory showed promise, for it points to the necessity of exploring further into other research fields as well. When looking into one particular reductive research field, one is required to keep in mind the caveats involved. Every level discussed – genes, hormones, neurons, environmental influence – constitutes a component part of the whole organism. To approach human consciousness in such framework, the multiple aspects affecting the predisposition for human behaviors, challenges the reductive dogma – in which a set of conditions could determinate behavior. Recognizing how ordinary we are, how the laws of nature govern human behavior as much as any other animals, we may be able to elucidate the early evolutionary steps making possible for the organism to access information about the neighboring environment and internal conditions.

Up to date, scientific description of the matter-to-mind interface is hardly exhaustive. Yet, with further study of the main modules in the brain, along with their respective mental roles, will there be anything about consciousness strictly beyond the scope of scientific research? In affirmative case, it may be relevant to note how speculative this entangled line of reasoning may become. We are not claiming that science has all the answers for consciousness, only suggesting that science is the most reliable source in the enterprise pursued in exploring the unknown horizon of consciousness.

Brain anatomy imaging techniques, such as Magnetic Ressonance, enables for establishing the morphology, topography and functional anatomy of the brain, describing how the neural pathways between modules evolved [SALLE, DUVERNOY and RABISCHONG 2006, KAMINA 2013]. Ideally, the theoretical relations hypothesized between modules should be constrained to the actual connections empirically observed in the human brain. From more primitive subcortical modules, climbing up to the more evolutionary recent ones, at the neocortex. Neuronal function can be linked to our species' fitness: homeostasis – coordinating and keeping track of vital functions and to regulate automatic muscle movement required for circulation and digestion; sensorial perception – in order to detect and process environment stimuli; memory – enabling access to information that can be hidden from the senses; language acquisition and use;

navigating group interactions between our social bonds; the capacity to feel empathy and care for others. None of those functions are uniquely found in humans. The loss of any function listed above will cause partial or total loss of consciousness.

This simplified reduction to isolated modules serves only as a convenient temporary platform. The platform's purpose is to present an easy and convenient way to describe the particular aspect of each module as if it were insulated from all the other parts of the brain, disregarding the complex net of relations they are embedded into, relations which can be clearly demonstrated through brain anatomy imaging techniques. The linear explanation possible through modularity – as a measure of the structure of networks, enabling for the division of an integrated network into insulated modules – is misguiding if taken too literally, as it forcefully ignores the network interfaces in between brain areas. The modularity model is very useful when limited to be applied to scientific research and not as an actual representation of the state of affairs.

For instance, the effects of maternal separation due to early weaning of an infant mammal, not only cripples the development of mood regulation and social behavior [YOUNG et al. 1973, SUOMI, HARLOW and KIMBALL 1971], its consequences go as deep as inducing metabolic dysfunction [GRACIA-RUBIO et al. 2016]. In order to demonstrate how the parts are integrated, first we are may study the mechanisms at play in each part. But, in order to study how each part functions, it would be difficult not to isolate it from external influences. One would hardly understand a drop of water by taking the whole ocean into account.

To overestimate a single field of study as deterministic to behavior is a common and predictable mistake, as scientists are encouraged to focus their efforts in isolated problems.

> Of course, like all over-simple classifications of this type, the dichotomy becomes, if pressed, artificial, scholastic, and ultimately absurd. But if it is not an aid to serious criticism, neither should it be rejected as being merely superficial or frivolous; like all distinctions which embody any degree of truth, it offers a point of view from which to look and compare, a starting-point for genuine investigation. [BERLIN 2013]

Even though the quote was taken out of context, the distinction between the reductive and holistic approaches bears resemblance with the fox vs. hedgehog analogy. As the tale goes, the versatility of the fox is no match against the hedgehog focus. The cognitive research mostly resorts at reductive approach for studying the multifaceted aspects of the human brain and yet, this distinction should not be overemphasized, considering human brain's plasticity it can be even more flexible than the cleverest fox.

3.1 Are we our bodies?

The body swapping trope was first introduced to pop culture by Freaky Friday, a 1976 movie, based on a novel by Mary Rodgers. The theme, however dates back to the 1872 novel entitled "Vice Versa". You probably have already performed a similar thought experiment, but this time, imagine the possibility of swapping your body for another with distinctive features when compared to your current body. A full body swap change to a different: gender, ethnicity, age, weight and height, attractiveness, health, scars and tattoos (or their absence), only two things of the old body remains the same: the body is still human, the same "you" lives inside this new body.

Or is it? Past knowledge, skills and memories would be magically transferred, reembodied into this new shell. The thought experiment raises a few interesting questions.

Objective differences: different blood flow, nutrients, hormones, gut neurotransmitters, muscle responsiveness, sensorial input, etc. Body anatomy and functioning is deeply connected to the emotional states, such radical hypothetical adaptation should bring along significant changes to personality and mood.

Subjective differences: is the experience exciting or traumatic? Embedded in cultural taboos, casual routines may become unbearably constrained or heartwarming liberating, depending on which accidental features came along with the new body. Would the new body be reason for pride or shame? Would friends and family realize what happened? Would their treatment change? Would one still identifies with the new body?

Usually, we take our bodies for granted. The body is just always "there", quite difficult for consciousness to leave it behind. Quite similar to our blissful ignorance to the important fact there is ground supporting our body, or to the influence of weather on our mood [SANDERS and BRIZZOLARA 1982]. The ground or the weather belongs to the background context. Sensorial input from the background context belongs to the awareness blind spot. Since we are mostly unaware of the background context its influence can play a more ubiquitous role. The body swap scenario suggests how easily one can underestimate the role played by our physical body in influencing our mind.

The accidental body features are analogous to other background circumstances. In this fictional scenario of a body swap, one would still remember the old personality, behaviors and habits from the previous body, chances are some of those old traits would inadvertently lurk back. Dressing a different outfit can impacts over one's personality [MOODY, KINDERMAN and SINHA 2010, WEI et al. 2017], to argue that "dressing" a different body would not impact on our personality seems to be a hard push.

The purpose of this thought experiment is to highlight how body features' exert influence over behavior. At some level, the particular features of the body one was born with partially distinguishes one's personality. This outcome may be specially brutal for minorities struggling to be accepted in authoritarian societies. The body versus

personality conflict derives not from the embodied self modules themselves, but from its interface with social, perceptual, ethical, linguistic and temporal aspects. The body constrains the behavior possibilities and living in a given society requires for even more possibilities to be constrained out. The behavior is constrained not because performing a certain action would bring harm directly to the body, but because of the consequences of such behavior for others. Unfortunately, the social constraints can backfire. For instance, the hate against same-sex couples. When the conduct of people deviates from our social construct of love, some may find it offensive or repulsive. Love is the highest human emotion one can feel, why should the love of others to bring about such negative feedback?

We are not going to digress much further, but one possible hypothesis may go as follow: mirror neurons are automatically fired by perceiving any behavior or emotion, mirroring the behavior as one's own; therefore for the observer watching a same-sex couple kiss it feels, at an non-conscious level, as if the observer was the one doing the kissing; to anybody who kept the same-sex attraction and desires deeply hidden and repressed at high expense, this scene would cause great discomfort to witness.

Human behavior is filled with interactions, too complex for more elaborated answers than educated guesses. Non-human animals, on the other hand, display more simple behavior, at least, when compared to humans. Let us briefly discuss the hyenas' example, as this species may pose a particularly interesting case when it comes to unorthodox sexual behavior in nature, driven by group forces. Hyenas' clan rely on the females for finding food [MCCORMICK et al. 2022]. As females are much more interested in raising the offspring in contrast to males. The later ones, given the opportunity, would mate with a great number of females, minimizing the risks involved in passing their genes forward. It seems informative to look to the clan's hierarchy feeding order, in order to understand the unusual behavior of female hyenas: the young hyenas eat first, high-ranking adult females next, low-ranking females latter and male adults last (if there is anything left at this point). The testosterone levels in hyena females is above average, at the point of increasing the risk for spontaneous abortion rates. Even experts have trouble in telling males from females by looking at their genitalia because the clitoris has the size and appearance of a penis and below it there is a deposit of fat that looks exactly like a scrotum would look like. The female hyenas are very aggressive and prone to intimidate males, who cowardly display full erections as their submissive signature move. Anthropomorphizing, the males would be saying: "I surrender. The food looks delicious, but I must wait. See, I am an adult male, I should know better where I belong.". The ethological example shows how drastically body and social group dynamic may interplay.

The only evidence we have of what we are comes from our bodies. A pragmatic and answer would be to say that, in the absence of evidence to the contrary, we, as any other animal, are our bodies. In the same sense an artificial intelligence can be

exhaustively described by describing the hardware and software it is constituted of. We do not know if the answer is correct, but it is an useful answer as it allows us a starting point, because methodological naturalism can afford to be tested.

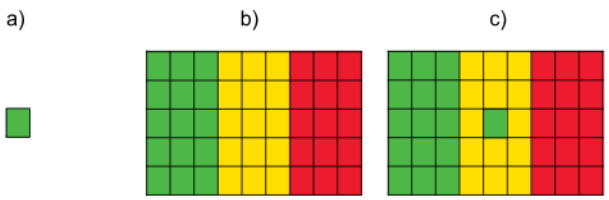
3.2 Embodied cells

Nowadays, information tools expand the reach of our bodies information. We can learn more about ourselves and share our knowledge faster and farther than our bodies could ever allow. Computers and artificial intelligence are already contributing to this new phase of the evolution of human consciousness. Awesome as this may be, we should not forget where it all came from.

The "building" of human consciousness depends on each of its small building blocks, each contribution, subtle as it may seem, adds something to the functioning of the whole and could not exist without sexual inheritance. Small increments accumulated over generations.

In order to visualize how each cell contributes for building up the body, imagine a digital screen formed by pixels [19], the higher the screen resolution [20], the less relevant is the lack of one or another pixel compared to lower resolutions. At high resolution each pixel by itself is almost negligible, only the joining of several hundreds of them in cooperation can form a high resolution image. A single pixel carries more information than an identical pixel that is combined with others to form an image. The intensity and color of the pixel may be the same, but what the pixel represents is fixed due its context.

Figure 5: Pixel analogy



On the left we have (a), an isolated green pixel. In the center and on the right we

[19] Pixel is the basic unit of individually variable color and intensity, which has fixed vertical and horizontal coordinates in the matrix that will form the image to be reproduced by the monitor.

[20] Pixel density per inch.

have sets of pixels, in low resolution, that form the flag of Mali (b) and Senegal (c). The green pixel (a) and the central green pixel in (c) have the same color, intensity and size. (b) and (c) represent the flags of different countries. Images (b) and (c), as we represent them, only differ by the color of a single central pixel. The green pixel of (c), due to its context, has its information constrained, while the isolated green pixel (a) could represent many different things.

The pixel metaphor serves to explain why two similar neurons, may hold different information, depending on their context. In the context of other neurons, the information of each neuron is constrained. The green pixel in (c) represents the star of Senegal flag because of its context within its neighbors. In this sense, we may recognize the merit of theories that explain the mind using the concept of self-organization. The whole carries no more information than the sum of the isolated parts, constrained by the patterns the parts are structured into.

The combination of the many cells that make up the human brain can hold a huge amount of information. However, if the neurons were unconstrained they would hold an even greater amount of information.

> A blasphemous sect suggested that the searches should cease and that all men should juggle letters and symbols until they constructed, by an improbable gift of chance, these canonical books. [BORGES, GIRAL and DESMAZIÈRES 2000]

This passage illustrates what the unconstrained neurons in the brain would look like. This *monkey-in-typewriter* strategy may exhaust all the possibilities, but it would quite cumbersome to find what you were looking for. Constraining the possibilities, reduces the information, the trade-off is that the information can thus become more relevant.

3.3 Social bodies

At risk of anticipating concepts that will only be properly covered in the subsequent chapters, to talk about bodies and ignore about prejudice against the accidental features of the different types of bodies would be a major mistake.

Some activities require active involvement in inhibiting empathy – a natural predisposition for feeling the other's feeling as one's own. In order to engage in misogynistic, racist or homophobic behavior, one is often required to inflict some degree of pain or other repulsive stimuli to others. Therefore, the person inflicting the punishment is either: suffering together with the victim, is inhibiting the empathic feeling, or suffers from some pathological disorder.

When one compares offender and victim, the former is more susceptible to Post Traumatic Stress Disorder than the latter [BENNETT and ROHLF 2005]. Violence

causes undesired consequences mainly for the victim, but for its perpetrator suffers as well. Given this organic backfire, it may seem paradoxical for social species to engage in violent behavior. Not only it constitutes maladaptive behavior, it constitutes harm to mental integrity. The survival of an individual belonging to social species relies upon becoming an integrated part of the collective group of social peers. In humans, paradoxically, this holds true even when the group one is willing to become part of built its cohesiveness on the shared hate against minority groups.

Racial dominance is fueled by political power, but also influenced by a complex cultural environment in which social injustice, violence, and racial discrimination becomes a constitutive aspect of "normal" social life. The status quo was only recently challenged, in the 20th century, when a significant sector of anthropological studies sought to demonstrate the autonomy of cultures and the absence of any evidence supporting biological or cultural determinations over morals, culture, religion and political systems [ALMEIDA 2019].

The pervasive social background context of prejudice against minorities hides the prejudice in plain view, similar to "a figure steadily presented, after a few seconds, in peripheral vision becomes perceptually filled-in by its background, as if it "disappeared"." [WEERD, SMITH and GREENBERG 2006, p. 335]. To be distracted away from what has always been there is quite easy. Haven't many of us grown insensible to the poverty, hunger, death and how unfair our society is? Being taught to look the other way when beggars cross our paths, we are introduced to a cruel lesson in how to ignore empathetic feelings.

In a coarse analogy, if the Oppressors vs. Oppressed was a game, the Oppressors have won way before the game has started. The Oppressors have written the rules and can change them up as the game goes; are friends with the arbiter; have blackmailed, bribed or schemed with the media covering the game; while being assisted by a team of expert advisors. The Oppressed are left with basically three choices: to resign, to keep playing a game known to be rigged, or to complain about the unfairness of the game and face the consequences. The saddest part is that the main difference between the analogy and the reality probably is that one is not fictional.

The complexity of the matter of human violence against minorities would require a more extensive discussion over the intersection of the social, ethical and historical aspects of human consciousness. Unfortunately we have no competence for a more throughout analysis of the unfolding of how tribal biased human consciousness can be. Nonetheless, despite not being the focus of our work, we chose to consider the matter because, if we were to approach the core embodied consciousness by applying the reductive method, we would be forced to ignore how the genetic body features interact within the social environment.

3.4 Between reason and sensitivity

Dennett, as one can read in "From bacteria to Bach and back: The evolution of minds" from 2017, argues that consciousness can one day be reproduced by an artificial intelligence [DENNETT 2017]. The multiple realizability of mind is philosophically interesting, but there is yet much ground to be covered. This is particularly true regarding the challenging aspect of emotions and feelings. Attributing emotional states (impairment on such task is associated with right somatosensory cortices lesions) and personality traits (left frontal opercular cortices) [HEBERLEIN et al. 2004] are both essential for Theory of Mind and partially indissociable neural systems. Damasio suggests emotion, feeling and biological regulation play a role in human reasoning [DAMASIO 2006].

Although Damasio agrees that the mind is embodied, he is at the same time representationalist, understanding that feelings, i.e., the perception of emotions, have as their object the physical process that triggers a set of signals that are mapped inside the brain [DAMASIO 2006]. He does not defend emergentism in his representationalist view. Damasio argues the set of compartmentalized parts of brain processing: the "body loop" , the "as-if body loop" , the "mirror neurons". Insula can get information from: subcortical regions: the multi-modal sensory system; hormonal fluctuations in the body, and neuro-receptivity. This pathways feed the insula with the information necessary for a self representation. There would be no need to add anything immaterial to the picture. No need for dualism. As in the slogan coined by Quine: "No entity without identity".

It considers consciousness as the relationship of a given organism and the objects (internal/intensional and external/extensional) in its mind. It suggests that human beings are capable of a deeper level of consciousness through their brain physiology. It points out that the lobe of the insula plays an important role for human consciousness. The necessary information to represent emotional, bodily, sensory and cognitive states converge to the insula lobe, and such representations can be accessed from the insula lobe to other brain networks, as needed for complex cognitive processes [DAMASIO 2006]. Briefly, a crucial brain area responsible for gathering information about internal states and making it available for other cortical areas is the insula lobe.

> Correspondingly, insula is also the cortical terminus of visceral and 'motivationally salient' afferent fibres through spinal cord (Laminar 1) to brainstem and thalamus where spinal, humoral and vagus nerve interoceptive information converge before projecting to posterior dorsal insular cortex. [SINGER, CRITCHLEY and PREUSCHOFF 2009]

Arising from the subcortical regions, mainly from the amygdala and hypothalamus, the visceral emotions can turn into human feelings, i.e. one can become aware of and report the emotions one is having at a given moment. Not getting ahead of ourselves,

Damasio understands that a fish, even in the absence of a neocortex (not to even mention the insula lobe), is still capable of experiencing pain [DAMASIO and DAMASIO 2016]. A fish can behave accordingly to a painful stimulus, the pain can even cause an internal aversive experience for the fish, but the fish has no higher level access to the experience in the same way a mammal would have. The strongest evidence against a causal role of the insula lobe in generating emotion comes from their study with a patient who suffered bilateral insular lobe injuries. Even after the loss of this area, after his recovery he was able to express all human emotions with relative success. His injury caused him to lose insight into such emotions, but the basis of his emotions remained untouched.

3.5 Is there a gap between the material body and immaterial mind?

Nonphysical entities can be useful for physics, when theory can tie them back to other physical observable entities. That being said, nonphysical entities are only used as a last resort, very parsimoniously and even then, often frowned upon. The main attractiveness of integrated information theory is to avoid postulating nonphysical entities. The whole is not reduced to the sum of the parts, the whole is not more than the sum of the parts. No, according to integrated information theory the information of the whole is to be understood as the information of the sum of the parts minus the integration between the parts. In this sense, reduction is but a particular case. Namely, when integration is null, the results from both information theory and reductionism coincide, in this case (and this case only): the whole is then equal to the sum of its parts. Reductionism can be derived from information theory, while the opposite direction is false, i.e. information theory cannot be derived from reductionism.

The behavior of the parts composing the Central Nervous System are observable, the integration between the parts is observable, the behavior of the whole system is observable. By taking complexity into account, through information theory, measuring such observables provide sufficient data for describing how the phenomena of consciousness takes material substance.

Even though mind is not directly observable, positing its existence, i.e. using the mentalist vocabulary, still seems helpful. The crucial task here is to tie the nonphysical concepts of mind, experience, consciousness back to physical, chemical, biological processes. Even though it may be very hard to see the whole from looking at the parts and how the parts are connected, those constraints are intrinsic to the scientific method.

Maybe there is something else beyond the reach of physics, but this is also beyond the scope of integrated information theory. Yes, the immaterial quality of the mind may prove to be beyond the reach of scientific research. Nonetheless, as there is no better alternative for the scientific method available, we should try our best to describe the components of the material body, how those components form patterns, structures and

hierarchies and how the body interacts with the internal and external environment. If one wishes to stretch our patience and insists in getting us to describe what is the thing lying beyond the scope of science, all we can do is to point to everything lying within scientific scope and say: everything that the scientific method has covered, or will cover in the future, is exactly the opposite of what is metaphysics.

Any hopes we should hold in providing evidence for the nonphysical quality of the mind is through the scientific method. In the case that science would fail in this goal, then the nonphysical quality of the mind is everything that the scientific method was unable to describe and then, and only then, we would have to come up with an alternative methodology for inquiring into this problem.

Will there be anything in the body impossible to dissect through the lenses of science? There are a huge number of possible combinations among the approximately 80 billions of neurons in the brain. Not to mention the whole Central Nervous System, how it interacts with the internal environmental factors: hormones, neurotransmitters and neuroreceptors interaction, gut microbiome, immunological threats, etc; and how it interacts with external environmental factors: family, friends, community and other people, fauna and flora, weather and surroundings, etc. The deterministic approach seems unfit to describe the multiple variable dependence intrinsic to the mind-body problem, we can trace back the irreducible nature from the physical interdependent variables that can influence human behavior. We can more accurately predict how will be the weather ten years from now than to predict who will be the elected president ten years from now. We can more accurately predict who will the president ten years from now is easier than to predict what will I be thinking ten years from now. Meteorology cannot be predicted in a deterministic fashion. Sociology cannot be predicted in a deterministic fashion. Would there be any reason to believe that psychology could be predicted in a deterministic fashion?

In the effort of seriously contemplating the build up of complex behavior in humans, one may take profit in examining more basic instances of animal behavior. The empirical source for the observation of the basic behavior building blocks in humans comes from ethological studies. Many animals pass the mirror test [21]. Among the mammals that pass this test: humans, elephants, gorillas, orangutans, chimpanzees, bottlenose dolphins, orca whales, bonobos, rhesus monkeys. Among the other classes we have only a few ant species and the magpies.

If there is a gap between the immaterial mind and the material body, we are not the only species able to cross the gap. By looking on the mirror and recognizing that the image presented in front of the eyes is the image of one's own body is no simple

[21] A self-perception measure devised by Gordon Gallup Jr., in 1970. Normally, the test is performed as follows: anesthesia is applied to the animal to be evaluated; a marking (e.g. an ink stain, or a stuck adhesive) is made, after the recovery of the animal, a mirror is exposed, well visible to the animal; touching or investigating the marking allows the scientist to conclude that that animal associates the mirror image with itself and not with any other animal.

feat. An it may be the case that there is nothing in the mind beyond what is happening in the body. The alternative is to be more than meets the eyes, but what cannot be observed and has no influence to other observable entities will always remain beyond the scientific scope. It may be an exciting mental exercise, but one of no practical consequence. No experiment will ever falsify the hypothetical gap between mind and body. That being said, it does not follow, from the fact that the dualism has no practical consequence nor use, that dualism is false.

3.6 Evolution of consciousness

Imagine a building. Is the building more than the parts the building is composed of? According to Information Theory, no, the building is not more than the sum of its parts. According to equation 1, the whole holds less information than the sum of its parts. Take the parts of the building apart and now it will be possible to arrange the parts in more configurations than just the building. The bricks in the building are constrained to a single configuration, the context of the building subtracts the information it can hold.

A building starts on the foundation. The capacity of reproducing itself, using a genetic code, is analogous to the foundation of a building. Dennett atributes intentionality to life forms as simple as plants. Monocelular life forms capable of reproduction may not fit the criteria for achieving conscious states. On the other hand, if consciousness were to appear in an organism without the ability to reproduce, said organism would be the last organism to have consciousness of its lineage. The possibility of generating approximately identical copies adds continuity to the picture. A rudimentary perceptual ability could be passed on to the next generations. It may not seem much, but the single celular organism capacity for self-duplication allowed for its evolution to multicelular complex organisms. The bigger organisms had greater capacity for storing energy, required by the operation of accurate perceptual system. At this rudimentary level, the functions of the nervous system is restricted to identifying food, threats or similar organisms.

Sexual reproduction has many advantages for the organism compared to asexual reproduction. Selection is faster within each generation through sexual reproduction. Criteria for choosing a sexual partner are applied, characteristics that increase the chances of survival already pre-selected during the marital courtship phenomenon, usually the female can afford to reject less attractive partners. Other advantages of sexual reproduction: Greater resistance to parasites; New genotypes; Protection against excessive genetic mutation and greater genetic variety.

In human society, many manifestations of sexuality are taboo and, according to orthodox psychoanalysis, the repression of sexuality often leads to psychic disorders [FREUD 2019]. Different points of view on the issue of gender lead to the social world being perceived differently. The description we make of ourselves and others is im-

pacted by our sexuality. Precisely because sexuality is a taboo, we hardly address this elephant in the room. It seems quite easy to underestimate the influence of sex to consciousness. Without sex, would there be anybody to read the words printed on this page?

Sex is one of the pillars of consciousness. Sexual organisms are much better candidates for having conscious states than asexual organisms. Even though human consciousness is much more complex, sex is an intrinsic part of it. Many functions are still missing. Let us take a huge evolutionary jump and we can now discuss a little about mammals. Add the Default Mode Network, social pain and empathic capacity, we are now even closer to good candidates for having conscious states. When a mammal is growing up, it learns through socializing, the appropriate sexual behavior to be enacted as an adult. The less opportunity for socializing a rhesus monkey has, the greater the chances for failure in finding sexual partners [SUOMI, HARLOW and KIMBALL 1971]. We cannot stress enough the important role sex plays for social animals.

Small increments from a generation to the next, adding up through the ages, and here we are. We cannot afford to dive into the details, but suffices to say that human evolutionary past constitute a significant variable in human behavior. Not that human behavior is determined by the human genes, rather human behavior is predisposed by the human genes.

The reader may have noticed we have given little attention to the difference between monocelular organisms and multicelular organisms. Chapter 2 advocated for the idea that we have to pay attention to the parts and the integration between the parts in order to describe the whole (the relation described in 1), we often turn to this idea because it lies on the core of our approach in describing human consciousness. The difference between monocelular and multicelular organisms is, unsurprisingly, the number of cells they are composed of.he various small parts, in themselves, would be little more than "nanobots" [DENNETT 2008] capable only of performing few and simple tasks, now they are combined and exchanging information with each other in a network. Each little brick added does not contain the consciousness itself, but contributes to its manifestation.

"Contrary to the hopes of pioneer cytologists such Ramon and Cajal, there is no specific cell category in the human cortex that is not to be found in the rats or monkeys." [22] [CHANGEUX 2006]. If there is anything new in our nervous system compared to that of our common ancestors with mammals, it lies in the high ratio of brain mass to body mass and the density of connections between neurons. The two adaptations do not justify claiming that the cells that compose us have something special in relation to those of non-human animals.

[22] Contrairement aux espoirs des premiers cytologistes comme Ramon and Cajal, il n'existe pas aucune catégorie cellulaire propre au cortex de l'homme. Celui-ci est construit avec les memes pièces détachées que le cerveau du rat ou celui du singe.

A brick has nothing of the building itself. It will only be part of the building when the brick is in such a configuration that it contributes to the other parts. When the building is finished, the brick is still made of the same material, what changed is the complex relationship it now holds with other parts. The isolated parts and the combined parts into the whole are made from the same matter. In order to properly describe a building, suffices to understand each of the parts and how each part fits together to other parts. The building metaphor relates to the mind-body problem. It seems to be no "building essence" that has to be added to any building for it to become a building. Likewise, we have no reason to suppose any "consciousness essence" needs to be added to the picture.

Add to the self-perception structure two more pieces – mentalizing and harmonization – and something interesting happens. The mentalizing network appears in primates and the ability to harmonize and incorporate cultural values (which must have appeared in *Homo sapiens* during the creative explosion of the Upper Paleolithic, approximately between 100,000 and 30,000 years ago). Human consciousness has gone through a long evolutionary process in which small increments add up, increments are not extraordinary in themselves, biology and genetics are able to explain them without resorting to up to skyhooks [23]

Mentalizing network overlaps with the Default Mode Network activity. Generating hypotheses about one's own mind and the mind of others is a powerful skill to have in order to avoid social rejection. To avoid social pain, which disables us if triggered, it proved to be crucial to foresee and plan the course of action that maximizes the chances of losing our social connections with parents, partners and friends. In the case of mammals, increase of encephalization was observed along evolution, as a general phenomenon, closely associated with the ability to form large social groups [SHULTZ and DUNBAR 2010,SHULTZ and DUNBAR 2010]. This is even more clear in the case of primates, which, in addition, also require a longer period of learning during maturation to reach adulthood [JOFFE 1997]. No other animal has greater encephalization than humans, furthermore humans dedicate a much smaller portion of the neocortex to vision than non-human primates. Not only we spend more time and resources activating the Default Mode Network, this network occupies a much greater volume of our neocortex compared to non-human primates.

The social aspect was critical for the evolution of human consciousness. The social nature of our specie drove the increase in the brain circuitry connections. The pieces of the puzzle of extended consciousness orbit around social consciousness. A creature that can recognize itself as a being that thinks, begins to question its own existence. Our hypothesis holds that the extended consciousness capacity is brought together from the

[23] Skyhook is a term coined by Dennett. Literally, it refers to a hook stuck in the air. The Skyhook metaphor refers to explanations that are not supported by science or natural evolution. It contrasts with *cranes*, which refer to well-founded Darwinian explanations.

cooperation of wmany areas of the brain working in parallel. No other animal is more efficient in allocating resources to the Central Nervous System. Over the course of evolutionary history there is evidence for an exponential growth in the diversity of types of life form, from simple and uniform organisms arising at least around 3,770 or possibly the 4.2 billion years ago [DODD 2017]. A slow start, with small increments over hundreds of millions of years, to a sudden acceleration in a matter of thousands of years. The first beings with sensory capabilities were bacteria that could rudimentary orient themselves to get food, run away from danger and recognize neighboring bacteria [GODFREY-SMITH 2016]. Perception evolved during many generations, as in the famous example of the exaptation occurred in mammalian middle ear bone auditory ossicles from a tube called a spiracle, found in fish's gills [MAIER and RUF 2016], the earliest eyes along evolution probably consisted of simple eyespots that could only detect differences between light and dark [TOMASELLO 2007].

3.7 Was consciousness necessary?

Theoretically, human beings could survive and reproduce by displaying automatic and deterministic behavior when presented to different stimuli. To flee, fight, feed, etc. as required by the appropriate conditions. Yet, deviant behavior is often observed in our species, even when the behavior impairs chances for survival and reproduction. If consciousness occurred as a mutation, why was it not a deleterious mutation?

Natural selection constrains the behavior of any given species. If consciousness affects behavior (the evidence suggests it does affect), it cannot follow that consciousness was neutral when it comes to natural selection. It may be possible, however, that this particular seemingly maladaptation proved to be beneficial when considering the environmental and contextual parameters. This would explain how natural selection enabled species to develop the neural pathways for enabling "conscious" access to internal mental states mutation, as the hypothesis goes, those species outperformed the species without such neural pathways. This evolutionary fictional tale could suggests a description for the rise of experience as a new tool for evolution. Experiential feelings would shape behavior in a non-deterministic way, i.e. a conscious biological machine's display superior flexibility compared to a non-conscious organism.

The main characteristics of human consciousness may be understood by accounting for their inclination to live in society. The emergence of human consciousness was made possible by a set of small evolutionary increments along the phylogenetic tree. The aspects of human extended consciousness are shared with other animals to some level, but no other animal expresses them in such a complex and integrated fashion.

It may possible to highlight the brain areas that were primarily responsible for each aspect of consciousness, especially in the neocortex. The human capacity for first-person subjective experience has an overall positive balance in increasing the evolu-

tionary fitness of our species, otherwise consciousness would gradually disappear or become negligible.

If consciousness was a mutation (Premise I) and consciousness only predispose organisms to maladaptive behaviors (Premise II), there would be natural selection against the "consciousness" trait (Conclusion).

What if the first premise is false? What if consciousness was not a mutation? Let us say that all organisms were conscious since the beginning of life and even inorganic matter was conscious before that. This scenario would not require any mutation for consciousness to appear because it was already there. We cannot afford to provide a deeper argument into such conjecture. Arguably, no evidence nor proof can falsify panpsychism. By considering consciousness to be ubiquitous in living cells and physical particles, one has to accept consciousness for granted. If one does not need evidence for claiming that grains of sand are conscious, why would one need evidence for claiming that the concept "grain of sand" is conscious? Or that virtual particles are conscious? This line of thinking may be useful in writing and reading fiction, but aside from that, it adds little to our description of the phenomena.

Still, for the sake of the argument, let us assume that all living organisms and particles are conscious, even when they passively float around. If that is the case, the consciousness present in a "conscious" entity would be indistinguishable from a "non-conscious" entity. Arguably, this scenario inflicts no change to the predictions for the phenomenon described in the theory. Occam's razor would advise us to choose the hypothesis with fewer assumptions, given it provides the same predictions, instead of the unnecessarily more complex alternative. We are not settling the debate, but merely avoiding it.

What if both premises are true, but the conclusion is false? This would violate the theory of evolution, because it would imply no natural selection against a strictly maladaptive mutation. Darwinian theory's core accepts that natural selection favors adaptive mutations against maladaptive mutations. Claiming that premises I and II are true, but the conclusion is false would require for a revolution in the way we understand biology. This reasoning strongly suggests we should not pursue this conjecture any further.

Accepting first premise as true, and that the conclusion follows from premises I and II, we are left with two alternatives: Premise II is true, humans with the "consciousness" mutation should not be the rule, but the exception. Premise II is false, consciousness can promote not only maladaptive behavior, but adaptive behavior as well.

> Curiously, pain, which I regard as one of the main determinants of the course of biological and cultural evolution, may have begun as an afterthought of nature, an attempt to deal with a problem that has already arisen. I used to think of pain as putting a good lock on the door after a house has; been robbed, but Pierre Rainville has suggested a better

> metaphor to me: putting a bodyguard in front of the house while you repair the broken window. After all, pain does not result in preventing yet another injury, at least not immediately, but rather in protecting the injured tissue, facilitating tissue repair, and avoiding infection of the wound. Pleasure, on the other hand, is all about forethought. It is related to the clever anticipation of what can be done not to have a problem. At this basic level, nature found a wonderful solution: it seduces us into good behavior. [DAMASIO 1999, p. 101]

Pain mitigates harmful behaviors, while pleasure predisposes healthy behavior. Both pain and pleasure are deemed to play relevant roles in human consciousness. The organism's experience of pain and pleasure affects the behavior. The experience associated with pain and pleasure have contributed in how consciousness have evolved. Theoretically, the same adaptive behavior for avoiding harm and being motivated toward survival could have been achieved automatically, without any associated experience. In practice, however, the experience of pain as distressing and pleasure as blissful were successful mechanisms developed by nature in shaping behavior better fit to increase organism's chances for reaching adulthood and reproduce. For an organism to have experiences according to favorable and unfavorable circumstances in a particular way may have brought along some drawbacks regarding fitness, but, as the organisms incapable of having such experiences were overtaken by the ones capable of having them, we can only assume that the maladaptive nature of behavior – such as self harm due to the experience of intense suffering or voluntary celibacy – was an affordable evolutionary trade-off in terms of the other adaptive behaviors it enabled.

Experiencing pain with an undesirable quality inclines the organism to avoid pain. The predisposed avoidance behavior raised by the aversive quality of the painful emotion suggests it was an evolutionary adaptive mutation.

This suggests that the qualitative aspect of consciousness has played an evolutionary aspect in human development. If it were not for the emotions, our ancestors would have little drive in avoiding pain and seeking pleasure. It seems that conscious experience was necessary as it played a significant role in our past and present. Emotions are part of our lives, the way we are affected by external stimuli is a crucial aspect of who we are.

3.8 Ending remarks

The embodied aspect of core consciousness is a *sine qua non* condition for consciousness. Compared to the extended consciousness, it runs in a much more basic and simple level. Even most of the rudimentary life forms on this planet may share this aspects with humans. We may list the main criteria for core consciousness as: to be able to be in awaking and sleeping states; the presence of a nervous system; a proto-representation of itself and of its environment; the capacity for feeling pain. According

to this theory, there is no evidence that rocks have core consciousness because rocks do not fulfill any of the criteria. Artificial Intelligence may fulfill the criteria if one is comfortable in redefining what it means to be awake, asleep, what is a nervous system and, more importantly, what is pain. From the realm of living organisms, the only one that may fulfill the criteria is the Animalia. If our criteria for consciousness is the same criteria for having core consciousness, most animals would fulfill the criteria. That being said, the criteria for extended consciousness is much more restrictive than the criteria for core consciousness. By applying the concepts of core consciousness and extended consciousness, we can hopefully better clarify the concept of consciousness.

4 Social Consciousness

4.1 The neuronal correlates to social pains and pleasures

To be left out is painful, not metaphorically, but a pain as real as the pain from a broken bone [EISENBERGER, LIEBERMAN and WILLIAMS 2003]. The inclination for creating social connections is an important aspect of humans. Most of the brain's resources and time are devoted to a group of cortices known as the default mode network, areas involved in creating the Theory of Mind superpose themselves to the Default Mode Network areas [SPRENG and GRADY 2010]. We highlight the dorsal Anterior Cingulate Cortex (dACC) – among other functions it detects pain signals coming from nociceptor neurons, generating a repulsive experience when activated; and the Ventral Striatum – related with the reward system, linked to the anticipation before pleasure, densely packed with dopamine receptors [NISHI, KUROIWA and SHUTO 2011]. Recently the number of research papers correlating the psychological social processes to neuronal activated regions through imaging techniques is on the rise [OCHSNER and LIEBERMAN 2001].

The novelty in mammal's evolutionary history was the recruitment of the already existing module for alarming physical pain as stressful to include social pain. This is linked to increased avoidance to the loss of social bonds, promoting prosocial behavior in mammals. The present chapter's goal is to review some literature about the biologic mechanisms involved in maintaining a healthy fabric of social connections. Hopefully shedding some light to the nature of social human dispositions and the crucial role it plays on consciousness. Some philosophical implications are raised by neurological research about social pains and pleasures, since it provides analytical tools for portraying the Theory of Mind. The main focus is to cover some literature regarding the neuronal circuitry involved for inhibiting and stimulating the psychological processes required for avoiding rejection and seeking approval in navigating human society.

Homo sapiens would hardly leave Africa continent as lone explorers. The environmental challenges required group strategies beyond individualism.

The social breakthrough in our species would not be possible if our mammalian common ancestor have not evolved the capacity for social pain. Animal studies show more cingulate, medial thalamus, medial prefrontal cortex, and right orbitofrontal cortex activity with infant cries compared to white noise [LORBERBAUM et al. 2002]. For instance, young rodents will vocalize calling cries when their mothers are absent, on the other hand, in such scenario the respective mothers will express similar negative emotions, generally along with prompt maternal behavior, such as orienting, searching, and retrieving their infants [BELL and AINSWORTH 1972, BOWLBY 1969]. The adaptation for this hardwired behavior serves as an evolutionary leverage intrinsic to the mammal class as it promotes breastfeeding, delaying weaning, among other

protective behaviors.

Evolutionary developmental biology compares the developmental processes of different organisms when inferring ancestry relationships. The idea behind this approach can be simplified as follows: the embrional stages show similarities to previous evolutionary steps their ancestors gone through [RICHARDSON and KEUCK 2002]. The neuronal circuitry in the human being were evolutionary selected to predispose toward prosocial behavior.

Human social minds are wired to promote cooperation between pairs. We may distinguish, for simplicity's sake, three main levels: social connection – divided into the networks of reward and pain; "mentalizing" – the network devoted for guessing what others may be thinking; and "harmonization" – which describes the possibility for internalizing group beliefs and values.

Mentalizing and harmonization neural circuitry were consolidated through evolutionary tuning that introduced fundamental social functions into our common ancestor's brain. Mammals share a social connection from birth. Our well-being deeply relies on our connections. Babies manifest this basic need to be cared for and to connect to someone. After the early developmental years, the social needs get more complex, but in its essence we linger to be loved and love others throughout our lives. The disposition for calling out for caretakers increases the infant's chances for survival, in later years new relations will blossom, but the need for social belonging remains [LIEBERMAN 2013].

In the regard of the social brain, the next significant change probably appeared along the primate's order from which we descended. The capacity for theory of mind – to estimate mental states, including beliefs, desires intentions emotions and thoughts underlying others' behavior, including our own. In a social environment to have this capacity would enable greater fitness. Also called "mentalizing" this function helps us understand psychological states such as others' perception and goals [HERRMANN et al. 2007, p. 1361]. The empathy capacity is similar, but not identical to the capacity of theory of mind. The data available from our senses provides clues in analyzing what could be the underlying drives motivating others' behavior.

Recently (at least in evolutionary terms) the harmonizing capacity appeared in the homo genus. This adaptation was a stepping stone in terms of enabling societal organization and culture.

Even though the gene/environment interdependence was not constant over time, but a dynamic relation subject to fluctuations, it seems plausible to say that the evolutionary drive favored the homo genus ancestor's brain with greater social cognition, required to navigate the context of larger groups. "It takes a village to raise a child" is an African saying that summarizes the optimal environment required for the healthy human development and growth, it seems no accident that the same goes true regarding the cradle of human evolution. The best predictor for greater Encephalization Quotient

for all primates is the group size [DUNBAR, MACDONALD and BARRETT 2007], primates with lower EQ are unable to gather in groups with larger numbers. On the other hand, bigger brains need more food and time to mature. Living in larger communities has several trade-offs, it would make little evolutionary sense if the scarce resources spent in raising the fragile and needy offspring with off-the-chart high EQ only for them to be wasted in small insulated groups. The complex cross-dependent network is quite hard to keep track, but there is strong evidence supporting the idea that the demands of living in greater communities shaped the growth of human skull volume recorded in the evolutionary short time span between 4.2 million years ago (at the time the cranial capacity of the Australopithecus averaged between 420 to 550 cubic centimeters) and 100 thousand years ago (when *Homo sapiens* was exhibiting the outstanding average 1300 cubic centimeters) [SMITH, GANNON and SMITH 1995].

Risking being repetitive, among the distinctions we raised, the evolution of human social aspect is just one among other aspects. Isolating it from the other aspects is required in order to pursue some organization to the thesis. The reductive methodology requires for us to pinch out one variable in order to study it. One alternative method would be to track down which interdependent variable was responsible for which consequence in the chain of causes and effects. The non-reductionist path leads to a maze of multiple interpretative scenarios, each one more or less probable as the next. Even with all the initial parameters at hand, predicting the outcomes for any complex system, be it the oscillation of a double pendulum or the evolution of human brain, becomes increasingly non-deterministic as time goes by.

> In weather, for example, this translates into what is only half-jokingly known as the Butterfly Effect – the notion that a butterfly stirring the air today in Peking can transform storm systems next month in New York. [GLEICK 2011]

Bearing the complexity of the human brain in mind, still there may be hope for describing how the observed phenomenon of consciousness is manifested. This Herculean task requires we venture through the science behind: the organic components inside the human body; the external natural surrounding environment we live into; the context of human society. The mentioned components are constituent building blocks for consciousness. But in order to afford for describing the whole, the reductive approach that enables for studying each of the independent variables must be coordinated in the effort of considering how the structure of the components is integrated, as seen in chapter 1. The information of the whole is the information of the sum of its parts – deduced by how integration constrains the possibilities each part can assume, given its embedded context. The non-deterministic nature of the problem of consciousness requires for a methodology that transcends the linear analysis of the variables in the

equation.

Even in this innocent optimistic hope we cannot highlight enough the caveat that this only touches the description required for answering the *how* question, not the explanation for the *what* question nor the *why* question of consciousness. For the latter two questions there seems to be no hope, even provided we have the most advanced scientific techniques. The pessimistic perspective seems justified due to the unsolvable ontological problems raised by the qualia.

The great book by the flashy title "Consciousness explained", by Daniel Dennett, sells the optimistic idea that consciousness can be explained by science. This idea resembles the bootstrapping reasoning that got Mincha usei out of the mire by pulling himself by his own hair (bringing his horse up in the while). Science is a construct of the human mind. Not only the complexity of consciousness defies the deterministic logic, in addition to the self-defeating solipsistic problem of a mind that explains itself, the present chapter force us to take into account the social aspect of human mind. The pool of knowledge one has access to comes not exclusively from oneself, but it includes much of the knowledge accumulated from previous generations. This intrinsic collective social nature adds further layers to the matter of consciousness – not only one's mind would have to bootstrap itself, but pull human knowledge along from the mire.

Unsolvable as the noumenon puzzle is, to momentarily resign back to more mundane elementary matters seems to be justified.

Mammal (from Latin *mamma*, breast) class is a group distinguished from other vertebrates by the presence of mammary glands, whose main purpose is to breastfeed the infants. The baby mammals' need to be breastfed increased the importance of the bond between progenitors and offspring. The loss of the maternal bond is life-threatening to mammals, arguably more than any other class. This evolutionary drive probably favored the social pain capacity and the individuals having such mutation had higher survival and reproductive chances. As the Homo genus belongs to the mammal class, it means that the social need played a significant role as an evolutionary drive in the development of our species.

It may be interesting to look into examples of parental care in other classes. Ethological studies of the African social velvet spider Stegodyphus mimosarum and the Stegodyphus dumicola provide evidence for maternal sacrifice as food for the spider babies as the ultimate form of suicidal maternal care, after a long period feeding the babies via regurgitation.

> Providing parental care is costly for the parent, but generally beneficial for the young whose survival, growth and reproductive value can be increased. Selection should strongly favour an optimal distribution of parental resources, depending on the relationship between the costs and benefits for parents and their offspring. [SALOMON, SCHNEIDER and LUBIN 2005].

Maternal care is not exclusive to the mammal class, it can go as far to the point that it makes evolutionary sense for a mother to sacrifice its life as a valuable food resource in order to increase the chances of the offspring. An important distinction present in mammals and absent in the other classes is the recruitment of the physical pain circuitry to alarm for social pain as well. To hear the baby crying hurts, it makes perfect biologic sense. Opening up a new chapter in our evolutionary history, the social character is critical to describe how the human brain developed. But let us not get ahead of ourselves. As an illustration of how crucial is the bond between mother and infant mammals, it may be useful to introduce yet another ethological study:

> Premature breaking of the maternal bond between a cow and her calf triggers a strong behavioral response which renders separation and weaning major welfare challenges in suckling systems. [JOHNSEN et al. 2015]

In the study, cow and calf were separated from: "either with a fence-line (...) allowing physical contact or with a solid wall (...) allowing merely auditory contact." The group with less physical contact between mother cow and calf presented greater stress-related measures of behavior compared to the group merely separated by the fence. Both calves were offered the same amount of milk from their mothers and, apart from how they were separated [24] the researchers recreated very similar environmental conditions for both groups. The bond between mother and child is strong among all mammals.

4.2 The rejection alarm

Einsenberger et al., inspired by the Kipling Williams Cyberball paradigm, performed a fMRI study monitoring the brain areas activated when experiencing social rejection. The subjects of the experiment played a virtual game in which each time they got the ball they would have the choice to throw the ball back to the player on the right or to the player on the left, unbeknownst to the subjects the other "players" were not actual players but computer simulations, programmed to throw the ball to the player for a few minutes and after that time to completely ignore the subject, forcing the subject to watch right and left player exchanging passes while rejecting the experiment participant from the game. This particular moment interested the researchers, monitoring the reaction when the subject was experiencing rejection from the other "players". The fMRI scanner detected greater activation in the same brain area responsible for activation during physical pain. The study participants also reported felling discomfort for being left out from the Cyberball game, consistently, the subjects with greater dorsal anterior cingulate cortical activation reported greater levels of discomfort.

[24] What greater stress for a mother and her baby than for them to be separated away from each other? No culture in the world regards baby kidnapping as ethical.

The social pain and the physical pain activation patterns are indistinguishable when one is only presented with the fMRI scan results. This evidence suggests that, from the mammalian brain's perspective, to lose a social interaction produces the same painful alarm that any other physical injury would trigger. Previously linked to the unpleasant sensation caused by physical pain, dACC activity is now suggested to be linked to social pain as well. Besides, right ventral prefrontal cortex (rVPFC), known to play a pivotal role in inhibiting physical pain, can inhibit social pain as well, through the same neural path. Right ventral prefrontal cortical activity is associated with lower discomfort due to social rejection [EISENBERGER, LIEBERMAN and WILLIAMS 2003].

The same alarm system dedicated for physical pain was recycled [25] or detecting social pain. Nociceptors spread throughout the body converge to dACC. This brain area is responsible for the unpleasant sensation related to physical pain, is thus claimed to be responsible to social pain as well [EISENBERGER and LIEBERMAN 2004]. The claim is counter-intuitive, a doctor could remain skeptical and ask: "should I prescribe a pain-killer to a patient reporting he has got a broken heart?". This narrow relation between physical and social pain contradicts the common sense, namely the idea that physical pain is real while emotional pain is metaphorical. Nonetheless, a further study was performed in order to clarify how effective pain-killers are against social pain.

During 21 days two groups were monitored: the experimental group took two 500 mg acetaminophen pills (commercially sold as paracetamol) one after waking up and another before sleep; control group followed the same medication regimen, but have been given placebo pills instead of the actual drug. Throughout the experiment subjects had to report how much social pain they felt during the day. Compared to control group, the experimental group reported significant lower levels of social pain [DEWALL, JR and DECKMAN 2011].

The same strategies that can be used in order to dull physical pain have been proved effective against social pain and vice-versa, effective strategies in reducing social pain are also effective in reducing physical pain: staring at the photo of a romantic partner reduced both physical pain reports and dACC activation levels measured through fMRI scan [EISENBERGER et al. 2011]. Apparently, from a physiological standpoint, physical and social pain share the same system and are both affected by chemical intervention and unorthodox methods. Traditionally, medical science could rely on objective data, however recent research suggests that subjective variables can be just as important for the patient well-being.

[25] The term recycle is neuroscientific jargon for a novel use for a network that were activated for a similar task. This is what the term "recycle" means on this thesis. One can find the term being used by Dehaene [DEHAENE 2009] for example.

4.3 Social pain evolution

Reptilian ancestors are only capable of physical pain, the capacity for social pain, on the other hand, is uniquely found in mammals. At the bifurcation point, our mammal ancestors have developed an interesting feature, the brain area responsible for making pain unpleasant was now being recycled for making social pain unpleasant as well.

We allude to the ancient myth of Pandora's box. In the myth, the box (or jar, in the original version) appears to be a gift, but once opened, it brought a multitude of unexpected threats along with a hint of (probably illusory) hope. Estimating the most likely content in the mind of others and on our own fundamentally changed our introspection. In a context in which human kind has created numerous potential threats to life on earth, knowing that much of our development as a species is based on the ability to attribute intentional states can alert us to a number of unforeseen dangers. If acquiring knowledge about our inner mental life was one of the triggers for the creative explosion of the upper paleolithic, it came with the drawback that this significant change in our neural pathways also enables us a far from natural range of behaviors.

One could even extrapolate, saying that the very access to our mental inner lives will allow for our future demise. Maybe it would have been safer for us to remain ignorant "Many were increasingly of the opinion that they'd all made a big mistake in coming down from the trees in the first place." [ADAMS 2010] about what is going on with our thoughts and feelings, unfortunately or not, to go back is impossible. Once that "box" is already open.

4.3.1 Social pain as an alert of human disposition that claim for the satisfaction of social needs.

One of the central and not completely resolved questions in social cognitive neuroscience is: why do human beings create social bonds? Is it possible to link the activation of the dorsal anterior cingulate cortex (dACC) and the feeling of social exclusion? The flow of blood in a certain region of the brain, something measurable, is associated with the report of the feeling of social pain, which is subjective; suggesting a link between nociception and the resulting emotion. Pain is an alarm activated by the presence in the environment, mainly, of a stimulus that is life-threatening. It can be physical if the stimulus directly affects the body, or social if the stimulus restricts interpersonal relationships. When experiencing physical pain, the person is usually able to indicate the location on the body and the intensity of the pain (identification of the type). Physical pain is interpreted as uncomfortable (emotional reaction) in people who have intact dACC.

The review requires meta-analysis of studies using multiple brain imaging methods, involving questions concerning social pain and the literature on philosophy of social neuroscience. Both empirical and theoretical works were analyzed to contribute to the

debate on the anguish present during isolation. The demarcation is not precise between different areas of knowledge that are interested in the subject in question. An effort is required for pushing forward the interdisciplinary dialogue. Contributions from different areas can complement our take on the subject.

We can observe some aspects of extended consciousness in non-human animals. For example, in the aspect of temporal awareness, elephants stand out for a memory that enables them, among other feats, to minimize the distances traveled in the search for water during the dry seasons [POLANSKY, KILIAN and WITTEMYER 2015]. In terms of perception, chimpanzees have a visual acuity of the same order as humans [BARD et al. 1995], some experiments indicate that chimpanzees have the same occipital region quite developed in relation to ours, even managing to process some images faster and more accurately than human beings. It may be interesting to contrast different types of mind to better understand how aspects of extended consciousness have emerged throughout biological evolution.

In the case of human evolution, the introduction of the social pain mechanism was a milestone that fostered the improvement of brain modules in the neocortex that were better able to process information regarding the ethical and symbolic aspects of extended consciousness. Such aspects are crucial for human coexistence in society. It may have brought about the increase in cognitive abilities as a side effect.

Can we know for sure whether the capacity of human consciousness is evolutionarily adaptive in the human being? There are many reasons to hold that the capacity for solipsistic reflection would be a maladaptive for most nonhuman animals. Apparently this was not the case for us.

We can propose the following thought experiment: a hypothetical “frog sapiens” [26]. This non-human animal reserves as much time, energy and resources to question its own existence as humans do. Would the “frog sapiens” experience any advantage in survival and reproduction chances in relation to the other frogs? Such distribution of energy seems inefficient for a frog, there would even be a risk for the frog to conclude that the frog’s life is unsatisfactory, the frog sapiens may want to end his not particularly fulfilling existence.

Suicide and celibacy rates are higher in humans than in other species. It should not be difficult to argue that human consciousness predispose such behavior. By reflecting too much on oneself, doubt may be brought for one’s reason for continuing to live, or doubt regarding the choice to have children. Calculating the happiness of continuing one’s life is an inefficient use of time and energy. To calculate whether or not one should mate and generate new copies of ones genes makes little evolutionary sense. Were the mutations that made human consciousness possible concessions that natural

[26] This is a pun with the sound of the word “sapo” in Portuguese and the Latin word “sapiens”. Frogs intelligence is quite average among non-human animals, other than that the frog is of no particular interest, any other animal would suffice.

selection made because they brought advantages that surpass those presented, or are, from an evolutionary point of view, undesirable byproducts?

4.3.2 Is there identity between dACC activation and social pain?

Even though, activation of the dACC does not necessarily entails social pain. The functional Magnetic Resonance Imaging (fMRI) study that investigated social pain presented as a result that, whenever the individual reported social pain, there was activation of the dACC. In fact, the greater the intensity of the report for social pain, the more significant was the activation recorded on the detection instruments [EISENBERGER, LIEBERMAN and WILLIAMS 2003].

- Social pain $\implies$ activation of dACC [1]

Such studies were repeated [YANAGISAWA et al. 2011] confirming previous results. However, many other circumstances can also activate dACC. This is the case for physical pain, for example. Activation of dACC can occur in the absence of social pain:

- Activation of the dACC $\wedge\neg$ social pain [2]

So it cannot be the case that:

- Activation of dACC $\implies$ social pain [3]

In order to exist an identity between social pain and dACC activation, a bi-implication relationship between dACC activation and social pain has to be established. Both [1] and [3] conditions would have to be true in order to apply the inference logical rule and introduce the biconditional:

- activation of dACC $\iff$ social pain [4]

[1] may be true, as the Eisenberger and Lieberman experiments suggest, but [3] is false. Therefore the identity represented in [4] is false. If the identity theory were to be found true, the neuronal activation would always entail its mental correlate, as the neuronal activation and the mental correlate would be identical. In establishing that every concrete particular falling under a mental kind may be correlated to some neurophysiological happening is not sufficient to establish an identity relationship between the mental state and the physical mechanism. For establishing an identity relationship, a neurophysiological happening would have to be unique to and only to a specific mental state. The neurological nature of human makeup requires neural redundancy, allowing for a set of neurons to perform different tasks or multiple tasks at once. It would be very inneficient if each neuron or each set of neurons were exclusively dedicated to a single task.

> Human cognition can be decomposed into a number of functionally independent processes, each of these processes operates over a distinct domain of cognitive information [...] functional independence, the fact that one can be affected, in part or in totality, without the other being affected, and vice versa" [BERGERON 2007, p. 176]

Evidence suggests that neural reuse – the "redeployment" or "recycling" of neural circuits across wildly dissimilar cognitive domains – is widespread in the human brain. [ZERILLI 2019].

4.3.3 Excessively social

Generally, human beings feel aversion to the pain that loneliness imposes. The capacity for social pain predisposes the creation of social skills as they are useful for avoiding social isolation.

The painful experience derived from loneliness will push us toward applying the mentalizing network for predicting others behaviors, avoiding future isolation. Memory is influenced by emotions, fearful and painful experience greatly enhances memory consolidation an access [PHELPS 2004]. In evolutionary terms, it makes sense for us to pay more attention to threatening stimuli. However, the pain from a broken heart heartbreak is often played down as a metaphorical "pain". No one questions whether a broken leg causes real pain. But social pain, the pain that comes from losing interpersonal contact, is not taken as seriously as it should. Physicians are trained to search for symptoms of physical pain during a medical appointment, but how often do they ask about emotional feelings such as grief or sorrow?

One of the longest-running and most thorough studies of mental and physical well-being in history – a 75-year longitudinal study following 268 Harvard educated men – the Grant Study of Adult Development charted the physical and emotional health over the years plotted against a wide range of variables presents as its key finding that, apart from every other aspect reported, the warmth of relationships has the most positive effect throughout life [VAILLANT 2012]. It suggests that doctors should pay closer attention to the families of their patients [BERKMAN 1995].

Humans share common ancestors with mammals. Therefore, survival strategies derived from the evolution of the mammalian class are relevant to understand our functioning as a species. A fundamental characteristic of mammals is the breastfeeding in the first months of the infant's life. One plausible theory is that, to ensure that mother and baby are engaged in breastfeeding behavior, the capacity for experiencing social pain played a fundamental role in natural selection.

A study in rhesus monkeys was carried out to identify the effects of lesions (i.e., surgically disconnected areas) in different parts of the medial frontal cortex (which includes the dACC) on stress vocalizations when socially isolated. The only region that consistently eliminated stress calls was the dACC; if other regions were damaged,

while keeping the dACC intact, the calls were still recorded [MACLEAN and NEWMAN 1988]. Electrical stimuli applied to the dACC provoke specific vocalizations for social isolation in rhesus monkeys [ROBINSON 1967].

Babies who vocalize less when socially isolated have lower survival chances (which constitutes a case of negative selection). In humans there are at least two other adaptations that have specific functions for socialization, namely: mindreading, i.e. the process of creating hypotheses about psychological states such as goals and perceptions of others [HERRMANN et al. 2007]; and harmonization that ensures that a set of values is widely shared by the community [LIEBERMAN 2013].

"It is a basic feature of human experience to feel soothed in the presence of close others and to feel distressed when left behind." [EISENBERGER, LIEBERMAN and WILLIAMS 2003]. According to Lieberman, in certain situations, social needs may prevail over physiological needs. This point of view challenges Maslow's hierarchy of needs. The new proposal defends a hierarchy of human needs different from the traditional hierarchy, in which it was argued that physiological needs always overcome social needs.

Lieberman's position is related to the way our brain circuits were selected, enabling the organism to recycle the same neural circuits that transform the aversive stimuli of physical pain to also be activated during social pain. Social pain is the unpleasant sensation triggered when there is a threat or a loss of the social relationships. With advances in the resolution of images obtained by the fMRI technique, it was possible to estimate brain activation during a context of social exclusion. The results suggest that social pain activates the same brain location as active physical pain, namely: the dorsal anterior cingulate cortex (dACC).

This chapter intends to contribute to the debate on the relevance of social pain caused by rejection for the social aspect of human consciousness. The goal is not to discuss whether social pain influences happiness, neither to deal with the role that emotions play during the moral judgment of actions. These are important debates that involve the issue, but we cannot afford to focus on such implications here. Our focus is to describe the mechanism of social pain and how it influences the social aspect of human consciousness.

4.3.4 Context

We do not deny that, after long periods of intense social contact, some time out break – with little or no social contact – may predispose a calm and relaxed attitude. But this is only the case when enough time was spent among other peers. One of the most severe punishments prisoners may face is to be held in solitary, without any social contact for long periods of time. This serves as an unfortunate example of how social interaction is an important factor for mental health, due to the fact that solitary confine-

ment is associated mental illness [DELLAZIZZO et al. 2020] . Bearing this in mind, studying the neuronal aspect of social pain may help elucidate the biological aspect of humans as social animals.

The social pain evolution hypothesis: the function of physical pain is to promote avoidance behavior against physical harm. Likewise, the function of social pain would be to promote avoidance behavior against rejection.

Here is an argument for holding that the human brain circuitry predisposes us to bond with others: social pain makes perfect evolutionary sense for mammal species. Being close to friends and family increases survival and reproduction chances for passing the genes forward. In other words, a disgusting experience associated with betrayal motivates prosocial behavior. The more one is fearful of rejection, the more one is willing to avoid it. It seems plausible that the "social circuitry" increases the human gene's chances to be passed on forward. Section 4.2 pointed out an association between being socially excluded and feeling a painful experience.

Freud is recognized as the father of psychoanalysis. In his interpretation, father figures exert great influence. This lingers long after childhood. Much of the psychoanalytical attention as given to probing for the origins of neuroses by focusing on the patient's early years. Freud considered that often the patient's illness was related to repressed memories of the patient's mother, father or parent figure, specially during the first stages of childhood. Freud was the precursor of the study of the characteristics of infantile sexual manifestation, according to his hypothesis, father (in the case of the daughter) or mother (in the case of the son) populate the imagination of children. He argued that, in most cases, during puberty the incestuous interest is redirected. Interest in parents or caregivers is then transferred for alternative affective interests.

In a nuclear family, in the usual order, the first contact with the other is established with the mother's breast, then with the mother, with the father and gradually passes to the other people.

Freudian theory opened up several interesting fields of research. Sure, his scientific methodology was quite unorthodox, an easy target for criticism such as presented by Karl Popper [POPPER 1963]. But it sparked academic interest to an important field that was basically neglected until then.

In the Freudian theory, the future characteristic of a person (sexuality, personality, identity) can be related to the characteristics of the bond between caregivers and children. Therefore, protecting the child from early life abuse is crucial. A safe childhood prevents future mental disorders and increases the chances for optimal development. At the early years, the infant is physically fragile and mentally immature.

One may argue all humans to be prematurely born. Among animals, human infants take a very long time to be able to walk. "Adult brain mass accounted for 94% of variance in time to walking onset postconception" [GARWICZ, CHRISTENSSON and PSOUNI 2009]. The time it takes for our species to walk is proportional to the

adult brain mass. This evolutionary compromise offered us a much greater potential. Potential that can be jeopardized if our children are not embedded in a broad social context, with an abundance of healthy relationships. It takes a village to raise a child.

John Bowlby in 1950 published "Maternal Care and Mental Health" [BOWLBY et al. 1951], in which the effects of the institutionalization of European orphans in the post-war period were evaluated, highlighting the consequences for the mental health of children triggered by the absence of strong relationship between the caregiver and the orphan. The abandonment of boys and girls is still a sad reality, as is child sexual exploitation, abuse and child labor. These harsh conditions create obstacles for the future of those children.

"If the oxytocin receptors are not stimulated by love and attention early on, they fail to develop." [ZAK 2012]. Oxytocin incites the feeling of trust. With the activation of oxytocin receptors, the social pain felt can be more aptly managed. An unfounded distrust in others, reduces the chances for creating affective bonds. An exploited child, subject to humiliation, having their privacy violated is more likely to develop psychological disorders.

Recent MRI brain studies suggest that social pain is analogous to the neurocognitive function of physical pain [EISENBERGER et al. 2006]). Social pain and physical pain are intertwined. The chemistry of social pain and physical pain is similar: Antidepressant medications or selective serotonin reuptake inhibitors (SSRIs) also have similar effects on physical and social pain.

> Antidepressant medications or selective serotonin reuptake inhibitors (SSRIs) also have similar effects on both physical and social pain. Antidepressants, typically prescribed for treating anxiety and depression, often related to or resulting from social pain, are effective in alleviating physical pain as well [...]. In fact, antidepressants are now regularly prescribed to treat chronic pain conditions. [EISENBERGER and LIEBERMAN 2004].

A drug such as Tylenol suppresses both physical pain and social pain. The regions of the anterior cingulate cortex (ACC) and bilateral anterior insula "whose function, among others, is the sensation of pain" showed less activity in response to social exclusion due to the anti-inflammatory effect [DEWALL, JR and DECKMAN 2011]. The same headache drug can also help with the hurt a person feels. Social pain is different from physical pain, however, the pain is just as real. The same regions activated by physical pain are also activated by social pain and the activation of these regions is greater depending on how hurt the affected person feels.

The dACC is responsible for the unpleasant sensation caused by pain. So why would we be built this way? At first glance, the fact that the aversive character of pain can be so agonizing that it can bring us down for days or weeks seems like an evolutionary misstep. For example, pain makes us less productive. "Nearly 20 percent

of adults live with chronic pain, leading to countless lost workdays and deep depressions." [LIEBERMAN 2013].

Excessive pain can even predispose fatalities. The pain that the suicidal person feels is sometimes physical, sometimes social. Why has evolution "gifted" us with a feeling that can make us take our own lives? Ostracism increases the chances for suicidal thoughts [CHEN et al. 2020]. From an evolutionary point of view, such distress may be considered maladaptative. An imbalance in the nociceptive system that causes continuous pain – as is the case with those who suffer from chronic pain – can cause the unbearable feeling of pain to overcome the survival instinct.

Physical pain is associated with a higher risk of suicide mortality. Most human beings have an aversion to pain. The greater the pain, the greater the risks we are willing to take to alleviate the pain. It seems reasonable to ask whether the same goes true for social pain. Social pain often appears as a motivation presented by the suicidal person.

> Perceptions of social distance can, at times, lead to such intense social pain that the consequence may be suicide. Over a century ago, Emile Durkheim, a French sociologist, highlighted the pain of perceived social distance through his work showing that suicide is most prevalent among those lacking social ties [...]. Consistent with the hypothesis that social distance directly contributes to the social pain that leads to suicide, the most frequent topics addressed in suicide notes or suicidal communications are social isolation, emotional pain, and relationship breakups. [EISENBERGER and LIEBERMAN 2005]

This lead us to an evolutionary puzzle. If pain can be a cause for death, it must be some evolutionary compromise, granting other advantages in having the capacity for feeling pain. Just like physical pain, social pain may not be pleasant in a moment, but we are lost without it. When a healthy person feels physical pain, it comes along with an unpleasant subjective quality, the normal behavior during such conditions is to avoid the painful stimuli, moving the body away from all sorts of dangers. Were we not gifted with the perception of pain, there would be greater risks: "Children born with congenital insensitivity to pain are incapable of feeling pain and often die in the first few years of life because they injure themselves relentlessly, often falling victim to deadly infections." [LIEBERMAN 2013].

The social pain that a healthy person plays a similar role to physical pain. Social rejection and separation from family members is unpleasant. This aversive quality that comes along with the social pain predisposes prosocial behavior. Just as one learns during childhood to avoid physical dangers in the external environment, as they are unpleasant; one learns from social pain the social behaviors to avoid.

For Maslow, there is a hierarchy of needs. The higher-level needs can dominate the organism if and only if the lower-level needs are already satisfied.

> At once other (and 'higher') needs emerge and these, rather than physiological hungers, dominate the organism. When these in turn are satisfied, again new (and still 'higher') needs emerge and so on. This is what we mean by saying that the basic human needs are organized into a hierarchy of relative prepotency. [MASLOW 1943, p. 375].

According to Maslow, the list of physiological needs can include almost as large a number as desired, since the degree of specificity of description can include the most diverse needs. The pyramid of needs has, at the base, the physiological needs (such as food, water, sleep), then safety needs, social needs, esteem needs and, at the top, self-actualization needs. No one, according to Maslow, can survive without satisfying their physiological needs. The other needs would not be mandatory, although they enable better living conditions when satisfied.

Lieberman does not deny that babies need food, water and shelter (physiological needs). He just adds that having access to physiological needs is only possible for most mammals when they are cared for. A baby mammal in an environment with access to food, water and shelter is less likely to survive if left alone. Young children were purportedly nurtured without human interaction in a 13th-century experiment allegedly conducted by the Holy Roman Emperor Frederick II in an effort to ascertain whether or not they may exhibit a natural language once their developed voices. No need to say that, unfortunately, no children survived the experiment.

Another ethically problematic study provided data relevant to the issue at hand. Harry Harlow, after coming into contact with John Bowlby's research, wondered about the impact of the separation between mother and baby. He designed and performed a series of experiments for the purpose of studying rhesus monkeys in contact deprivation: "Social deprivation in monkeys" [HARLOW, DODSWORTH and HARLOW 1965]. The infant monkeys, when separated from the socialization with their biological mothers. [27]

The psychological consequences observed in the animals during this laboratory practice became more acute the greater the degree of isolation inflicted on the monkeys. Multiple experiments were carried out, exposing rhesus monkeys to complete or partial isolation for different periods of time. The monkeys were able to meet their physiological needs. All the "normal" living conditions of the animals in captivity were maintained, the only variable changed was the presence of other monkeys, which was purposely removed in one group and kept in the control group.

> No monkey has died during isolation. When initially removed from total social isolation, however, they usually go into a state of emotional shock,

[27] At the monkeys disposal there were mother surrogates, babies monkeys would spend significantly more time with the soft terrycloth mother that provided no food and less time with the one that provided nourishment, but was made of wire.

> characterized by the autistic self-clutching and rocking. One of six monkeys isolated for 3 months refused to eat after release and died 5 days later. The autopsy report attributed death to emotional anorexia. A second animal in the same group also refused to eat and would probably have died had we not been prepared to resort to forced feeding. [HARLOW, DODSWORTH and HARLOW 1965, p. 92].

In the experiment, a third of the rhesus monkeys that were isolated from other monkeys would die. The researchers had to intervene, resorting to force-feeding in order to collect more data from the animal. The experiments are justifiably criticized for endangering the health and welfare of laboratory animals and we should not repeat them, however the results still bear significance. If Maslow is correct, then how to explain the death of the isolated monkeys? Physiological needs were provided, what then caused the monkeys to die? At the risk of anthropomorphizing the case, perhaps the rhesus monkey in Harlow's experiment has, in the solitary environment in which he was raised, lost something vital to any mammal. The death by starvation of baby rhesus monkeys who are isolated for a long time supports the hypothesis that social pain is more crucial than common sense suggests.

Lieberman argues that the primary need for the mammal is social need. Caregivers must make sure that the baby will have all the needs met. Thus, the mammalian brain must function in such a way that, as a rule, it prioritizes social connection. Such strategy proved to be optimal in terms of survival chances: caregivers protect the child from external threats and keep them close to them, taking care that all their needs are met. The rhesus monkey that died in Harlow's experiment was certainly feeling pain from starvation, but his environment affected him in such a way that the social pain overcame his urge to eat, ignoring the food he was offered for five days before dying from emotional anorexia, according to the autopsy. This dramatically shows the importance of social need.

> What all mammalian infants, from tree shrews to human babies, really need from the moment of birth is a caregiver who is committed to making sure that the infant's biological needs are met. If this is true, then Maslow had it wrong. To get it right, we have to move social needs to the bottom of his pyramid. Food, water, and shelter are not the most basic needs for an infant. Instead, being socially connected and cared for is paramount. Without social support, infants will never survive to become adults who can provide for themselves. [LIEBERMAN 2013].

More than the need for satisfying biological needs, mammals require social connection. This is because mammals are often born immature, dependent on others for their care for a longer period. This is especially true for humans who, before age 4, are basically helpless. If parents did not feel social pain when hearing their child cry, they would not be as predisposed to care for their offspring during their early childhood.

4.4 Overcoming impulses

Overcoming impulses is important for human society. Other non-mammalian animals live in societies even without our social pain mechanism. To understand the difference between human society and gregarious animals, it may be interesting to consider the case of herring fish. Herrings swim in groups at a distance from neighboring herrings. Such a distance is approximately the distance that plankton (their food) is able to jump. Therefore, the plankton that is in front of a herring jumps the exact distance to the mouth of the herring nearby. The herring does not need to suppress its impulse to feed, so that the other herring eats, just following its impulse enables the food to reach its neighbors and vice versa. A relation was found for the inversely proportional relationship between school size and time to locate food [PITCHER, MAGURRAN and WINFIELD 1982]. The faster one species can find food, the greater the size of the schools, the relation is intuitive because big schools require greater amount of food.

Needless to say, the context of human society is far more complex than the context of herrings. Nonetheless, the resemblance is clear. Villages usually have better food security compared to a single hermit, being social and belonging to big groups was, from the evolutionary point of view, a viable survival strategy on our species, considering the drawbacks. The ability to feel social pain in our case is coupled with the ability to navigate big groups. Acting selfishly tends to drive people away. On the contrary, generously overcoming narcissistic impulses for the good of others makes these individuals more charismatic and attractive.

> A number of neuroimaging studies have examined the process whereby individuals intentionally override a prepotent response or impulse. The two brain regions that have consistently been associated with this process are dACC and LPFC. [LIEBERMAN 2007]

Anterior Cingulated Cortex is an absent area in reptilian's brain, but present in mammals, an important differentiation distinguishing the subjective quality of the pain experience to be more aversive in mammals compared to reptilians. The absence of ACC does not mean that reptilians are unable to experience pain, it only suggests that the pain experienced by reptilians may lack the same first person quality of the pain experienced by mammals. The report from a patient after cingulotomy are quite elucidative of the point at hand.

> I vividly recall the particular patient, sitting in bed waiting for the operation. He was crouched in profound suffering, almost immobile, afraid of triggering further pain. Two days after the operation, when Lima and I visited on rounds, he was a different person. He looked relaxed, like anyone else, and was happily absorbed in a game of cards with a companion in his hospital room. Lima asked him about the pain. The man looked up

> and said cheerfully: "Oh, the pains are the same, but I feel fine now, thank you." [DAMASIO 2006]

Due to the fact that the Anterior Cingulate Cortex is the densest brain region for opioid receptors, it brought the attention from behavioral and neuroscientific research [TANAKA and NORTH 1994, GREMEL, YOUNG and CUNNINGHAM 2011]. Both from theoretical and empirical reasons, the ACC area is deemed to play an instrumental role in attributing the unpleasant character of the physical and social pain experience. Furthermore, ACC is associated with affectionate behavior between mother and child in human and non-human mammals. [LIEBERMAN 2013]. This area is important for social function in humans. Avoiding the unpleasant feeling of loneliness, people approach each other. Social interaction generates well-being and health. Isolation, on the other hand, worsens illness, increasing the mortality risks [BERKMAN 1995].

In our species' evolutionary history, the social connection network played a fundamental role in favoring the cohesion of groups. "Social cognition is about understanding other people." [LIEBERMAN 2007]. According to Lieberman, there are at two main neural pathways for understanding others' mind and one's own mind. The first pathway is rational, knowledge of social rules and norms mediating about what is believed to be going on internally in the other person's mind. The second is intuitive, we feel the others' experience as if we were in their skin. In the latter form of empathy, one considers the others' emotions as one's own feeling. The former is addressed from the "theory of mind" network.

Humans have the ability to create a theory of mind, or an ability to attribute internal emotions and motivations to other individuals. Thus, in a way, we place ourselves in the shoes of those we are trying to understand.

> Theories of mind are, in a figurative sense, readings of the mind. In social terms, we learn to predict the actions of other persons by means of theorizations about what is going on in their minds, and these theorizations are acquired through social relationships. [STEIN 2003].

In order to predict others intentions, one is required to see the world through the eyes of others. When practicing this behavior, one's own experiences are inhibited, for a less biased judgment.

> [B]oth neuroimaging and neuropsychological investigations have suggested that right ventrolateral prefrontal cortex (VLPFC), a subregion within LPFC, helps to inhibit one's own experience during the consideration of another's state of mind. [LIEBERMAN 2007]

The rVLPFC region can suppress other brain areas related to self-experience, enabling to consider the experience as felt by others. This reduces the solipsistic bias,

enabling greater empathetic influence. Social pain is a strong drive in directing our interest to what we assume to be going on in the minds of others.

Back to our main recurrent theme of how the parts are integrated to the whole. We can subdivide the social aspect of extended consciousness into three main aspects: social pain; theory of mind and harmonization. The areas responsible for each aspect are not isolated modules, but complement each other. Therefore, instead of finding a center for the social aspect of consciousness, evidence suggests for it to be spread over an intricate neural network.

> One discharges fancy homunculi from one's scheme by organizing armies of such idiots to do the work. [DENNETT 2017]

Brain areas interact, inhibiting or stimulating each other. Human consciousness would be impossible were it not from the contributions of many different parts. For instance, evidence suggests that the evolution of social pain coupled with mentalizing processes in human kind enabled us to be brought together in bigger tribes. The tribal behavior of *Homo sapiens* in history and prehistory would be quite impossible in the absence of those areas. Depending on the circumstances, a person may be willing to risk and even sacrifice his own life for the sake of their family, friends, or community. Human tribes rely on the cooperation of its members, strength brought from the union of the many individuals structured into a community. Arguably, no other specie is as adapted to different environments as our own, nor has greater capacity for consciousness. Could this correlation be coincidence?

We follow Damasio distinction of human consciousness into two main different aspects: core consciousness and extended consciousness. Moreover we will consider the hypothesis of further distinguishing extended consciousness in different aspects. To isolate consciousness in different parts is merely a simplification method, it does not properly represents the complex intricacy found in human consciousness. Distinguishing different aspects is solely an analytical tool, focusing in first describing the basic elemental parts, a necessary step for later tackling the whole problem by adding the parts together and subtracting how the parts are constrained due to integration.

Chapter 2 presents a brief discussion over the reducibility of consciousness. Even though the reductive analysis is unfit for a full description of consciousness, the reductive analysis is the default scientific approach used when describing complex systems into more basic components. After the analysis of the complex system into independent parts a further step can be made in order to describe how the parts are integrated into a whole. The mathematical tools developed by Information Theory offer a description of the information contained by the whole, the parts and the integration between parts into a single equation. Namely, the information contained by the whole is equal to the information of the sum of the parts constrained by the integration between the parts.

This introductory chapter is crucial for the thesis because it proposes a methodology for "sewing" together the main aspects into the whole.

Chapter 3 presents a brief discussion about core consciousness. Deep and non-conscious bodily processes may ground the foundation of consciousness, this is the case, assuming Damasio's interpretation for empirical evidences in patients suffering from conditions such as locked-in syndrome and deep coma. Before further developing the hypothesis that distinguishes extended consciousness into its component parts, core consciousness had to be properly introduced.

Further chapters can develop the hypothesis, supposing one has sufficient understanding of: the relations between the whole and the parts; as well as, the underpinnings of core consciousness. Chapter 4 unfolds extended consciousness into one of its main aspects, starting with the social aspect. A distinguishing feature of the mammal class is its capacity for social pain. No other primate has greater neocortex nor gathers in bigger groups than humans.

> According to the hypothesis, since the neocortex is commonly believed to play a crucial role in handling social relationships, its size should set an upper limit on the number of stable social relationships that primate brains can keep track of and maintain. [LINDENFORS, WARTEL and LIND 2021].

The best predictor for neocortex size in primate order is defined by group size. This evidence suggests the nomenclature *Homo sapiens* to be misguiding, maybe a name better fit for our species should be *Homo socialis*, emphasizing the scientific reason for our disproportional neocortices' size. Navigating through complex social interrelations requires a brain skilled in theory of mind, i.e. the capacity for generating hypothesis regarding others' beliefs and thoughts. The default mode network – denominated as "default" because this group of interacting brain regions remains active even when there is no task to be handled with – and the mentalizing network perfectly overlap.

4.5 Justification and relevance

Being able to better understand the human relationship process opens up possibilities for work on several fronts. Social cognition is a process that guides interpersonal attitudes. Brain structures play an important role in understanding social actions and connections. The interface between several areas of knowledge enables us to understand the integration between the parts. Different techniques have emerged to produce images of brain functioning [28]. The fMRI technique is one of such techniques. It can

[28] All processes related to neuronal activity require energy in the form of adenosine triphosphate (ATP). This nucleotide is produced mainly by the mitochondria through an oxygenation process, which generates carbon dioxide as a by-product. Fully oxygenated blood hemoglobin (HbO2) is responsible for delivering oxygen. Oxygen-carrying hemoglobin (HbO2) is diamagnetic, like the rest of brain tissue "which

be said that fMRI performs a scan that is sensitive to deoxygenated hemoglobin. The fMRI technique has the disadvantage of low temporal resolution – the measurement moment is not simultaneous with the neuronal activity, and there may be a lapse of seconds between each image.

"The temporal resolution is very low, with an image (a 'frame' in the movie) acquired about once every 1 to 3 seconds." [GREENE 2013, p. 367]. As an offset, fMRI has good spatial resolution, which makes it possible to point out more clearly the area that was more activated during the test, when the activation is distributed over a longer period of time.

Studies using the Electroencephalography (EEG) technique have better temporal resolution. On the other hand, its spatial resolution is lower than that of fMRI. In the case of studies recording activity of longer duration, social pain experiments for example, fMRI techniques tend to be more reliable than EEG. For experiments where temporal resolution is crucial, odd-ball experiments [29].

Neurosciences have brought different areas of study together, such as biology and psychology. This is a point where hard sciences interfaces with humanities. Measuring and interpreting the data obtained is no simple task. The alliance of efforts suggests that a major evolutionary drive of our species was the capacity for socializing. As a consequence for human social needs, came the need to exchange ideas. Although skull shape and brain volume have not undergone any significant changes, archaeological evidence from the period of the Upper Paleolithic creative explosion, around 70,000 years ago, suggests that the ability to communication and use of symbols must have been accompanied by some reorganization of the brain circuitry.

"Some parts of the social mind can be traced back to the earliest mammals hundreds of millions of years ago. Other parts of the social mind evolved very recently and may be unique to humans." [LIEBERMAN 2013]. The social aspect of the mind is also highlighted by Changeux, in his description of the selective ontogenetic development of the neural structures of the human brain, that is, of its evolutionary history [CHANGEUX 2006]. This discussion is at the interface between neuroscience and philosophy. If one wishes a label for the position we are advocating for here it comes: the theory of complementary theories.

All models are wrong, but some are useful. Depending on the question one wishes to answer, one may search for a model better fit to tackle it. For example, even though it

makes it magnetically indistinguishable. After delivering the oxygen to the region irrigated by the blood, the hemoglobin becomes deoxygenated (Hb) and starts to have a highly paramagnetic behavior" which makes it magnetically different from the rest of the brain tissue. Because of the difference between the magnetic behavior of deoxygenated hemoglobin (Hb) and the rest of brain tissues, the fMRI scan is able to highlight the regions receiving greater blood flow than the other regions. [HUETTEL et al. 2004].

[29] Odd-ball is an experiment in which a type of stimulus is presented to the volunteer much more frequently than the odd-ball (80% of times versus 20%, for example). In the odd-ball type stimuli, greater positive activity is registered 300 ms after the stimulus (P300) in relation to the stimulus that appears with greater frequency. Such difference is usually explained due to the forecast error. The fMRI technique tends to produce less accurate data than the EEG technique for time sensitive experiment designs.

is possible, it makes little sense to calculate the position of a car over time by applying relativistic equations, for such a task, classical mechanics provide much simpler methods for finding a satisfactory answer. Understanding consciousness would be analogous to understanding motion. Both concepts, consciousness and motion, are such vague and big concepts that no single theory will be fit for answering all the questions regarding them. Instead of arguing for which is the best theory, we should pay attention to what question we want answered and then search for the theory better fit to tackle the problem. The more theories at our disposal, the greater are our chances to: get feedback and criticism crucial for improving or falsifying the theories; and to find the model best fit to answer a particular question.

Interestingly, investigating the processes involved in creating social connections involves a better understanding of the area of the brain that registers pain. To recreate in the laboratory experiments that arouse in a more salient way the feeling of social pain compared to experiments that arouse social pleasure is relatively simpler. It suffices to play the boring game called cyberball, choosing to which of the two characters displayed on the screen to pass the ball, just enough time to engage in the exchange, after that while the other players exclude the subject from the game, exchanging passes between themselves.

Social pleasure is a more complex emotion to evoke. Not every social relationship we are a part of will bring us pleasure. On the other hand, just being alone for a long period of time – as unfortunately, is the case of a prisoner in solitary regime – will be enough for evoking social pain.

An ingenious way around this difficulty is to compare the pleasure associated with a monetary reward in a non-social context against the pleasure of having participated in a cooperative social relationship that results in a reward of equal value. Using a variation of the prisoner's dilemma, the obtained results suggest that the monetary reward in the context of social cooperation is linked to greater activation of areas of pleasure in relation to a simple monetary reward, without the social cooperation [RILLING 2002].

A counter-intuitive result, however compatible with the previous one, was obtained by comparing three conditions: (a) in which one can choose to make a donation at personal cost; (b) in which you choose to donate free of charge; (c) pure monetary reward. "Interestingly, the ventral striatum (together with the adjoining septal region) was also more active for donations than for pure monetary rewards." [MOLL 2006].

Corroborating the following neo-Darwinian hypothesis:

> Thus, evolutionary pressures may have created internal mechanisms that register being socially cooperative as pleasurable and being ostracized as painful in order to promote the maintenance of group bonds and ensure survival. [LIEBERMAN and EISENBERGER 2009].

From an evolutionary point of view, the ability to experience social pain and plea-

sure makes sense if having such capacity is adaptive to our species, promoting protection and care in the early years of life. The threat of complete isolation, or, on the other hand, the comfort of being part of reciprocal relationships motivates to strengthen social bonds. Seeking to understand how such processes influence the disposition of social groups, it was necessary to develop several techniques to gain access to areas of the brain that are activated while patients are engaged in different activities, in tests designed to stimulate specific mental states. The correct location of brain areas and structures that are activated to produce certain types of sensations [30], perceptions [31] and thoughts can significantly contribute to understanding social cognition, this effort requires a large number of scientists, our modest contribution is to analyze and gather part of their findings.

A study co-authored by Lieberman and Fiske, among others, investigates default-mode network activation.

> Some human brain areas are tonically active in a resting state when subjects are not engaged in any overt task. The activity of these areas decreases when subjects are engaged in a wide variety of laboratory tasks designed to study cognitive operations. It has been suggested that these areas, among them the medial parietal and the dorsomedial prefrontal cortex, may support a "default state" of the human brain. [IACOBONI et al. 1993].

In order to study the "default mode network" a research design was carried out in which participants watched video clips while the fMRI scan recorded each participant's brain activity. "In each scan there were two clips of Authority Ranking relationships and two clips of Communal Sharing relationships." [IACOBONI et al. 1993, p. 6].

As the same region activates similarly for both situations in which the relational model of Authority Ranking is observed and the one in which the relational model of Communal Sharing is observed, apparently it does not depend on the type of relationship. The study of the medial parietal and dorsomedial prefrontal cortices made in the article suggests that these regions, in fact, respond specifically to social relationships (potential or actual) [IACOBONI et al. 1993, p. 11].

The default mode network is associated with mind reading. Mentalizing, or theory of mind, is a psychological process of creating hypotheses about what goes on in the minds of others and oneself. The mentalizing system contributes a distinct set of brain regions that reside along the cortical midline and temporal lobes, including the medial prefrontal cortex, the temporal junction -parietal, temporal poles, posterior cingulate cortex and posterior superior temporal sulcus. A famous paradigm for studying this social capability in experimental psychology is the false belief task.

[30] By Damasio's definition, sensations presupposes awareness

[31] Which can be conscious, or not. Most of the information coming from the perceptual channels does not reach consciousness, because working memory has limited resources.

> We postulate that when an individual is awake and alert and not yet actively engaged in an attention-demanding task, there is a default state of brain activity that involves, among other areas, the mPFC [medial Pre-Frontal Cortex] the posterior cingulate and precuneus. [RAICHLE et al. 2001, p. 682].

Lieberman reckons that the areas of social cognition overlap the areas of the default network. Suggesting that, due to its dominant activation over the remaining neocortical networks during waking hours and even when sleep. "We are interested in the social world because we are built to activate the default network during our free time." [LIEBERMAN 2013, p. 20]. Anthropological recordings suggests a fast growth in human group size numbers, culminating only recently, coinciding with the peak in neocortical size.

> The problem for modern humans is that we have a natural group size of about 150 individuals [...] At some point in our evolutionary history, hominid groups began to push against the ceiling on group size. The only way they could have broken through this ceiling so as to live in groups larger than about 80 individuals [the ceiling for great apes size group] was to find an alternative mechanism for bonding in which the available social time was used more efficiently.
>
> Language appears to serve that function perfectly, precisely because it allows a significant increase in the size of the interaction group. Grooming is very much a one-on-one activity [...], whereas conversation group sizes typically contain up to four individuals. [DUNBAR 2004, p. 102]

Among social animals, The Mammalia class' social complexity stands out. Yet, when it comes to energy consumption, the human social brain invests an incongruous amount of its precious resources navigating social context.

Access to our own thoughts recruits the same areas to access the thoughts of others. The mentalizing aspect contributes to the social extended consciousness. There is no direct access to mental states, even in the mental processes themselves, one relies on the creation of hypotheses about their own motivations, beliefs and desires. Most of the time people get it right, but we can also be wrong about our own intentional states. The ability to appreciate what goes on inside others has given us the ability to do the same for ourselves. Without this mechanism, human consciousness would be much more constrained as far as the inner world is concerned.

You have likely had the experience of interacting with a salesperson who has not picked up on all of your verbal and non-verbal cues, who keeps trying to sell you the product you had never any intention on buying. The mind that cannot estimate its own and others' internal processes wastes resources when it needs to perform tasks that require cooperation and group work.

4.6 Considerations on localism

The debate on whether or not the activation of a specific area of the brain can be related to a function performed runs through the discussions of this chapter. In essence, cerebral localism defends the possibility that, from the perspective of neuroscience, one can point to regions of the brain where the modules responsible for certain functions are found. Traditionally, the neuroscientific literature considers that neuronal sets and areas of the brain are specialized and compartmentalized to fulfill certain functions and not others, with little external interference. However, this position has been problematized by holism, the theory of embodied cognition and the theories of dynamic systems. Brain plasticity is a recurring argument to attack brain localism.

The position of Maturana and Varela tends toward holism. They argue that, in essence, an autopoietic system is one whose main task is the production of a network of processes that, taken as an entire fabric, comprise such a system. The areas work together as an aggregated field that can only be understood by taking their structure into account. All parts of the brain would form an autopoietic network, which cannot be reduced to the sum of its parts, since the structure of the parts would add information that the parts alone do not have.

When interpreting measurements with fMRI, can thoughts be given a literal location in the brain?

Does a thought reside somewhere in the body? A thought has no volume, this apparently led us to believe that thought is not spatially located. In order not to get into a merely abstract discussion, consider the following approach:

One approach, first proposed by neurophysiologist Edward Schmidt, assumes that voluntary motor commands can be extracted in real time from the electrical activity of populations of cortical and subcortical neurons that have been spared by the underlying disease and then used to perform motor functions or by direct stimulation of the patient's musculature or controlling the movements of artificial actuators, such as robotic arms. [RIBEIRO 2007].

In practice, specific and localized area activations are capable of moving a mechanical arm. Even though other brain areas may not be directly necessary for the movement of the arm, the area responsible for moving the arm did not performed the operation on its on. The arm movement depends on visual cues, motivation, etc.

Each movement behavior has a context – an arm movement reaching out for touching another person can range from a comforting gesture to a harassment. Is the identification of the neural activity patterns during social behaviors enough in order to exhaustively explain them? The possibility for similar neural patterns to result in different behavior in different people suggests that complex social interactions are not reducible to the correlate neural activity [STEIN 2017].

The inclination to build social connections is an aspect of the human brain that

contributes to understanding the social mind. Areas that are highlighted in this network are: the dACC - which is related to the unpleasant sensation of pain [EISENBERGER and LIEBERMAN 2004]; and the ventral striatum - which is related to the pleasurable reward system [LIEBERMAN and EISENBERGER 2009]. These two functions are probably the first neural adaptations related to the social aspect to occur during the evolutionary history of mammals. The biological mechanisms involved in the fabric of social connections may shed new light on the nature of human personality and behavior. This effervescent area of scientific interest has profound philosophical implications. We review here some of the literature that shows how human neural circuits stimulate social connection and psychological processes, such as social pain and social pleasure.

4.6.1 Challenges of group life selected primates with good group strategies

Social skills were probably quite important when *Homo sapiens* left Africa to populate the world. We may ask ourselves how social skills emerged in our species.

In the course of their research, the results of which have been well documented and replicated, Eisenberger [32] together with Lieberman [33] collected evidence that leads us to believe that, ceteris paribus, we are inclined to live in groups rather than alone. Observing a group and staying out of it causes activation of the same area of physical pain and has a similar aversive quality. The evidence from the experiment suggests that the fMRI scan can show which regions of the brain are activated due to certain internal psychological processes taking place as they occur.

We must emphasize the exponential expansion of research that correlates psychological processes and neural regions through the use of neuroimaging techniques [OCHSNER and LIEBERMAN 2001]. We inherit from our common ancestor with the great primates, the basis of neural circuits that inclines us to live in society. To such an extent that today, the most plausible hypothesis to explain our encephalization quotient so high compared to other animals would be due to the need for high social cognition for each social group. The classic hypothesis that explained the large size of the human neocortex as selected for greater cognitive capacity has been questioned.

Evolutionary developmental biology compares the developmental processes of different organisms to infer ancestry relationships. The idea behind this approach can be simplified as follows: embryos from different species show similarities and the stages through which they pass keep resemble their evolutionary past [RICHARDSON and KEUCK 2002]. The development of the human being, after birth, repeats stages of

[32] Naomi I. Eisenberger, born in San Francisco, is a psychologist, professor, and director of the Social and Affective Neuroscience Laboratory (https://sanlab.psych.ucla.edu). Awarded with the APA prize for distinguished contributions to psychology. She is recognized for her research into the neural bases of pain and social connection. Eisenberger and Lieberman are married.

[33] Matthew D. Lieberman majored in psychology and philosophy at Rutgers College. He has a doctorate in social psychology at Harvard University. He is director of the social cognitive neurosciences laboratory (www.scn.ucla.edu). Some of his areas of interest are social cognitive neuroscience and the neural bases of social rejection and physical pain.

maturation in the same chronological order of biological changes that occurred in the ancestors from which we descend.

Our social minds have connections that ensure that human beings are inclined to bond naturally and pervasively. The systems that have the greatest contribution to this effect are: the social connection - divided into a seductive reward network and an unpleasant pain network; "mentalizing" - estimating probable intentional states for others; and "harmonization" - which enables the influence and internalization of group beliefs and values.

Neural circuits consolidated through evolutionary tuning introduced fundamental social functions into the brain of our common ancestor. This occurred when mammals, when separated from other vertebrates, over generations, underwent mutations that made them capable of feeling social pain and social pleasure. This changes have deeply linked our well-being with the well-being of our community. The baby manifests the basic need to stay connected. In adult life, the desire to participate in community life is a sign of good health. The innate desire to be with caregivers is necessary to ensure their breastfeeding and protection. This desire changes with growth (new relationships emerge), but the need for social contact is a constant throughout our lives [LIEBERMAN 2013].

The next striking change that was incremented in the social brain of the lineage from which we descend occurred during the emergence of the primate order. A set of mutations enabled the emergence of the potential to better predict the actions and thoughts of those around [34]. As a result, primates with this mutation can better navigate complex social hierarchies. By creating hypotheses about what goes on in the minds of their peers, in certain contexts, the human child ventures more successfully into the realm of social interactions. This mental function is called *mind reading*, the process of attributing psychological states such as goals and perceptions to others [HERRMANN et al. 2007], according to the evidence that our senses provide for analyzing them. This activity is so natural that, not content with imagining the inner lives of people and animals, we often imagine intentions in objects, figures, and even meteorological events.

Only recently (in terms of biological evolutionary history) has the last mutation process pertinent to the social brain occurred. The sense of *self* - the introspection about our own personality and character - gains maturity in pre-adolescence and "solidifies" in adolescence, still retaining a certain flexibility in subsequent periods. According to traditional theories of psychological development, most personality changes take place during the adolescence phase of development. The idea of personality development during adolescence and young adulthood is quite plausible. Psychologists such as Helson and Caspi rely on cohort studies from recent history and the 20th century to suggest

[34] A caveat: without the company of peers and caretakers, during the critical period of infancy, this potential is permanently weakened.

that most personality changes occur during the young adult life stage. Furthermore, evidence suggests that myelination in prefrontal cortex is affected during adolescence exposure to social situations, altering not only brain shape but also function [MAKINODAN et al. 2017, p. 1].

Harmonization ensures that a set of values is widely shared by the community [LIEBERMAN 2013]. In pre-adolescence and adolescence more attention is focused on being integrated into our social circles. This function has only been identified in the human species, it happened more recently along the evolutionary line, and is the last drastic change our brain has gone through in terms of social connection.

"The gift of speech also evidently proves that man is a more social animal than the bees, or any of the herding cattle." [ARISTOTLE 2011]. Even in the light of the more refined description of bee's language [FRISCH 1974], our undeniable greater encephalization quotient [SCHAIK et al. 2021] enables us to convey social exchanges of much higher complexity than any living animal. Aristotle's intuition in considering man as a social animal proved to be quite accurate over time. The evolutionary pressures exerted on our species favored humans social skills. Lieberman points out, with an acceptable margin of error, that the first neural circuit to receive a socialization function, in our common ancestor, is the capacity for social pain. The social pain is responsible for making little or no social contact to be unpleasant. Locating pain anatomically (in the brain) and evolutionarily (in time) was a significant development, but Aristotle's intuition proved to be on the right track. The social relationships forged throughout life, especially before adulthood, produce marks that shape our personality and habits. Based on this perspective, we are animals whose bonds say more about us than any other characteristic, in short, much of who we are is the result of who we are with. As the saying goes, birds of a feather flock together.

4.6.2 Experiments demonstrating that the same areas of physical pain are activated during isolation

Eisenberger et al., inspired by Kipling Williams' paradigm, called Cyberball, carried out an fMRI study of the brain during an exclusion situation. The experimental design utilized for this consisted of the cyberball game, in this virtual pass-swapping game between volunteers and two other "players" (who were controlled by programmed computers, while the real player thinks the other two are also real). When study participants stop receiving the ball from their partners, the scanner detects activation in the brains of these volunteers in the same region that is activated by physical pain. Study participants report feelings of discomfort during testing. This pain is caused by the social rejection felt during Cyberball, even though there is no physical pain stimulus.

> In summary, a pattern of activations very similar to those found in studies of physical pain emerged during social exclusion, providing evidence

> that the experience and regulation of social and physical pain share a common neuroanatomical basis. Activity in dorsal ACC, previously linked to the experience of pain distress, was associated with increased distress after social exclusion. Furthermore, activity in RVPFC, previously linked to the regulation of pain, was associated with diminished distress after social exclusion. [EISENBERGER, LIEBERMAN and WILLIAMS 2003].

There is a neural alarm system for pain. Synapses from several pain-related neural systems converge on the dACC. Activity in dACC is responsible for the unpleasant sensation of physical and social pain [EISENBERGER and LIEBERMAN 2004]. This overlap is a counter-intuitive fact. Yet many people remain skeptical. What should a doctor say to someone who has been rejected? To recommend pain medication for a moderate case of jealously? The mention of this close relationship between physical pain and social pain still casts doubt on common sense. However, contrary to the premonitions that may have aroused, the theory withstood against the empirical tests.

The following experiment was carried out: for 21 days the first group received two pills of 500 mg of acetaminophen (an active formula of Tylenol with analgesic and antipyretic properties) after waking up and the same dose before going to sleep, while the control received the same amount of the same-looking placebo - naturally, without either knowing whether they were taking the real drug or not. It was concluded that the first group showed a significant decrease in the report of feeling of social pain over time, while there was no change in the control group [DEWALL et al. 2010].

Physical and social pain mechanisms coincide in such a way that pharmacological strategies to reduce physical pain are shown to be effective in reducing social pain. Just as strategies to reduce social pain also contribute to reducing physical pain, looking at a picture of a loved one - a romantic partner - mitigated reports of pain, as well as pain-related neural activity [EISENBERGER 2011]. When devising strategies to tackle the problem of pain, we should seek to know as much about it as possible. Knowing that this overlap exists, one can now apply the strategies used to deal with physical pain in the treatment of social pain and vice versa. We must keep it as a warning that we must not underestimate the feeling of social rejection, it has the same disabling potential as any other pain.

Through a meta-analysis with the software Neurosynth [35]. The most probable main function of the dorsal anterior cingulate cortex (dACC) was established. This effort is justified in the fact that other neuroscientific studies claim that the dACC contributes to other psychological processes such as the executive, conflict monitoring and salience processes. By making statistical analyzes of which are the psychological processes that appear most frequently when the dACC region is activated, Lieberman and Eisenberger

[35] Open source project whose project is available for academic use at https://github.com/neurosynth/neurosynth/. The website, created and maintained by developer Tal Yarkoni, introduces the program to interested audiences and provides access to fMRI images and meta-analysis. There are currently 14371 studies in the Neurorsynth three-dimensional imaging database that is continuously fed by researchers using fMRI techniques.

conclude: “Based on available evidence, the clearest account of dACC function is that it is selectively involved in pain-related processes. [LIEBERMAN and EISENBERGER 2015].

This approach differs from the one traditionally applied in fMRI studies. The experimental setup generally seeks to trigger a certain psychological process and observe which region consumes the greatest amount of oxygen during the psychological process. The meta-analysis of this 2015 study explored two directions of approach.

In the traditional approach, looking at the activated region with experiments using the executive, conflict, salience and pain psychological processes (*forward inference* [36]) studies treating all four psychological processes produced at least some dACC activity.

The purpose of fMRI studies is to establish the relationship between psychological processes and the location in the brain that was respectively activated to produce such an effect. The explanation presented in the article that justifies why *forward inference* is not the most appropriate approach for establishing causation: “Just because psychological process A reliably produces activity in region X does not mean that activity in region X in a new dataset indicates that psychological process A was invoked.” [LIEBERMAN and EISENBERGER 2015].

The chapter investigates the role of the dACC, among a range of candidates. It concludes that the theory most consistent with the results available in the Neurosynth database is that the dACC is more involved with the psychological process related to pain in the individual.

The physical pain alarm system, which already played a role in the brains of our reptilian ancestors, possibly came to be used in another way in the brains of the mammalian ancestors as well.

> [...] it is possible that the social attachment system, the system that keeps us near close others, may have piggybacked onto the pre-existing pain system, borrowing the pain signal to signify and prevent the danger of social separation. [EISENBERGER and LIEBERMAN 2005].

The thesis is that the neural network responsible for physical pain was already being used, but in mammals this network gained an alternative function: social pain. Gould [37] was one of the advocates that many of the higher functions of the human brain are unintended side effects. Clearly the exaptation mechanism of the kind he dubbed “franklin” is consistent with the way in which the possible emergence of the network responsible for social pain has been described. “Franklins are not current but

[36] On July 30, 2018 the neurosynth website was updated, the analytical methods named through the terms *forward inference* and *reverse inference* have now been renamed, respectively, as *uniformity test map* and *association test map*. However, we kept the old nomenclature to maintain consistency with the 2015 article by Lieberman & Eisenberger.

[37] New York-born paleontologist and evolutionary biologist. He worked at Harvard University institutions, the American Museum of Natural History and New York University.

unemployed ‘things out there.’ Franklins are alternative potential functions of objects now being used in another way” [GOULD 2002]. A controversial question raised is whether this supports the thesis so valuable to Gould that the higher functions of the human brain (such as human sociability) are a collateral evolutionary consequence, or if a more deterministic view of the evolution of society and human action must be respected. Lieberman mentions Gould’s work, but as far as our research enables, he does not propose to tamper with this wasp nest. The purpose of including this author is just to mention a discussion that is related to the presented topic and that deserves an attention we cannot afford at the present work.

4.6.3 Social pleasure

Analogously to borrowing the brain region that alerts to physical pain to also fulfill the function of social pain, social pleasure have also recycled the reward network responsible for physical pleasure.

> Social rewards activate the same reward network as desirable foods and drinks. Having a good reputation, being treated fairly, and being cooperative all activate the ventral striatum. Strikingly, making charitable donations activates the reward network more than receiving the same sum of money for oneself. [LIEBERMAN and EISENBERGER 2009].

The association is counter-intuitive. The pleasant feeling from the abstract display of generosity does not seem to have the same concrete experience from eating chocolate. Nonetheless, when social needs are satisfied, the brain responds in much the same way as it responds to more tangible rewards. [MOLL, OLIVEIRA-SOUZA and ZAHN 2008, TABIBNIA, SATPUTE and LIEBERMAN 2008, IZUMA, SAITO and SADATO 2008].

Making a donation to charity feels good, but why? After making the decision to donate to charity there was found an increase of activity in the ventral striatum, suggesting that this action promotes pleasure. After all, the ventral striatum activation is correlated with a rewarding sensation of pleasure. From the evolutionary standpoint, the motivation for the expensive behavior of giving resources away may seem maladaptive, but it makes perfect sense from a social perspective. It would make little sense for the group to reject generous individuals, as the group greatly benefits from generous behavior.

This begs to the concept of “disinterested altruism”, since, from the neural perspective, altruism itself causes pleasure. Disinterested altruism crudely means to give away without hope of getting anything in return. How would that be possible? Disinterested altruism is not possible, because the very altruistic deed will immediately cause the ventral striatum to signal, rewarding the behavior. The neural mechanisms predispose humans to perform good social deeds, as the neural regions with physical pleasure were likely recycled to also activate for social pleasure. The pleasure predispose behavior in

a cyclic manner, it does not matter how much pleasure one has already had, its appetite is insatiable. The desire is never fulfilled because it only nurtures more desire. The classical "last bite" mentality that empties the ice-cream jar also applies for doing good deeds.

> If you would like to be selfish, you should do it in a very intelligent way. The stupid way to be selfish is seeking happiness for ourselves alone. The intelligent way to be selfish is to work for the welfare of others. [LAMA et al. 1994].

4.6.4 Relationship between brain, body and social group

The living human body is inseparable from the brain. When the brain is removed from the body of any living animal, both brain and body lose the necessary conditions to recover their original state [38]. Changes and injuries to the brain change not only our cognitive and perceptual capacities, but may also impact vital functions. The brain has mapping representations for the structure and condition of the internal organs [DAMASIO 1999].

The brain-in-a-vat thought experiment commented on by Alva Noë, [39] stands as an argument against the computationalist theory of the mind. Briefly, The dividing line between the skull and the external world is not as clear as the input/output computer analogy suggests, as the line is often difficult to draw and, even if the line could be clearly established, there would still be the possibility of crossing the line [NOË 2009]. In order to understand what we are, it is advisable to think about the interactions between the brain, the body, other people, the environment. Just looking at the brain is not enough. A similar reasoning for when we were discussing how looking exclusively to the gene or exclusively to environment was insufficient, because a gene may only activate under a particular enviromental condition and the particular environmental condition may only alter behavior in the presence of said gene.

> We should always stress the fact that human beings belong to an evolutionary drift in order to be able to explain predispositions and intentions in brain-body-environment interactions (see Maturana & Varela, Clark and Millikan). [STEIN 2012, p. 170].

From the bit of biological evolution covered in this thesis, we can at least see that it was advantageous for our ancestors to add social functions to neural systems that were

[38] The advent of positive pressure tracheal ventilation in the 1950s and cardiopulmonary resuscitation in the following decade led to the concept of brain death. Nenad Sestan mentioned a controversial study in which brain cells from 100 to 200 pigs from slaughterhouses were kept alive for 36 hours with the brain separated from the body. The brain was kept "alive" with the help of pumps, heaters and bags of artificial blood at body temperature. [REGALADO 2018].

[39] The creation of this thought experiment is originally attributed to philosopher Gilbert Harman.

previously only activated by physical pains and pleasures. This is one of the important changes that has increased our ability to form larger, more cohesive groups. In primates there is a direct relationship between the size of the neocortex and the number of individuals that the group supports. The increase in the neocortex made it possible for new opportunities to arise, especially in the social field. An ecological habitat that requires a larger group size is only invaded by a primate species that has sufficient neocortex mass. The size of this area of the primate brain limits the number of possible social relationships [DUNBAR 1992, p. 486].

4.6.5 Discussion

The social brain theory is about our well-being. Understanding the motivations for creating social bonds enables us to devise better strategies to improve the quality of life. The way in which society is established or constituted can be strongly influenced by social interaction. For a long time we had evidence that social isolation can be devastating to children's development, however the underlying neural mechanism was still unknown. The focus on brain circuits that promote social connection is an important academic contribution by Lieberman and Eisenberger.

Scientific research itself would be harmed if it were not for the relative pleasure of gaining a good reputation and the aversion to ostracism. Our work finds itself in a circularity, since its cause and its end permeate the question of social connection. To estimate the extent of influence that social connection has on us is difficult. It may be reasonable to believe that, after the recruitment of the physical pain recording system to also report social pain, natural selection began to prioritize more and more the improvement of our processing capacity in the neocortex. Without the ability to feel social pain, we would be less inclined to form large groups, without large groups, powerful brains would be maladaptive. Only primates with a high encephalization quotient form the largest groups [DUNBAR 1992].

One of the objectives of this chapter is to gather a selection of the available information regarding social connection to contribute with a limited and approximate description of the laws of human disposition that incline us towards prosocial behavior. The multidisciplinary effort aims to disseminate results that may be of interest to the academic community. The social isolation is a major problem that should not be neglected. The social isolation affects differently according to the different groups of social strata, the lower class being at greater vulnerability. It seems advisable to take social pain into account to the sociopolitical theories, better accommodating recent research. Public actions that promote social interaction should be part of the political agenda. A better understanding of the neurological wiring of human social nature may help us to understand that the fragmentation of the society brings harm for everybody, but specially for the poor. Much research is still needed in order to help decision makers

to develop new solutions to face the challenges in bringing people together. Drawing attention to the debate involving social pains and pleasures points for the dangers of narcissism and segregation.

The nature of the human being is to be in society. The Hobbesian thesis - that the state of human nature is the miserable conflict of all against all - finds no support on the research referred to in the present chapter. When looking at the networks of social pains and pleasures, a growing body of evidence is being gathered suggesting that being part of society is something we do according to our natural predisposed desires, fears and needs and not necessarily according to a rational calculus.

The fMRI images reheat questions that already inhabited the intuition of classical thinkers. Today we do not need to be satisfied with just knowing how human beings behave, we can venture more properly into the underlying question of the inner mechanisms at play, prompting human beings in acting in a prosocial fashion. Gradually, the information about which areas of the brain are activated in certain contexts, or to achieve certain purposes is becoming more accessible. The dACC and ventral striatum regions that are related respectively to the sensations of social pain and pleasure that, according to the interpretation present in the bibliography studied so far, can be understood as a central part of the neural circuits of social connection.

After all, what are human dispositions? The question may remain the same, but the means to get an answer are becoming more objective than ever.

4.7 Needing the other, without direct access to the their mind, motivates one to reflect upon himself

During the dream there is activation of the network in a standard way [DOMHOFF and FOX 2015] and even in slow wave sleep there is activation of the Default Mode Network [WINDT, NIELSEN and THOMPSON 2016]. Is there consciousness during this time interval? Such evidence raises a possible problem for Carruthers' theory, for during most dreams and most sleep we are in a state that is called non-conscious.

Usually, we are unable to come up with a theory about our mind in certain dreams because, during such dreams, we have no knowledge that we are dreaming. Default Mode Network show great activity associated with dream during sleep.

Another point to be discussed is that when we are engaged in an activity, there is a deactivation of the Default Mode Network induced by the task [DARIO et al. 2010]. This may help explain why during time-sensitive and intellectual demanding tasks, we often remain unaware of our surroundings and reflections over thoughts. The mind gets caught up in the thoughts themselves and has little resources left for the meta-thoughts.

Social pain is important for us to feel the need for the other. To feel rejected is unpleasant, this inclines us to avoid rejection. Seeking the other enhances our chances for survival. Social pain constitutes an important evolutionary mechanism in the mammal,

which relies in breast milk at the beginning of its life. The newborn mammal depends on its mother. Wanting to be with the mother is a matter of survival for the baby mammal. While it may not necessarily be the case for other species, some birds and reptiles do not necessarily need to create a social bond. Some live isolated and this isolation may even be advantageous from an evolutionary point of view. Having a social life can mean more competition for food. What advantage would a crocodile have for the company of big social group if it were possible to live in a place without less crocodiles competing for food?

Being in society, in the case of humans, is the norm. But there are exceptions.

The phenomenon of voluntary isolation like the report of Ho Van Thanh is very rare. The story of Ho Van Thanh is quite shocking [KO 2015]. He fled the village of Tra Kem with his two-year-old Ho Van Lang after losing his wife and two other children to a landmine explosion. Hidden in a remote area, he alone raised his son, only to be found 39 years later.

The Pirahã tribe, maybe for a similar self-protection reason, are in a region far away from other communities that can only be accessed by ship or plane [40]. Pirahã people share hermetic language, culture and habits [EVERETT 2005].

Only in dangerous situations humans are found in extreme social isolation. Even if living in society eventually causes some suffering and may be stressful, the alternative of becoming a hermit is unattractive for most people. A punishment applied in "solitary" causes serious damage to both physical and mental health [DELLAZIZZO et al. 2020].

Language is a social tool. Otherwise To imagine what other people are thinking, we would have to rely solely in the Theory of Mind – understanding how we think and then projecting ourselves into the context lived by the other people. If this indirect route can be integrated with language, there will be fewer chances for error. Language can be ambiguous, but when language is contrasted with social context the correct meaning usually becomes explicit. Applying chapter 2 terminology: the whole is the sum of the possibilities from the parts minus the integration between the parts. Put a sentence with ambiguous meaning in the right context and one meaning will no longer applies, constrained by the circumstances.

The default mode network contributes to the formation of awareness about intentional states. It makes it possible to generate models to predict the behavior of others, in order to do so, attribute beliefs and desires to others. The same network also enables, as a consequence, the possibility to attribute to ourselves ideas about what internally goes in our mind. As Sartre would say, the look of the other causes us anguish because we

[40] A tribe so isolated that the correct number of its population is inaccurate, approximately between 150 to 250 [EVERETT 1998]. They live in the lands cut by the Marmelos River and almost the entire length of the Maici River in the Amazon and have remained monolingual, even after more than 200 years of regular contact with Brazilians and the Kawahiv. The number is outdated, but, as far as we know, no more recent counting was performed.

do not know what the other thinks. Trying to understand the other, to alleviate the anguish, we end up looking at ourselves. The other people's gaze cause us an uncertainty for we have no access for the thoughts behind the eyes. This anxiety force us to engage in self-reflection, because we have only our own emotions serves as the only parameter for how the other may feel his emotions. To know what motivates the other, one first needs to understand one's own motivations. This is an important aspect of extended consciousness, for it is the source for elaborating all sorts of hypotheses about one's own mental states and the mental states of others. Did our evolutionary past shape our way of seeing the others and ourselves?

When our brain is not engaged in anything in particular it activates the default mode network. The mentalizing network and the default mode network shares almost precisely the same areas [MOLNAR-SZAKACS and UDDIN 2013, HYATT et al. 2015, SPUNT, MEYER and LIEBERMAN 2015, LIEBERMAN 2013, MARS et al. 2012]. Default Mode Network is also activated during dreaming [DOMHOFF and FOX 2015]. Those are the areas in the brain to spend more oxygen, energy and other resources throughout our lifetime (bearing in mind that the brain is the most energy-demanding organ). There would make little evolutionary sense to spend that much resources in Default Mode Network areas were those areas irrelevant for our survival and reproduction chances.

> For example, Hasenkamp and Barsalou (2012) recently identified four different mental states during meditation with each state being preferentially related to activity in different intrinsic brain networks: focus on the present experience was most strongly related to dorso-lateral prefrontal cortex activation of the Central Executive Network, mind wandering was associated with the Default Mode Network, awareness of mind wandering was linked with activation in the Salience Network, and a shift of attention back toward focus on the present experience was again linked with the right dorsoLateral PreFrontal Cortex (dLPFC) and right posterior parietal cortex with both regions being part of the Central Executive Network. [DOLL et al. 2015]

When there is cognitive demand, Default Mode Network is deactivated, while Central Executive Network is activated. Back at rest, Default Mode Network activates and Central Executive Network is deactivated. Salience Network probably plays some role in balancing this shift, inhibiting and stimulating the proper areas accordingly.

Whenever there is some free time, the brain is predisposed toward social thoughts. Thinking about family, friends and ourselves is the brain's comfort zone. Creating theories about what goes on in one's own mind and in the minds of other people is the brain's leisure activity. The mentalizing areas are specialized for Theory of Mind, ascribing mental states, guessing what beliefs and desires may be motivating other people. This neuronal devotion to social consciousness has been evolutionary successful,

no other animal relies more on others' cooperation than humans.

In the case of humans, natural selection favored ancestors that had focused most of their time, resources, and attention on what was going on in the social realm, on what was going on others' minds, as well as their own minds. This suggests that the trial by fire for an individual of our species is how well he can integrates to society. Arguably, no other feature has greatest impact on human fitness than the capacity for being social. One may be incapable (or unwilling) to finding one's own food and shelter and still survive and thrive by managing to get support from others. No other species has an organization of greater complexity (or perversity).

The *Homo sapiens* not only knows how to cooperate, but can reorganize their cooperation. What would be the use of producing tools if they only served the inventor himself? Without receiving the legacy from previous generations and peers, in each generation we would be forced to rediscover by ourselves everything that was already known by our ancestors. We inherit part of the collective memory preserved, from the deceased members of the society. The time and resources necessary to develop and sustain brains as big as ours is no frivolous matter, it seems unlikely that the capacity to share with others came as a mere byproduct. Human social skills were positively selected in our species and poses as a reasonable candidate variable for explaining the volume of our skulls in relation to the volume of our bodies.

Our high encephalization quotient seems to have been selected for, because small-brained apes can only form small groups [SHULTZ and DUNBAR 2010]. Forming large groups was essential to the living conditions our primate ancestors faced in the environment they found themselves in. Having a small brain in relation to body size would reduce our ancestors' chances for survival and reproduction. This evolutionary mechanism describes the selective pressures that predisposed our brain volume to more than double in the timespan of 3.5 million years, which is quite short when considering the evolutionary time scale.

Human development in isolation is no longer a possibility. All great apes form groups, in fact, the best way to predict which primates will form the largest groups is to find those with the highest encephalization quotient [DUNBAR 1992, SHULTZ and DUNBAR 2010].

Social pain unites mammals and the mentalizing network increases the richness of possible social interactions, enabling highly complex interpersonal relationships in which individuals can play numerous roles. Another animal with a high encephalization quotient is the dolphin. The species *Tursiops truncatus* exhibits a rare behavior in the animal kingdom, in which a dolphin can play the role of bringing the shoal to the surface so that other dolphins can hunt more easily [HOPKIN 2005]. To take turns with another dolphin at a later time, as the dolphin scaring the fish away cannot feed at the same time. Having greater encephalization enables one to better understand others and assume special positions that enable a greater range of strategies.

Humans are even capable of empathizing with human and non-human animals. Of all brain areas, the strongest candidate for empathic deficit in the event of injury is the ventromedial prefrontal cortex (vmPFC). We inherit such an area (Brodmann area 10) from the common ancestor of all mammals. A dog empathizes and feels social pain if rejected, because in addition to the area just mentioned, also has Brodmann's area 32, which in humans is called the dorsal anterior cingulate cortex (dACC). The latter is activated both when we experience the unpleasant sensation of physical pain and social pain [EISENBERGER, LIEBERMAN and WILLIAMS 2003]. Opioid receptors densely populate these brain areas. Not surprisingly, a drug such as Tylenol reduces both the reporting of physical and social pain, as well as the activation of such regions [DEWALL et al. 2010] Neuroscientists have several reasons to believe that mammals have the capacity for empathy as well as other basic emotions in a way that is similar to our own. "Based on anatomical and physiological evidence, subcortical structures and even the peripheral and enteric nervous systems appear to make important contributions to the experience of feelings." [DAMASIO and DAMASIO 2016].

Our ability to reflect on our emotions [41], that is, to have feelings [42] of emotions, seems superior to that of other mammals. Damasio maintains that the insula lobe converges information from the bottom – senses, proprioception and emotional states – allowing this information to be later available to upper areas of the cortex. Damasio argues that the access insula has to the subcortical levels is the gateway to the feelings of basic emotions, while the insula access to cortical level relates to and oversees feeling states including cognitive processes, such as decision-making and imagination. In this sense, the insula lobe would serve as a bridge between cortical and subcortical levels.

It seems that we have more ability to reflect on our own internal states than non-human animals, yet we share the same basic emotions and the basic social pain network with our mammal relatives. There are no other areas spending more time active than the Default Mode Network, the same regions recruited by the Mentalizing Network [LIEBERMAN 2013], responsible for giving us access to our own feelings and thoughts, as well as the feeling and thoughts of others.

4.7.1 Priming and social behavior

Because we are more often exposed to our own name, a person is more likely to hear one's own name more than any other name. The frequent association of "Juliet" after hearing "Romeo and" means that the name Juliet is primed after hearing the name "Romeo", the association makes the memory of a name more likely to be accessed

[41] Emotions are automatic responses in the body, E.g.: pupil dilation and increased heart rate due to the increase in adrenaline after seeing a dangerous snake in front of you. Allow a quick reaction. They can occur in both the body and the brain.

[42] Feelings do not happen immediately and are based on emotions. We could call them "meta-emotion" . E.g.: realizing the emotions that seeing the snake provoked in you. They allow you to reflect on mental states. Occur only in the brain.

as compared to the name "Juliet" in other contexts. Priming is an effect in which an individual, after having been exposed to a certain type of stimulus or engaged in a certain activity, is more likely to change his judgment, perception and even behavior in a specific manner [HARRIS, BARGH and BROWNELL 2009, DIJKSTERHUIS and BARGH 2001, DOYEN et al. 2012]. The context in which we find ourselves changes our way of looking at situations, after leaving the context, however, this effect it had on us disappears in a short time. As time passes, the effects of priming are replaced by the effect of frequent associations to which the individual was chronically exposed in his past [BARGH, LOMBARDI and HIGGINS 1988]. E.g. Asians are generally told more often in their context that cooperation between individuals and co-dependency are important, while Americans, on average, are more exposed to the appreciation of independence and freedom. This priming predisposes most Asians and Americans to have different ideals regarding society's organization. Human beings tend to harmonize with the values of people around them. We often internalize the moral values from our social context.

We have all been chronically exposed to our own name, which makes it stand out more easily to our conscious access compared with other names. In Brazil Daniel, Gabriel and Matheus are, on average, more recognizable names, when compared to Zon, Chen and Xing. In Taiwan, on the other hand, the inverted claim would be true.

Frequently observed associations are more likely to become conscious. In social psychology, desensitization is a treatment or process that lessens the emotional response to a negative, aversive, or positive stimulus after repeated exposure to it. In the evaluation of the influence of the environment on the behavior of an individual, it may be illustrative to look at the stressful working environment of animal research laboratories and animal shelters. By actively engaging in the euthanasia procedure on Nonhuman Animals, the likelihood for veterinarians in such working environments to develop Perpetration-Induced Traumatic Stress (PITS) [43] [BENNETT and ROHLF 2005] is statistically more prevalent. Analogous to being primed to one's own name by being repeatedly exposed to it, the environmental exposure can predispose many different sorts of behaviors.

The most unwanted disturbance caused by traumatic fear memories is post-traumatic stress disorder in which a given episode or series of episodes (death threat, torture, sexual assault, serious injury, extreme danger) becomes virtually impossible to get rid of, and the sufferer experiences recurring flashbacks of a "bad" memory, avoidance, and extreme anxiety for months after the event(s) at non-chosen times. Post Traumatic Stress Disorder is more common in women, very common in war veterans, and uncommon in children. It makes a regular life impossible or at least extremely difficult.

[43] Also known as "moral stress", this disorder is distinguished from Post Traumatic Stress Disorder (PTSD) not because they are subject to the traumatic situation, but are actively causing the trauma in others. [MACNAIR 2002].

Post-traumatic stress disorder belongs to the category of anxiety disorders along with panic and phobias.

Empathic capacity may be strained when the very area that should be recruited in a context evocative for empathetic emotions, is chronically inhibited. The conditioning necessary for an individual to get used to an environment that would normally bring repulsion, requires the areas related to empathy to be actively inhibited. Successive training repetitions reinforce the behavior [IZQUIERDO 2002]. Eventually, with successive repetition of the repugnant stimulus accompanied with a dull behavioral response, may gradually predispose the same response in the future when confronted with similar scenarios.

It does not suffice to understand the brain areas, one also has to understand the context such brain areas are embedded to. Consistently, it does not suffice to understand the human dispositions, one has to understand the immediate context and the long term context each person has been exposed to.

4.8 Conclusion

To ask oneself about the meaning of life can provoke such a profound crisis of the ego that may lead to suicide, definitively ending any chance of reproduction or to care for any eventual descendants. But this is maladaptive behavior probably came as a side effect brought by the same change that drove the increase in social and cognitive capacity in our species. We populated every continent, that was only possible through human social cooperation. As a drawback, along with the Default Mode Network, came the angst of not knowing what is going on inside other people's, along with the existential doubts.

An approach to describe the acquisition of the ability to think about one's own and others' beliefs and thoughts suggests that it would be unfruitful to look for explanations in what lies beyond our ability to measure. A naturalized and transdisciplinary perspective seems to be the most adequate tool for probing on the problem of knowledge acquisition [PAPINEAU et al. 2016, STEIN 2014].

Maybe, there are those who doubt: "to what extent do the laws of nature impose themselves on human beings?". Human alterity allow us with power to say no [44], enabling us to transcend the natural limits in a qualitative jump [RUIZ 2016], such a perspective points out how narrow the deterministic idea that human behavior would be the inexorable result of the natural laws.

We should recognize the limitations of the interpretative power of our hypothesis confronted with this alternative hypothesis. No matter how many different areas of knowledge we study and to what depth, the knowledge we have will always be infe-

[44] The "potency of no" is a concept of Giorgio Agamben. In short, This concept means that, even though a human being is able to perform an act, he can also decide not to.

rior to the knowledge we do not have. We can always suspect that there may be, in us, something more than what we are capable of measuring with the available tools. Let us conjecture about the scenario in which we are wrong, that there will always be something about human dispositions outside scientific scope. An unobservable entity can only be valuable to a scientific model if it influences the behavior of observable entities. The perspective of interactionism holds the existence of a two-way communication between the mind and the body, where mental states are the result of brain states and that mental events can influence the brain [HERGENHAHN and HENLEY 2013]. Even though science has no tools for measuring the mind, if, through a model of the mind one would be able to predict changes in the brain, this would be a useful model. Scientists goal would be to contrast the model's predictions to the measuring of brain activity. This approach may circumvent some of the difficulties faced by Descartes when explaining how mind and body interacted.

The Integrated Information Theory is neither a dualistic theory, nor a reductionist theory. Not dualistic because it expresses the impossibility for the whole (mind) to be greater than the sum of its parts (body). Not reductionist because it stresses that the whole (mind) is not a simple linear sum of its parts (body). This chapter focused on the social aspect of extended consciousness. In this chapter, integration plays a specially relevant role. To socialize is to become integrated with others, the more integrated with are with our peers, the more constrained our behavior will be in order to harmonize with the behavior of our peers. Freedom, on the other hand, is lonely: one can do as one wishes because there is nobody else there to judge. The integration versus freedom paradox may be at the root of many conflicts faced by societies. Chapter 6 will discuss how humans manage to navigate through the dilemas brought from being social. But we will not be ready yet to discuss such abstract concepts. Next chapter will introduce us to the interface between our brains and what lies outside.

5 Perceptual Consciousness

By applying the methodology of bibliographical review, we begin by discussing Prinz' proxytype theory describing the roles played by concepts and perception during knowledge acquisition. Prinz recognizes critical difficulties faced by his proposed theory and suggests for an alternative theory that could overcome said problems. Being less optimistic, we intend to explore the difficulties a little further. Facing the historical schism between empiricism and rationalism, it seemed natural to ask: does the scientific evidence suggest a preferable theoretical framework for describing how knowledge acquisition occurs? In order to contribute to this discussion, we review some of Prinz' theory and present a few considerations about perception.

5.1 Introduction

The contemporary philosopher Jesse Prinz argues for conceptual empiricism, presenting us with a starting point for our discussion. In order to set his goals, Prinz proposes a language desiderata: Scope, Intentional Content, Cognitive Content, Acquisition, Categorization, Compositionality and Publicity. After reviewing the major adversarial theories and critics of empiricism, he presented his alternative, arguing it adequately satisfies the language desiderata thus proposed.

Conceptual empiricism is the temporary step stone for section 2. Section 3 is about some problems faced by proxytype theory, promptly acknowledged by Prinz. In section 4 we problematize data neutrality. The focus in section 5 regards innate knowledge in animals.

Although we see strengths within proxytype theory, the enthusiastic optimism about empiricism seems exacerbated. Has empiricism satisfactorily dealt with the criticism it received? A compromise between empiricism and rationalism may prove to be the parsimonious (and unexciting) way out. We are not as convinced that neurological evidence favors exclusively empiricism. Reentry loops [LASHLEY 1933, LASHLEY 1933], neural integration and degeneracy are well known processes. The evidence discourages the possibility for neutrality during data collection by the sensory system organs.

One of the main banners of proxytype theory is multi-modality. Some regulation between modules is presupposed, or else - in absence of control - conflict between sense modalities would likely rise. To coordinate senses in a coherent narrative, bottom-up information flow has to be integrated to a dynamic network.

5.2 Proxytype theory

P2 First, let us disambiguate intentional content from cognitive content. Such similar items on Prinz's desiderata may be confusing, if we carelessly proceed. "To say

that concepts have intentionality is to say that they refer, and those things to which they refer, I call their intentional contents" [PRINZ 2002]. The same referent can have more than one name for it. The "morning star" and the "evening star" are different names for referring to planet Venus. Both contain the same intentional content. As a workaround to that, Prinz includes cognitive content in the desiderata. "Cognitive content is what enables two coreferential representations, be they terms or concepts, to seem semantically distinct to a cognitive agent." [PRINZ 2002]. The cognitive content depends on the terms uttered. Two different words may refer to the same thing, but their cognitive content is different.

The proxytype theory got its final form from different theories. It can be summarized as this idea: "concepts are mechanisms that enable us to enter into perceptually mediated, intentionality-conferring, causal relations with categories in the world." [PRINZ 2002]. To overcome abstraction and imagism, Prinz proposes a superposition. The multi-modal senses can superpose themselves to compose concepts. The same concept may have more than one modality contributing with some aspect regarding the concept.

Traditionally, concept empiricists have been imagists. They identify concepts with conscious picturelike entities that resemble their referents. [...] To bring concept empiricism up to date, one must abandon the view that concepts are conscious pictures. Contemporary cognitive science helps in this endeavor by identifying a rich variety of highly structured, unconscious perceptual representations. [PRINZ 2002].

According to Prinz, traditional imagism does not have enough advantages to balance out the serious flaws plaguing it. Consider the following desiderata requirements and how poorly they are satisfied in the view that "concepts were to be identified picturelike entities": scope - not every concept can have a image correlate; intentional content - some images are ambiguous, rendering reference to two or more different objects; categorization - in order to retain a mental image one is required to minimally specify some features, cannot be generic enough to facilitate the demand for categorizing objects; publicity - no person has exactly the same images for the same objects, and each person develops one's own private imagery; compositionality - combining simple pictorial elements can produce some complex objects, but not all of them, some objects may not be produced exclusively through the use of the combination of images.

Proxytype theory is presented as a theory for knowledge that overcomes the view in which concepts are simply picturelike entities. Prinz, while affiliated to empiricism, claims that the classical version of imagism, often defended by traditional empiricists, oversimplifies the operations required for generating concepts.

After criticizing other previous approaches to describe concept generation, one has to present an alternative explanation. As there are more academic studies on the subject, the reasonable move was to focus on the visual representations. Inside the visual modality there are further divisions on the group cells that have different functions.

> Electrophysiological studies of monkey inferior temporal cortex (IT) may help to resolve the debate. Cells in different parts of IT have different response properties. Some respond to two-dimensional forms, while others respond to three-dimensional forms [...]. Some respond to whole objects, while others respond to object parts [...]. And some respond to objects from a particular viewpoint, while others respond to objects from a range of viewpoints. [PRINZ 2002].

We may take it as evidence suggesting the use of mental cortical representations specifically responsible for the natural kinds. As discussed, perception is sensitive to some particular stimuli. The IT cortex seems to decompose the visual world into smaller parts.

One could say that, regarding the data analysis performed by IT, rules for analysis and synthesis are implemented. The pattern identified in monkey IT cortex supports the hypothesis of complex visual data being decomposed into simpler parts. After such analysis the information must, at some point, be grouped together. This final part of synthesis is not supported by the evidence found on the monkeys, as far as we can tell, but synthesis must be entailed by analysis. Otherwise monkey perception (and we have no reason to believe human perception is that much different) would be a confused patchwork of insulated two-dimensional and three-dimensional representations.

Reasonable amount of evidence in favor of the dorsal and ventral streams hypothesis, directed from the visual occipital lobe forward into the parietal lobe and temporal lobe, respectively [GOODALE 1991]. Visual information is divided into two main categories: guidance of actions and recognizing where objects are in space (dorsal); and object recognition and form representation (ventral). There is evidence for interaction between both streams.

Neurons in both streams encode 3D structure from binocular disparity, synchronized activity between parietal and inferotemporal areas is present during 3D structure categorization, and clusters of 3D structure-selective neurons in parietal cortex are anatomically connected to ventral stream areas [JANSSEN, VERHOEF and PREMEREUR 2018].

This supports local penetrability between dorsal and ventral streams. Penetrability between modules challenges the bases for justification humans often take for granted. Considering that our world model influences perception, it raises some worries that the things we see, hear, smell, are not out there, but are biased and internally constructed. Epistemology has to take such lessons into account [LYONS 2011], 2011). We are not passively gathering data from the concrete world as the naïve realism would suggest.

Superposition gets into action when we want to recall a certain concept, when confronted with a stimulus: “What information in our memory networks can contribute to detection? The answer is ‘All of it.’ ” [PRINZ 2002]. Instead of abstracting or only imaging, the brain would employ multi-modal groups of cells to call upon any concept. The dog’s smell, its bark, appearance, behavior... Briefly, any generic component

feature one would most likely find in dogs may call upon the concept of “dog”.

The absence or presence of other characteristics may or may not enable the incoming external input to excite the multi-modal dog detectors, delivering enough electric signal in the presynaptic cell to surpass the threshold potential, neuronally tagging it as pertaining to the “dog” class, with as much confidence as it was plastically calibrated to tell. Naturally, the above picture is a simplified caricature of what is really going on.

Indicators and detectors are two different models to receive external stimuli and process it with, respectively, less and more accuracy.

Detectors, unlike indicators, are often structured. Their parts detect parts of the things that cause them to be engaged. A detector for the letter R might have one part that detects straight lines, one part that detects semicircles, and a third that detects angles. An indicator for the letter R has no interpretable parts. If one hopes to find structured entities that are compatible with an informational semantic theory, detectors are the obvious choice. [PRINZ 2002].

If concepts use long-term memory, they would hardly intertwine between themselves. On the other hand, if concepts use working memory alone, a great deal of information required to conceptualize would not be accessible.

> [I]t would be better to say that concepts are mental representations of categories that are or can be activated in working memory. I call these representations “proxytypes” because they stand in as proxies for the categories they represent. [PRINZ 2002].

Prinz’s answer to the puzzle draws a compatibilism between long-term memory and working memory. Everything in our long-term memory could, in theory, be accessed by working memory. While they do not belong to neither long-term nor working memory, proxytypes connect the working memory to the long-term memory. This enables superposing concepts: two concepts can be linked to the same object, as the boundaries are foggy.

One item of desiderata was publicity. Mutual understanding can be achieved, “[i]f the dog proxytype I form on an occasion differs from the one you form, we may still be able to communicate in virtue of the fact that we are both thinking about the same class of things.” [PRINZ 2002]. While holding different views of what may represent the concept at hand, as our knowledge comes from the same external source, eventually the confusion will be dispersed.

Synthetically, Prinz states that, in some cases, we form public proxytypes because we are referring to the same class of things. Each individual will eventually form proxytypes according to biological proneness, stimuli exposure, social learning, etc. The difference basically resides in the fact that while the standard picture deals with ”concepts” and “words” Proxytype theory explains in terms of “proxytypes” and “class of things” Prinz states that the term “word” has a different meaning than “class of things”

> The usual assumption behind these experiments has been that these words correspond merely to classes, either exact, or perhaps built on paradigms or exemplars. I will argue that most of these common nouns stand instead for what I will call "real kinds," real kinds being natural units that are not defined, as ordinary classes are, merely by the fact that the members possess common or overlapping properties. [PRINZ 2014].

The context variability is used as an argument to defend proxytype publicity: "First, contextual variability may actually facilitate proxytype sharing. Contexts often place strong constraints on proxytypes." [PRINZ 2002]. We form different proxytypes in different contexts, and it would be easier to recall the correct concept when in the right context. Language is context sensitive, the same phrase can have different meanings uttered in different scenarios.

In proxytype theory there is no claim that features must be exactly the same for both locutor and interlocutor:

This concern can be met by relaxing the publicity requirement. Rather than demanding strict identity between default proxytypes, we can settle for similarity. If you and I agree about the most conspicuous walrus features, then we understand each other when we use the word "walrus," and we engage in similar walrus-directed behaviors. If the publicity desideratum is intended to explain such examples of coordination, a theory that predicts considerable conceptual similarity will suffice. [PRINZ 2002].

The most remarkable features are taken into account, while the less noteworthy features are deemed irrelevant. The interlocutor and locutor may disagree in some minor detail, but they can still grossly understand each other because the essential represented properties are shared.

Superordinate and basic-level are key concepts in proxytype theory. While basic-level composes things like "dogs", "cars", and "screwdrivers", superordinate is built from a group of basic-level files. The superordinate "vehicle" is composed of basic-level things like "cars", "boats" and "planes". As proxytypes are derived from perception, basic-level categorization bears advantage over superordinate categorization. One reason for that is because the basic-level enables for better checking for shape similarity than the superordinate level.

There can be no superordinate concepts without basic-level foundation, "That would explain why basic-level concepts are acquired before superordinates. It would also explain why we are faster at basic-level categorization" [PRINZ 2002]. An important argument supporting proxytype theory. Another reason for this differentiation between superordinate and basic-level is the fact "our perceptual systems discern gross shapes faster than fine details" [PRINZ 2002]. The core of proxytype theory relies on the perception affording to build up basic-level building blocks for the concepts. Simple concepts can cluster into unified compositions of higher complexity.

The idea of language meld together from basic perceptual representations compos-

ing more complex themes is appealing. As my eyes can see and my ears can hear, the many networks are recruited for decomposing the external stimuli into more basic components in representing the stimuli. As one is capable of identifying its instances in the external world, the same areas may have been recycled for being activated "as if" one was really detecting the visual or auditorial stimuli. The activated thoughts would mimic those stimuli and internally simulate sounds and images that can be combined as building blocks to form compounds. Blind and deaf from a very early age (19 months old), Keller reported that instead of internal sounds and images, tactile impressions populated her mind.

> In all my experiences and thoughts I am conscious of a hand. Whatever moves me, whatever thrills me, is as a hand that touches me in the dark, and that touch is my reality. [...] The delicate tremble of a butterfly's wings in my hand, the soft petals of violets curling in the cool folds of their leaves or lifting sweetly out of the meadow-grass, the clear, firm outline of face and limb, the smooth arch of a horse's neck and the velvety touch of his nose—all these, and a thousand resultant combinations, which take shape in my mind, constitute my world [KELLER 2004].

Internal representations matching only the accessible modalities suggests perceiving the world through senses may serve as the foundation for language acquisition. At some point along the child's brain development, linguistic consciousness seems juxtaposed with perceptual consciousness. But later language distinguishes itself from perception.

For example, lacking the infrared perception is probably the reason why no language has a specific word for infrared "color". If we would simply add the physical properties of infrared to the human perception, "infrared" could have its own word with no radical "red" in it. Our hypothesis is that the reason why "infrared" wave is not a good enough candidate to have its own word is because of the integration between the physical properties of light and the biological capacity of our eyes. Human language is constrained by the way the physical world present itself to us and the way our perception works. Most snakes' eyes can detect infrared, in a possible world of talking snakes, the infrared "color" would probably have a proper specific color name in snake language. Proxytype theory is a promising theory as its main strength relies in explaining how we incorporate the sensorial information into concepts. However, the weakness of proxytype theory comes when explaining the possibility for entertaining abstract concepts, because abstract concepts are not constrained by what is directly observable.

5.3 Difficulties faced by conceptual empiricism

"Essentially, all models are wrong, but some are useful." [BOX 1976]. The proxytype theory is no exception. Its main limitations comes from the trouble it has on explaining the knowledge acquisition of abstract concepts. A dangerous downside for the proxytype theory is its limited scope. It is a downside for empiricism as well. The approach discussed so far seems unfit to incorporate categories of concepts that cannot be directly perceived:

First, there are of concepts designating unobservables. These include concepts of hidden relations, such as *causation*, and concepts designating things that exist but are too small to perceive, such as the *electron*. "If such things are truly unobservable, there seems to be no way of representing them using perceptually derived representations." [PRINZ 2002].

Concepts are derived from perception in the empiricist model. If it is impossible to have access to an entity via perception, then the empiricist model is unable to explain how a concept has been derived. Consider the electron example, it has properties we can measure, such as charge and spin. We can detect indirectly if a single electron passed a slit or not. In a cathodic tube we can see with naked some particular electron beams. We can painfully experience the flow of electrons on our body. However, a single electron is not directly observable. We can only detect it with specific equipment. A singular electron is impossible to consciously perceive with our natural senses.

For the empiricist theory to tackle the abstract concepts of our society is not an easy task:

Concepts such as *truth*, *virtue*, and *democracy* are too complex and too abstract concepts to be represented through sensorial images. The instances of such concepts do not exist in the perception realm. On the contrary, are deeply nested in some theoretical background [PRINZ 2002].

The category of abstract objects is problematic to explain within the empiricist framework. "Abstract nouns designate actions (kiss, work, exit, tiredness), state and quality (pleasure, beauty), considered out of the beings, as if they had individual existence." [BECHARA 2009].

Some abstract nouns cannot be directly observed. Democracy, for instance, is a concept we have trouble grasping with any of our senses. We have no concrete object to point out and say: "Democracy, look, there is it", only by inferring from other cues and relations we may identify a possible instance of democracy. The same difficulty is present in the attempt to perceptually conceive mathematical quantities and logical operations:

> The concepts adverted to in formal systems are also frequently cited as counterexamples to empiricism. One class of formal concepts derives from logic. [...] These include concepts for individual numbers and concepts

> used in performing calculations. Mathematical concepts are so abstract that they seem to resist representation within perceptual media. [PRINZ 2002].

The number on itself, not linked to a specific amount of objects, is intangible. There are some instances of numbers that are available to experience. However, no human has the perception required to visualize absurdly huge quantities (e.g. google-plex). We have no perceptual access to huge numbers and that is true even for real numbers, not to even mention imaginary numbers. Hugely necessary in math and physics - imaginary numbers are, by the mathematical definition, impossible to experience through the senses. In the acquisition of knowledge about imaginary numbers, perception would hardly be the first source. The best case scenario for empiricist theory to describe mathematical learning, is that at some early phase, children learn to count with the help of countable objects (their fingers, etc) as a temporary crutch that will later be displaced to a more abstract region.

Victor J. Stenger, a physicist and astronomer writes:

> One often hears that science should concern itself only with what is directly observable. Here we have a situation in which the wave function inside the barrier describes a particle with nonphysical, imaginary momentum. Such a particle is unobservable. Yet taking its mathematical representation seriously enables us to make calculations of tunneling probabilities that can be compared with real measurements, such as the decay rates of nuclei. [STENGER 2006].

Unobservable entities play a significant of physical models, not as fundamental entities, but as tools for describing observable phenomena. Without the nonphysical, imaginary momentum added *a priori* to the theory, different results would entail. The model of quantum tunneling requires the used unobservable entities to explain nature. Somehow, including unobservable entities may be necessary for our theory o knowledge acquisition. Otherwise, the theory's scope desiderata would have to leave out any abstract concept.

Four-dimensional space: another challenge. Math is not limited to real world experience. Therefore no limit of dimensions constrain geometrical mathematical objects. To explain how, for instance, the concept of a tesseract (hypercube) would occur empirically, would require the visualization of an object that cannot exist in our ordinary 3-dimensional space.

No shortcoming of problems for the empiricist concept model to deal with: "concepts of fictional or nonexisting things. We have concepts of phlogiston, unicorns, fairies, ghosts, and gods, even though none of those things exist." [PRINZ 2002]. Fantasies and dreams have no necessary ground on reality, nor previous observation.

One could try to avoid the dificulty of the empiricist theory in explaining the fictional repertoire would be to consider it to be referring to the experience of being told

such stories. But the story's creator himself cannot have experienced it himself. Somehow the storyteller bootstraps the fiction out of the air. Arguably one could insist in this argumentative line by stating that concepts for non-existing things have properties derived from real things (the unicorn has the body of a horse added with a single horn on the forehead). The drawback being it would entail that experience is the source for an infinite number of hybrid beings. Paradoxically detecting the undetectable.

Puzzlingly, Prinz tirelessly defends the empiricist theory. Arguing for a theory of causation, he appeals to bodily knowledge: "In explaining concepts of causation, this argument does not undermine my appeal to bodily knowledge." [PRINZ 2002]. A sense of necessity brought on by frequent co-occurrence. Recordings utilizing fMRI technique corroborate the premotor cortex contribution to semantics. There is evidence that reading an action verb with literal meaning recruits the same parietal areas related to the specific parts in the body required for performing the action [AZIZ-ZADEH and DAMASIO 2008]. Damasio – in a different context nonetheless – also argues that humans make use of mental representations in a bodily fashion. Representantionalists are seldom favoring the embodied cognition framework, as the embodied mind is a recurrent argument brought by anti-representationalists against the necessity for representations (examples of this [CLARK 2000, MATURANA 2014].

Measuring the gaze duration time of 27 week-old infants exposed to animations of objects moving in ways that would violate, contrasted to the ones complying, causal relations, researchers were able to demonstrate that toddlers were more attentive (should we daresay stupefied) when watching little boxes colliding in bizarre patterns, compared to the logical ones [LESLIE and KEEBLE 1987]. The "bodily knowledge" explanation seems like a long shot, because it requires toddlers to have been born with it.

Let us discuss methods for knowledge acquisition. Humans do not seem to passively gather information from the senses. At least, some induction laws have to be respected in order to access the data that comes to the senses. Some logical rules are embedded, no matter how ordinary and random the processes may be.

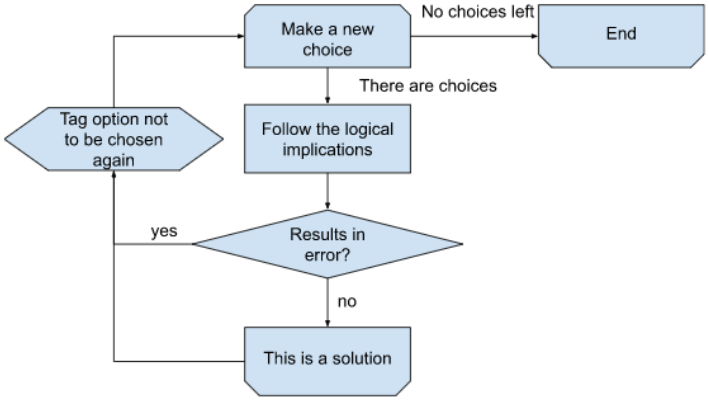
5.4 Discussion over the process of data collection

Life may be taken as if it came out of the result of an old evolutionary algorithm iterated from one generation to the next. An algorithm is a set of logical rules that, when correctly applied, will generate some output. Empiricism relies on some method for collecting information about the world.

When confronted with a maze, a logic puzzle, or a dilemma one can choose to adopt the algorithm called Ariadne's Thread (AT) in order to search for the solution. Ariadne's Thread method is an effective approach when there is no way to discern beforehand what arbitrary choices are more likely to produce the desired outcome.

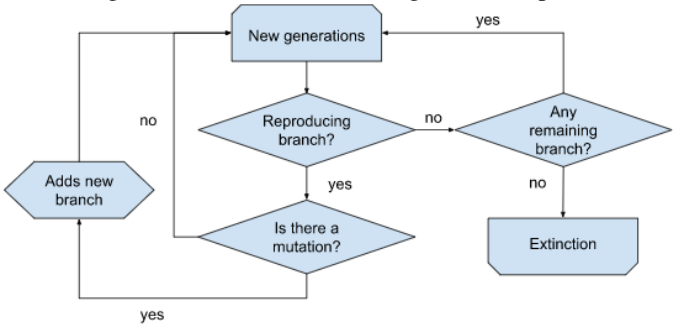
Figure 4 presents a flowchart of the AT algorithm:

Figure 6: Ariadne's Thread flowchart



The depicted algorithm is for primary choices. In the case of embedded secondary choices the algorithm recursively contains an adapted copy of itself as a subroutine inside the "Follow the logical implications" box, incorporating the bifurcation inside the algorithm. The same goes for tertiary choices and so on. We depicted the long version of the AT, exhausting all available routes. A less complete one would stop as soon as first confronted with a solution. The long version above will find all solutions to the problem, if there are any solutions. It seems useful to compare the AT algorithm to the biological process of natural selection (NS). The Fig. 5 depicts a simplified flowchart schematically describing how new species are created and get extinct:

Figure 7: Flowchart for the origin of new species



Ariadne's Thread is an artificial method, while natural selection is observed in nature. Even though there are differences, there are also some similarities. Both flowcharts explore multiple possibilities. The outcomes for the satisfaction of the criteria: in AT (does not result in error) means a solution was found; in NS (the species reproduces and consists of a new mutation) means the origin of a new branch.

AT and NS both rely on repetition. Due to the logical constraints built inside the

algorithm, there is bias over some choices/generations. There is this common misconception that automatic processes are neutral, but this is not the case for both AT and NS. Similar patterns are observed both in artificial and natural structures.

The invention of the lamp was no easy task: "Nearly a dozen inventors were working on incandescent lamps during the 1870s" [FERGUSON 1988]. Thomas Edison had many "bugs" (as he called them) in his lamp. The method he used could not be the AT, as it would be impossible to try every possible combination of materials until he found the correct one. Here he probably utilized an improved version of AT, called Trial and Error (T&E) method - the new information collected from previous tries guides the decision for the next candidate to be chosen.

Edinson, and other scientists, tried many materials in the filament before coming up with the carbonized bamboo solution. If there was a theoretical way to arrive at the right combination to produce a workable electrical source of light, it did not occur to anybody working on the problem. Other technical problems are involved in the making of a filament light bulb, but we are already discussing way more physics than it would be advisable for our purposes.

Biographers describe the history of Edison's method as follow:

The authors sensibly conclude that the "real" process of invention involves common sense, experience, whatever knowledge and news the inventor can gather, and willingness to learn from failure; all of these build to the lucky guess that yields a workable solution the inventor had been groping for. [FERGUSON 1988].

A possible interpretation for the highlighted "experience" and "willingness to learn from failure" is to relate them to the T&E method. While it would not be feasible to try out with every known material, every try enriched the tester with knowledge. After producing an error, similar materials could be discarded, in the pragmatic and heuristic method of T&E, while the AT method requires testing every material available.

The structure applied to the modern version of the incandescent lightbulb filament is fascinating, it forms a coiled coil. Maximizing the length of the curled filament in the limited space. It results in a higher resistance, which is a desirable physical property in an incandescent lamp.

Recurring patterns occur in various different contexts [STEVENS 1974, GLEICK 2011]. The filament of an incandescent light bulb is a coiled coil, DNA on the nucleus also forms the same structure, named as supercoil. If the DNA were stretched out the DNA would come out to be around 2.2 meters, impossible to fit inside the 5-10 μm size of the cell nucleus. For storing information packed on a very small package, the loops inside loops in the DNA structure optimizes the amount of information stored in a limited space. Natural DNA formation does not belong either to empirical or rational approach because this human distinction does not apply to spontaneous phenomena. The biological DNA structure is a crucial component brought about through NS, and at the same time, the packaging of DNA determines how available a specific gene is going

to be transcribed into RNA in order to be translated into protein [ALBERTS 2002]. The evolutionary older prokaryotic nucleus has a “less coiled” structure compared to the more recent supercoiled eukaryotic nucleus.

Coincidentally, NS and T&E share the supercoiled solution to the problem of packing a long string in limited space. The mentioned example suggest how solutions may be constrained by the features of the problem independent from the means that brought the solution. Back to the learning acquisition of abstract concepts, a purely empirical method seems ill-fitted for predicting the possible constraints faced when applying a theoretical solution.

5.5 Innate (capacity for learning) ideas

A recurrent argument against empiricism relies on the concept of innate ideas. The next quote summarizes the classical rationalist positions on the topic:

This was their belief in innate ideas and principles. Greek logic was wholly deductive, and this raised the question of first premises. First premises had to be, at least in part, general, and no method existed of proving them. The Stoics held that there are certain principles which are luminously obvious, and are admitted by all men; these could be made, as in Euclid Elements, the basis of deduction. Innate ideas, similarly, could be used as the starting-point of definitions. This point of view was accepted throughout the Middle Ages, and by Descartes. [RUSSELL 1945].

Many concepts of modern physics defy luminously obvious intuitive principles. Abundant examples: special and general relativity, duality wave-particle, quantum tunnelling, chaos, etc. Orthodox Science sometimes turns out to be misleading, the same goes for commonsense. The concepts brought by 20th century physics are not innate, if that was the case, they would flabbergast nobody. Classical mechanics itself broke havoc to traditional ideas held in middle-age Europe. Newton’s Three Laws of Motion were only deduced in the 1687 Principia Mathematica, drastically defying Aristotle’s motion theories. For almost two thousand years, Aristotle’s mistaken motion theories were taken for granted.

Biological evidence shows that certain animals are predisposed to imprint specific knowledge from birth. For instance, how to gather information from watching the stars movement in the night sky.

> [...] Indigo buntings’ learning which part of the night sky indicates north. This matters crucially to Indigo buntings, for they migrate over 3500 miles each spring (north) and fall (south), and they navigate by the stars. Because the earth tilts back and forth on its axis, what part of the night sky indicates north changes radically on a 30000 year cycle [...]. [I]t is unlikely that an innate representation of Polaris as the north star was created by natural selection, and indeed, [...] the learning mechanism through which Indigo buntings create the representation of north that will play such a crucial

> role in their migratory life. The learning device that achieves this analyzes the center of rotation of the night sky, and stores the configuration of stars that can enable the bird to recognize the position of north from a static sighting. [CAREY and SAXE 2006].

Not that most philosophers should obsess about scientific mistakes, but the 30000 years figure is a gross overestimation. A much better estimation for the time of the axial full cycle precession would be: "For one revolution (2 π radians), total period Ts in seconds for the Earth's case equals 8.133 $\times$ 1011 seconds (25,771.5 years)." [CORNEJO 2013-12]. Meaning that, for the fixed star (the one that points to geographical north) to change from Polaris to Vega it takes only half the precession time, about 12,885.8 years. After a full precession cycle, the fixed star is back to its original position. Leaving even less time for natural selection to imprint a representation of the northern circumpolar star from birth. This suggests that Indigo Bunting collects information from the observation of the fixed star in the night sky, allowing the bird to locate itself no matter if the fixed star is Vega or Polaris.

Carey claims that the Indigo Buntings does not have an innate knowledge, but were selected to be capable of learning a specific feature from birth. If the fixed star knowledge were socially learned, then an Indigo Bunting isolated from others would not be able to locate the star on the north. It was proven, by ostracizing Indigo Buntings from birth, that the birds could still learn how to navigate correctly.

Reviewing the human side of the discussion, the literature of young infants show they have innate eye detectors [BATKI 2000], they understand the referential functions of gaze and pointing [CSIBRA 2003], have, at least, a rudimentary theory of mind of how people gain information judging from what they pay more attention to [MELTZOFF 1999]. We are born with a rich inferential system for acquiring knowledge.

These innate mechanisms are crucial and the empiricist has a hard time explaining them. Nonetheless it would be a mistake to extrapolate from those innate mechanisms that we should ignore altogether the knowledge acquired through experience.

> We review the literature on infant causal representations, providing evidence that events are interpreted causally by young infants. However, there is as of yet no good evidence that these representations are innate. Furthermore, there is considerable evidence that these representations are not the sole source of the human capacity for causal representation. [CAREY and SAXE 2006, p. 144].

If Indigo Buntings are born with the mechanism for identifying the North Start, why should we doubt that humans also have an innate capacity for knowledge acquisition.According to Carey, we are born with the ability to perceive causal phenomena.

To declare a certain proposition as true or false requires some way of measuring the world. Measuring is only possible by comparing. In order to measure an object (let

us call it O) there must be: I. something to serve as a scale (S) - preferable an unit in the International System, but there is no particular physical object that cannot be used as a scale - to compare O with S; II. A perceptual being with the capacity to check the similarities (or differences) between both O and S. In order to measure one has to make judgments of similarity.

> A standard of similarity is in some sense innate. This point is not against empiricism; it is a commonplace of behavioral psychology. A response to a red circle, if it is rewarded, will be elicited again by a pink ellipse more readily than by a blue triangle [QUINE 1969, p. 123].

Myriad ways can give us access to knowledge, unfortunately the present author has only a narrow glimpse of them all. Prudence advises us not to block alternative paths just due to a more tempting road ahead. The empirical vs. rational debate is an old one and appears to be far from closure, we have suggested some reasons for why this debate will not reach a single winner. The easy way out is to admit both sides have their advantages and weaknesses, they depend on and complement each other. If somebody saw simplicity when looking at the Central Nervous System and the perceptual aspect of human extended consciousness, he was deeply mistaken.

In practice, one has to choose the most compelling theory, better fitting our present goals and scope. This pragmatism hides that the world is a mess, ignored theories may provide additional insight. We just have to deal with the idea that chances are that there will no pure unified theory of consciousness. Radical empiricism may dismiss theoretical path to new knowledge acquisition. The main problem of this tabula rasa approach is to overestimate the sensorial capacity for discriminating quality data from garbage data.

Pure rationalism, on the other hand, could conceive an unconstrained world, as there is no theoretical reason why there are any natural laws at all. If theoreticians were free to describe models without ever having to compare them to real data collected from experiments, nonsense would most likely follow. Trapping unicorns with mental ingenuity.

On one hand, in answering the question of how concrete concepts are generated, the proxytype theory is very promising. On the other hand, when we ask how abstract concepts are developed, rationalism provides a much more reasonable account. Instead of asking which is the better theory, we may ask which question are we willing to answer. Taken isolated both empiricism and rationalism theories are flawed, but taken together, the answers provided from them can cover up exactly the deficiencies present in each theory. The trick is to understand the limits and caveats of each theory and to look for how both theories can be integrated. No model is correct, but both models are useful.

5.6 Modularity, integration and the predictive brain

Is it wise to entirely dismiss the possibility that scientific methods may share features with biology, maybe human cognition as well? Theoretical and empirical experts are sometimes required to cooperate between themselves. Some brain areas are specialized in abstract thinking; others, perception centric.

In order for predictive brain theory to work, there must be interaction between perceptual and modeling modules. “Errors in predicting lower level inputs cause the higher-level models to adapt so as to reduce the discrepancy.” [CLARK 2013]thus perception plays an important role, furnishing the inputs from lower levels to be constantly monitored, to check whether higher-level predictions are frustrated or not. This hierarchical coordination of the neural networks processing information flowing from the outside world and body up to cortical regions and back again:

In practice, this means that top-down connections within a multilevel (hierarchical and bidirectional) system come to encode a probabilistic model of the activities of units and groups of units within lower levels, thus tracking [...] interacting causes in the signal source, which might be the body or the external world. [CLARK 2013].

It seems safe to assume that the Bayesian brain theory also suggests some complementarity between rationalism and empiricism, considering its emphasis in the bidirectionality of top-down/bottom-up connections. Summarizing this theoretical reference: for the brain to acquire information from the world it would rely on the probabilistic models fitting what the senses should detect and the bottom-up pathway responsible for detecting error between the prediction and the gathered information, sending up the detected detected difference between the inputs and the predicted models. “Reason” constrains what we should observe in the real world and everytime our theory’s prediction fails to fit the collected data, “reason gets notified”. As perception is fine tuned to observe what is already expected. The observer relies on a previous idea of the most likely phenomena to be searching for. Models are constantly being updated in order to accommodate prediction errors.

“No brain is an island” [SAPOLSKY 2017], in many species (ours included), the chances for the organisms are better in-group rather than out-group. No brain area is an island. Consistently, modules cooperate, synchronize, exchange exciting and inhibitory signals. Distinctively synchronization between brain areas occur during the theta phase NREM sleep [SCHREINER et al. 2018], also in the binding of human associative memory [CLOUTER, SHAPIRO and HANSLMAYR 2017]. Modules are faster and less resource demanding when working in relative independence [SPERBER 2005, WU et al. 2007]. However emotion and reasoning are coupled, in a two-way interface [DAMASIO 2006].

Brain imagery studies show evidence suggesting for reentry pathways between sensorial and higher order modules [RAFTOPOULOS 2001]. Visual perception shares ar-

eas with visual imagery [DAMASIO 1993]. Sensorimotor areas are recruited in order to give meaning to literal action verbs in accordance with the part of the body involved in performing the action [AZIZ-ZADEH and DAMASIO 2008]

Integration between modules can be quantified, and is a good indicator for assessing consciousness [EDELMAN and TONONI 2008]. From bottom-up, the senses can help the modeling the abstractions built in higher modules; on the other hand, top-down representations can filter perception.

5.7 Further research

> Confidence comes not from always being right, but from not fearing to be wrong.
>
> *Peter T. McIntyre,*

Readers hoping for the "AHA!" last minute moment, should now be frustrated as there is no surprise lurking at the end. The most likely (and disappointing) answer is: "perceptual consciousness is complex". Even though the fiercely disputed rationalism vs. empiricism debate is a long lasting one, neither side have landed a critical blow yet. We must restrain ourselves to the prudent interpretation suggested by the gathered evidence available. Rationalist theory deals better with abstract concepts and empiricist theory struggles with them; whereas, on the other hand, the rationalist theory is deficient in describing the acquisition of the basic building blocks, the empiricist theory shines when it comes to describe how an individual learns from environment stimuli. Were the problems presented beforehand, one could easily select whether the rationalist or the empiricist approach is more advantageous. However, problems are not laid out in front of us beforehand, they appear as life goes,. Having both rationalist and empiricist approaches in our mental toolbox compromise its resources, but this taxation pays off in enabling for greater flexibility to the circumstances as they present themselves. An interesting following unanswered question may regard the differences between the neuronal activation patterns during learning from abstraction vs. learning from exposition.

6 Ethical Consciousness

6.1 Introduction

Can human emotions influence the judgment of behavior as ethical? Can neuroscientific measurements provide relevant evidence for measuring human emotions? Are there objective criteria for stating whether an action is right or wrong?

Answer the last question with yes, is in favor of moral absolutism. Answering the same question with no, favors moral relativism.

The neoclassical theory of natural law proposes the possibility to deduce practical principles from natural laws. The natural laws would be the foundation for the artificial norms created by the human being.

In this chapter we look at some experimental neuroscientific and psychological studies on human ethics, drawing on empirical experience and theoretical models, to clarify some processes of the moral aspect of human extended consciousness.

Humanity has achieved normative legislations that are crucial for modern society. The laws of nature exert influence on the human mind, we can understand the reasons behind the practical principles that are almost universally agreed between different cultures. By law, in the republican conception, any of the citizens can be punished for infringing the legislation of their nation.

Neuro-cientista have found regions in the brain related to emotion and social functions. Thus, identifying brain areas that process information in a similar way in most human beings and that play a relevant role in the ability to express emotions, such as pain or pleasure. A human can share experiences with others who have similar nervous systems. The means I have at my disposal for getting my information from the world are almost homologous to means you have at your disposal to getting yours information. When we compare our human experience with the experience of non-human animals, the contrast becomes obvious.

> Similar biological capacities of recognition, re-identification, tracking objects, perceiving, sensing, moving, acting, expressing, and thinking in a general sense —such as the capacity of having intentional mental states and of establishing coherent relations between them. [STEIN 2014, p. 203,].

Most humans have a stressful experience of feeling pain. Most, at least once in their lives, feel happy for another, even for something that has not directly benefited them. By reading this text you should be trying to understand what I meant by the sentences I have written and maybe guessing whether or not I was under influence of psychoactive substances at the moment of my writing.

Having basic emotions, which are virtually universal for humans, inclines most men and women to adopt some basic social values, forming a set of social norms and

dogmas that are consistent with the way how our evolution has shaped our neural functioning.

Evidence supporting this line of thinking comes from all major religious forms professed in different cultures. Every major religion shares some variation of the golden rule "Each should treat others as he would like himself to be treated.". The golden rule or a variation of the golden rule is expressed in sacred texts (Mahabharata 5:1517; Udana-Varga 5.18; Analects 15.23; T'ai Shang Kan Ying P'ien, 213-218, Matthew 7:12; Luke 6:31; Leviticus 19: 18; Guru Granth Shaib, p. 1299, Shayast-na-Shayast 13,29; the Zhong Yong 13.3; Samyutta Nikaya v. 353; Mencius VII.A.4; Acarangasutra 5.101-2; Sutrakritanga 1.11.33; Talmud, Shabbat 31a; Tobit 4:15). If humans were incapable of expressing empathy, would there be a need for the golden rule? Moral relativism has difficulties in explaining how multiple cultures have achieved, through different approaches, invariance in central aspects of shared in different dogmas.

We present here our attempt to elucidate why some brain mechanisms motivate us to adopt moral behavior and why some other brain mechanisms may predispose us toward immoral behavior.

6.2 What are natural laws?

The goal of science is to understand the natural laws that govern the universe. We do not have direct access to the laws themselves. We only have our senses and some fantastic - but always limited - devices that heighten our sensitivity.

> Fundamentally, science deals with observations and their descriptions in terms of models. A model is more than simply a photograph-like image of a specific set of data. It should be able to successfully describe in a repeatable, testable fashion a whole class of observations of the same general type, enable the prediction of other unexpected observations, and provide a framework for further applications, such as in technology or medicine. [STENGER 2006, p. 37].

These models constitute our hope for discovering natural laws. Understanding the true structure of reality is an unrealistic goal. What science can do is to build, with the tools currently available, a model that fits the data and does not produce internal contradictions. The natural laws that we know are those compatible with the scientific consensus on nature. The ultimate natural laws should be universal and independent of us, our models seek to approach this as closely as possible. Unfortunately, we have no knowledge of a science that does not depend on human beings to be applied.

> Scientific progress is not different in kind from progress in any other fields, but the absence at most times of competing schools that question each other's aims and standards makes the progress of normal-scientific community much easier to see. [KUHN 1970, p. 163].

Kuhn argues that scientific progress, like progress in art and other forms of creative expression, depends on agreement among peers. For example, if Newtonian mechanics had not received any attention from academia, its merits would never have been revealed and it would not have contributed to the advancement it provided.

Arguably, even the most esoteric theologians and artists are more concerned with the opinion of their peers about their work than the most orthodox scientists. The final result, however, for both cases is evaluated on its merits according to the opinion of colleagues in the profession.

If ethics has an organic basis, science may present some method for elucidating it. If ethics has no organic basis, then the failure of the scientific research for describing the human dispositions may be a symptom for this. Does the considered adequate ethical system depends on the cultural context? This last possibility may be quite unnerving. If the criterion is only the cultural context, in the context of slave-owning communities, slavery was ethical. A radical moral relativist, in order to be consistent, would have to admit such absurd claim.

The main strength of moral relativism seems to be in how it invite us to accept the different, the person who thinks differently. Who has a different system of reference.

> [O]nce I intend to give a scientific description of the observer as a system capable of making descriptions (language), I need to assume as my starting point that the nature of science is subject-dependent . [MATURANA 2014, p. 125]

Does nature itself depends upon the subjective point of view? We may never know. Does science depends upon the subjective point of view? Yes, the answer is yes and we invite anyone in disagreement to check the history of science of the previous century.

"The project of giving to ethical life an objective and determinate grounding in considerations about human nature is not, in my view, very likely to succeed." [WILLIAMS 2006, p. 153]

In the present chapter we will discuss some problems that may hinder the goal of determining the basis for ethical life may not likely succeed. Why is it so difficult to propose an ethical model grounded upon the objective science describing the laws of human nature?

6.3 Natural law and its relationship with neuroscience

The neoclassical theory of natural law, as presented by Grisez, Boyle and Finnis, defends the possibility of extracting, starting from a set of laws of human nature, a code that enables explaining the motivations for human actions. [GRISEZ, BOYLE and FINNIS 1987]. Human beings are born with a set of inclinations shared by most of us. Thus, it would be possible to describe a code of conduct consistent with our natural predispositions.

> As Goldsworthy points out, Grisez, Finnis and Boyle disavow the claim of neo-scholastic natural law theorists that practical principles can be deduced from purely theoretical ('facts') about (human) nature. [ROBERT 1996, p. 23]

Which can be verified, as in the following passage: "As first principles, they cannot be derived from any theoretical knowledge [...]. Thus, they cannot be verified by experience or deduced from any more basic truths through a middle term. They are self-evident." [GRISEZ, BOYLE and FINNIS 1987].

We will analyze the following statement:

- Premise 1. Practical principles cannot be deduced from purely theoretical truths ("facts") about nature;

Physics and historical evidence holds that: the law of gravity IS a law of nature;

- Premise 2. Architects have used practical principles that can be deduced from theoretical knowledge about the nature of gravitational law;

It follows that:

- C. Practical principles cannot be deduced from purely theoretical truths about nature and practical principles can be deduced from theoretical truths about nature. $(1 \wedge \neg\, 1)$

We used the method called reductio ad absurdum to reach the conclusion that, starting from the authors' premise 1 and pragmatical use of physics knowledge in premise 2, to reach a contradiction.

Scientists in human history have struggled futilely trying to build a perpetual motion machine, for instance. It would be very useful to society, most people would like to have a car that could do work indefinitely without any source of energy. The scientific consensus is very skeptical about the possibility of perpetual motion. This hypothetical machine violates the first and second laws of thermodynamics. These laws to which we refer are theoretical knowledge, from such knowledge we can derive practical principles. In order to use a moving vehicle in our world, a source of energy is required.

Man is constrained by the laws of nature. As much as man tries to subvert nature to his whim and modify the environment to better suit his interests, he has never been able to violate any laws of physics. At most he can extrapolate his possibilities of action, pushing as far as the imposed limitations allow.

Some practical principles are recurrently found in ancient sacred texts from different cultures. Neurological findings may help describe the inner mechanisms behind human inclination. Some biological predispositions are virtually universal in our species. Paradoxically, humans do not always behave in accordance to the laws of human disposition. It may be possible to better understand how rights granted by the Declaration of

Human Rights reached legitimacy from a scientific perspective. The same laws of human dispositions can help describe why we unfortunately need a Declaration of Human Rights in the first place. An important caveat to bear in mind:

> [W]e do not wish to minimize the role of social interactions and cultural history in the construction, refinement, codification and transmission of those values. We are not reducing human values to inherited biologic instincts. We simply wish to suggest that the construction was constrained and oriented in certain directions by preexisting biologic conditions. It did not enjoy infinite freedom. In no way does this view reduce the merit of the intelligent construction; neither does it oblige culture to follow biology blindly. [DAMASIO 2006, pp. 47-48]

The moral conduct of human being has a set of biological predispositions, even before the onset of the civilizations. Having a natural starting point, common to most people, made it easier to regulate civil behavior. We can use reason to understand why is it beneficial to obey the written laws, but way before our intellectual development, our natural tendency is to comply. The human social nature is to be influenced by the surrounding culture and this is exactly where all the complexity comes from. If we behaved solely based on our biological predisposition it would be easy to derive practical principles from the laws of human dispositions, but that is not the case. Usually culture follows most of the natural biological inclinations, but, unfortunately, this may not necessarily be the case. Some exceptionally violent cultures do appear through history, sadly, the children raised in such cultures will be predisposed to adhere (or to harmonize, to use social psychology jargon) to the values shared in such communities. Acting in conformity to the values of one's tribe is natural behavior. In a community that is violent to its non-members, the natural tendency to seek support, love and be loved by the parents and friends may turn out to prevail over other natural tendencies such as to avoid telling lies, bring harm or even death to others. But before we can jump into this conclusion, first we have to analyze some neurological details of this discussion.

6.4 Human Rights' neuroscience

An experiment was conducted comparing two groups: a group of volunteers who had damage to the ventromedial prefrontal cortex (vmPFC) and a control group, with healthy vmPFC [KOENINGS et al. 2007]. Both groups were presented with situations where they would have to choose between two different possibilities. Half of these situations involved low-conflict options and the other half involved high-conflict options. The high-conflict situations presented emotionally aversive scenarios. The vmPFC is responsible for social emotions like guilt and compassion. The prediction was that damage in this area compromises the emotional reactions observed in ethical dilemmas. In essence, classical utilitarian calculations focus on maximizing well-being and do not

necessarily require compatibility with emotions aroused by the actions involved. Patients with vmPFC damage were more willing to adopt a utilitarian behavior, ignoring aversive emotions, compared to the control group.

Human actions are under influence of our emotions. The vmPFC activation correlates to the internal moral compass alarm [DAMASIO 2006]. An intrinsic functional connectivity binds the vmPFC to the amygdala [JALBRZIKOWSKI et al. 2017], this corroborates with the idea that emotions play an important role in ethics. Repulsion, anger, shame and fear are emotions that drive high influence over the moral compass. While the amygdala is responsible for triggering the emotional hormonal cascade, vmPFC activation can inhibit, i.e. regulate its functioning [MOTZKIN et al. 2015]. The interdependence between amygdala and vmPFC goes back to the interdependence between reason and emotion.

Knowing that sacrificing one's mother to save five strangers is an altruistic course of action and compatible with a utilitarian calculation. However, a course of action being altruistic does not always seem enough to convince us to opt for it. Sacrifice would bring about the maximization of average well-being, but emotional alarm influences judgment, which can override the utilitarian calculus. Both our reasoning and our emotions must be taken into account in order to describe our actions.

Psychopathic behavior is frown upon in most societies. The brain functioning in psychopaths, as will be seen later, deviates from the average in the following sense: they recognize an action as moral or immoral, but the immoral action will not feel the same they would feel for most people. Antisocial behavior without good reason is usually punishable by law and is against our inclinations, given the average brain structure. In the context of an antisocial community in which violent behavior against non-members of the community would be socially acceptable and would remain unpunished, having the average moral conduct, i.e. feeling guilty about the idea of killing a non-member of the community would be frown upon.

After the World War II, the UN was created, for one thing, in the attempt to prevent the rise of new totalitarian dictatorships. The establishment of the Universal Declaration of Human Rights was a necessary answer to the horrors perpetuated against humankind.

> Whereas recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family is the foundation of freedom, justice and peace in the world [...] Whereas it is essential, if man is not to be compelled to have recourse, as a last resort, to rebellion against tyranny and oppression, that human rights should be protected by the rule of law, [ASSEMBLY et al. 1948, preamble].

We cannot afford to pay attention to the rights of UDHR at length, as we have no competence for such. Instead, we will focus on a brief discussion for some instances

of rights that bear roots to our natural biological predispositions. Humans are innately curious, yearning for knowledge. “Everyone has the right to education.” [ASSEMBLY et al. 1948, Article 26]. Remaining ignorant while having the opportunity and means to learn about the World is incompatible with human natural predisposition. Our brains have evolved in such a way that we are naturally predisposed eager to acquire language and knowledge. If this predisposition is cultivated and not repressed, it can flourish during the lifetime. To withhold or to deny the access for education goes against our natural thirst for intellectual achievement. Creating obstacles to information access, therefore, contradicts the natural structure of the human brain.

> The finding that activity in the left PFC is correlated with curiosity is also consistent with the idea that curiosity is associated with an intrinsic value of learning, because neurons in the left PFC receive input from neurons in the substantia nigra via the dorsal striatum . The dorsal striatum responds to the magnitude of primary rewards and reward prediction [...] and shows sustained phasic activations during reward expectation. [KANG et al. 2009, p. 971].

If humans’ brain were not motivated to be curious and would not reward intellectual achievement, would a right for public education be legit? Our brains feel pleasure when they learn, as a rule, we often feel excited when acquiring novel knowledge. Learning comes with a moderate stress, but as the stress from learning is not the same as chronic stress, which predispose us to diseases, but a moderate and sporadic stress, will keep our wheels turning [SAPOLSKY 2004]. Children often actively seek knowledge and ask questions. The universal right granting access for public education is consistent with the rewarding feeling that discoveries are wired to trigger in our brains.

“No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment.” [ASSEMBLY et al. 1948, Article 5]. Would it be necessary to ban torture in a possible world where no being would be able to express the ability to feel any kind of pain? Our neuroanatomy lays the groundwork for an explanation for this crucial principle expressed in the Universal Declaration of Human Rights (UDHR). Our brain has mechanisms that make harmful stimuli uncomfortable. “The dACC and anterior insula, located in the front half of the brain, respond to the unpleasant aspects of pain - the feeling that makes pain something we really do not like.” [LIEBERMAN 2013, p. 52]. The fact that pain is aversive to humans helps us understand why we Article 5 forbids torture.

We can deduce from the fact that humans experience pain as unpleasant, that a practical principle that criminalizes the act of causing unnecessary pain is necessary. Our empathic capacity even enables us to put ourselves in the place of the victim of the aggression and feel their pain (although, generally, the pain felt through empathy is less intense than the pain felt in the person who suffers the aggression directly).

We are inclined to dislike pain and torture is painful. Therefore, from the point of view of the human dispositions, forbidding torture is consistent with our innate predispositions. Laws such as those expressed in the UDHR are needed to constrain the courses of allowed actions. Societies or states in which torture was accepted or encouraged are the exception, such behavior runs counter to many of human natural dispositions.

States in which torture is not prohibited, or permitted and encouraged are promoting deviant behavior. This paradox will be dealt with in greater detail in the next section 6.5. In summary, we can explain herd behaviors as the natural tendency of each individual to mimic the behavior one observes among the majority of the group. Natural human laws ensure some prohibitions and rights to be attractive or repulsive. Intrinsic predispositions in the human brain incline us to act in a certain way. Human behavior, for better or worse, can deviate from the natural predispositions. For example, some deviant cultures may encourage violent behavior, against the natural inclination for empathy. Unprovoked violent behavior arouses aversive emotions, if this behavior is well spread, others will be more predisposed to engage in violence. After all, human actions rely on harmonizing with the group values. The human predisposition to harmonize, will align one's own conduct with the behaviors majorly observed among peers. Acomodating one's own values to the values of the surrounding community.

"Everyone has the right to rest and leisure, in particular, to a reasonable limitation of the duration of work and periodic holidays with pay." [ASSEMBLY et al. 1948, Article 24]. This is also something that neuroscience can help us understand. We love to celebrate and party with family and friends. We look for social contact, rooted deep in the constitution of our neural circuitry. "[T]he brain's free time is devoted to thinking social" [LIEBERMAN 2013]. The standard mode network, a network activated during the wakeful rest period, "consists primarily of dorsomedial prefrontal cortex (DMPFC) in Brodmann areas (BA) 8/9, precuneus and adjacent posterior cingulate cortex (PC/PCC), temporoparietal junction (TPJ), and anterior temporal cortex (ATC)." [LIEBERMAN 2012, p. 4]. The areas related to social cognition are the same areas activated by the mentalizing network. The default mode network and the mentalizing network are superimposed, with one exception: the ATC is activated to generate hypotheses about what is happening in the own mind and in the other's mind, but not o, during waking rest. The other areas mentioned are activated in both cases, no other is significantly more activated for one network and not the other.

A growing body of evidence suggests for the close relation and overlap between the default mode network and the mentalizing network [MOLNAR-SZAKACS and UDDIN 2013, HYATT et al. 2015, SPUNT, MEYER and LIEBERMAN 2015, MARS et al. 2012]. The network that activates when we are awake and at rest inclines us to see intentional states in everything around us.

The Heider-Simmel illusion [45] suggests that we assign intentional states even to inanimate objects and geometric shapes. This is the social prism through we see the world. Filling the inner life of everything we observe with intent. In animism, this is especially clear: objects, places, and creatures have distinct spiritual essences. For example, if the stone fell, it was an intention in the stone that caused it to fall.

Theory of mind, also called attribution capacity or mentalizing, is the ability to estimate what may be the beliefs and desires on the minds of others and one's own mind. The mentalizing network is the group of areas in the brain that are activated when we are trying to "read" other people's mind. Navigating in complex societies would be much harder without the mentalizing capacity. The mentalizing network is also prioritized to be activated during leisure, spending more time activated than any other network in the human brain. Add to the mentalizing network the capacity for social pain, and it becomes clear that the human being is a very social animal. Perhaps the choice of name *Homo sapiens* may not have being the most appropriate. *Sapiens* means wise or sagacious. Are note humans, on average, none the wiser? Would it not be more in consistent with human dispositions, if our species was called *Homo socialis*?

Therefore, it makes sense that the UDHR intends to promote the guarantee of free time for social interaction. Evidence gathered by neuroscientists suggests that we are inclined: to form social bonds [GALINSKY, KU and WANG 2005]; to suffer for the loss of such bonds [EISENBERGER, LIEBERMAN and WILLIAMS 2003]; to perceive intentions and feelings in everything we see [HEIDER and SIMMEL 1944]; in addition, higher encephalization quotient in mammals are associated with sociability [SHULTZ and DUNBAR 2010]; and the size of the neocortex in primates is directly proportional to the size of the groups formed by them [DUNBAR 1992]. Vacations are often enjoyable because we can use our free time as we please, which usually means to socialize with family and friends.

In primates growing in greater groups the mentalizing skill is of great importance. The mechanisms behind the ability to reflect on the beliefs and desires of our own and of others require a complex and well-developed brain structure, mainly involving the Mentalizing Network and the insular cortex, the latter is involved in reading the emotion from facial expression images [SPRENGELMEYER et al. 2011]. Culture has an impact on the way we see the emotions of the facial expressions [RUSSELL 1994]. Integration between the individuals composing society is required for harmonic coexistence. In any group of people, the integration between individuals constrains the

[45] The illusion created in 1944 is caused by a video that shows two triangles and a circle, one of the triangles being larger than the other two shapes, which are the same size inside a rectangle. Apparently the larger triangle is trying to attack the smaller shapes as they try to run away and hide inside the rectangle. At some point the bigger triangle breaks the rectangle – serving as a "room" around the triangle and circle "couple" were trying to hide and escape – apart in an attempt to find the other two. Personally, the ending looks satisfying because both the triangle and the circle have managed to escape. In a cold and objective interpretation, often reported by people with autism describing the scene, one can simply describe the movement of the shapes without the anthropomorphic narrative.

possible behaviors, in a highly integrated group of people, less deviant behavior is observed. The better a person's understanding of the beliefs and desires of others, the greater the chances for avoiding conflict. Our brain circuits predispose us to connect and harmonize to the groups we belong to, avoiding social rejection. According to Dunbar's number, our social brain structure is fit to interact with a number of friends up to 150, based on human encephalization quotient.

If it were not for our need and predisposition to live in society, what would prevent us from increasing our efficiency and production, working like machines on Saturdays and Sundays without rest? Working excessively causes mental and physical burnout, especially due to the time spent away the people we love. Unfortunately, the working conditions during the industrial revolution taught us this hard lesson and it was necessary for workers to fight for labor laws regulating work hours and vacations.

The law needs to be coherent with the organic functioning of the human being. If we did not need to use bathrooms, what would be the reason for the obligation to install toilets in public buildings? Civil laws that are incompatible with the functioning of the human body are illegitimate. If, to save on the budget, the law enabled a public building to be built without toilets, it would soon become the target of rotten criticism.

States that promote segregating laws violate principles that are based on our predispositions. To interpret this possibility, we will see that there are ways to circumvent our normal behavior. What Hobbes calls the "state of nature" is in contradiction human natural social dispositions. If antisocial behavior were the human norm, how could our ancestors have thrived for so long? Adherence to a social contract seems to be a rational choice, but we suggest that it was nature that took this choice for us. If we had to watch our backs every time, it remains unclear whether we would have been able to populate the land the way they did. One of the natural human dispositions is to be social [LIEBERMAN 2013, BARGH, LOMBARDI and HIGGINS 1988, OCHSNER and LIEBERMAN 2001, RILLING 2002, SHULTZ and DUNBAR 2010, EISENBERGER, LIEBERMAN and WILLIAMS 2003, GALINSKY, KU and WANG 2005, HERRMANN et al. 2007]. To care, protect and trust others is human natural disposition. Antisocial behavior, on the other hand, is deviant. Such behavior, if intentional and without good reason, is considered murder, it constitutes a violation of Article 3 of the UDHR, consistently the Brazilian Penal Code abide to the Article 3, punishing murder under Article 121.

A law that would enable impunity for antisocial behavior would neither be legitimate nor consistent with human natural predisposition. However, there are contexts in which such laws can take advantage of the man's tendency to behave in accordance with his group.

6.5 Is it possible to ignore our moral compass?

The trolley dilemma is a well-known thought experiment in the field of ethics. A generic way of presenting the trolley dilemma goes as follows:

There is a runaway tram running down the railroad tracks. Up ahead, on the tracks, are five people tied up and unable to move. The cart is heading straight for them. You are some distance away in the train yard, next to a switch. If you pull the lever, the cart will switch to another track. However, you notice that in this detour there is also a person unable to move. You have two options: do nothing and enable the cart to kill the five people in the main lane. Or, you can pull the lever, swerving the cart into the side lane, where it will kill a single person.

The question is: What would you do in such a situation?

Joshua Greene explains that the more "personal" an action is (such as pushing someone with your hands to stop the tram, rather than pulling the lever), the more it will sound an emotional alarm, primarily activating the vmPFC and the amygdala [GREENE 2013]. Greene defends such a position on the basis of experimental data collected during moral decisions in such scenarios. Lab partners asked fMRI volunteers what they would do in variations of the trolley dilemma. The outcome of the decisions was always the same, the difference was some subtle change in the context of the action: pushing with the hands, pushing with a stick, pushing a button. Whether if you pay somebody to kill a chicken or if you kill a chicken yourself, the consequence will still be the same, what changed was the context. The more personal distance from the action, the less emotional one is about to get. The vmPFC takes very little time to be activated and is affected by intuition, not reason.

Higher amygdala activity and vmPFC were good predictors for the frequency with which people would chose whether or not to save the lives of several people. In contrast, greater activity in the Dorsolateral Prefrontal Cortex (DLPFC) was correlated with choices approving of one person's sacrifice in favor of saving more people's lives. Deliberate utilitarian calculation as opposed to the automatic emotional response from vmPFC.

It may be informative to study deviations in human behavior to understand the biological underpinnings of morality. Dysfunction of limbic and paralimbic regions is predicted to cause exaggeration or attenuation of basic motivational and emotional states, thus affecting moral behavior. Lesions in the hypothalamus, septal nucleus, basal forebrain and neighboring structures are expected to produce general distortions of the valence of moral values, attitudes and emotions. This is consistent with the observation of unprovoked anger, lack of empathy, and abnormal sexual behaviors following isolated damage to the limbic and paralimbic regions. [MOLL, OLIVEIRA-SOUZA and ZAHN 2008, p. 807].

Psychopaths are a minority in our population [NEUMANN and HARE 2008]. Most

humans are capable of expressing feelings of compassion and guilt. Psychopaths have structural differences in the brain compared to the average population. One of the differences found: there is a significantly reduced microstructural integrity between the white matter connecting the amygdala and the orbitofrontal cortex when psychopaths are compared with controls [CRAIG et al. 2009]. A psychopath knows the difference between right and wrong (since the vmPFC is still there), but is less predisposed to feel guilt, as the vmPFC has a significant reduced capacity to activate the amygdala. Psychopaths, like other individuals, do not necessarily behave in ways that ignore moral rules. The difference is that, when following the rules of conduct, they rarely do so motivated by feelings, in general, they are more predisposed to calculate their decisions based on reason, by activating the Dorsolateral Prefrontal Cortex pathway.

"The look that the eyes manifest, no matter what kind of eyes they are is a pure reference to myself" [SARTRE 1943, p. 298, translated by Hazel E. Barnes] [46]. The look of the other points to a self-reflection. Through the eyes of the other, a bridge is built reaching to oneself. When asked about our opinion about ourselves, How often we turn to think about what others think about ourselves? The others serve as a frame of reference, allowing us to judge our own strengths and weaknesses.

Most of the time we want to be seen with "good eyes". Our brains, on average, predispose us to have prosocial internal states. Violence is the exception in our lives, not the rule. If our brain structures were different, we would have different moral principles. Let us say a charismatic leader prompts his followers to hate outsiders and other minorities, based on accidental human characteristics. Assuming the followers engage in this violent behavior. Why is it possible? Were we not arguing that the human predisposition was towards prosocial behavior? We often seek for validation of our actions from our peers and our authorities. Usually, the intolerant behavior is deviant, but sometimes peer pressure and authority pressure can validate a behavior that would normally cause us fear of being seen as a bad person. Human prosocial disposition is not deterministic, there can be scenarios where the prosocial disposition is overcome by peer pressure or other influences from the context.

> We should therefore claim, in the name of tolerance, the right not to tolerate the intolerant. We should claim that any movement preaching intolerance places itself outside the law. And we should consider incitement to intolerance and persecution as criminal, in the same way as we should consider incitement to murder, or to kidnapping, or to the revival of the slave trade, as criminal. [POPPER 1945, p. 544].

To be intolerant in the name of tolerance is a paradox, but it can be understood from analyzing the context. We build our identity through the eyes of different people, by allowing for the intolerant to have free speech, we are opening a dangerous door

[46] Le regard que manifestent les yeux, de quelque nature qu'ils soient, est pur renvoi à moi-même.

for fascism to enter. In a real democracy, the intolerant voice must be silenced for the minorities to have voice. The intolerant is incapable to understand the different, to apologize, to recognize a mistake. The intolerant denies his own nature, seeking the approval of the authority and the peers. The psychological analysis of the fascist movement is interesting for us to understand how it is possible for humans, having a natural moral compass, to simply ignore it. The fascist leader is praised almost as a god, any criticism against the leader is considered the greatest offense. We suggest that one of the mechanism at play here is approximately as following: social pain drives us to seek others' approval; normally being disrespectful would be seen as a character flaw; in order to compensate for the disrespectful actions from the leaders and the followers, people boost the fascist authority in worship and flattery, seeking approval.

The fascist political movement seems so unlikely to gain popular support, until it is too late and has already taken power. For preventing for fascist dictators to reclaim what they had lost after Second World War, the United Nations signed the Universal Declaration of Human Rights. This context is implicit in the following quote:

> All human beings can invoke the rights and freedoms proclaimed in this Declaration, without any distinction whatsoever, namely race, color, sex, language, religion, opinion. political or otherwise, of national or social origin, fortune, birth or any other situation. Furthermore, no distinction shall be made based on the political, legal or international status of the country or territory of the person's birth, whether that country or territory is independent, under guardianship, autonomous or subject to some limitation of sovereignty. [ASSEMBLY et al. 1948, art. 2].

No scientific evidence supports race supremacy. Deriving principles that deviate from social behavior is not only wrong, it is dangerous. This is a complex and delicate matter. The authority's approval allows ordinary people to subject themselves to committing immoral acts [MILGRAM and GUDEHUS 1978], the empathetic capacity shows racial bias, as the neural empathetic response to own ethnic group is increased, while it is reduced for other ethnic groups [XU et al. 2009, CAO et al. 2015]. On top of all this, the group's behavior not only authorizes but can reinforce a sudden escalation of violence [ZIMBARDO, MASLACH and HANEY 2000]. This evidence suggests to a wicked side of the human dispositions, a side we are reluctant to accept or reveal. The pain of the other is not felt the same depending on the color of one's skin. Chapter 3 discussed how body functions are at the foundation of consciousness. The social aspects of extended consciousness are embedded within the core consciousness.

Emotional circuitry is flexible and adapts according to context and regulation in nonhuman primates and humans [DAVIDSON, FOX and KALIN 2007]. Voluntary control from prefrontal activity exerts power over emotional response from the amygdala. This suggests some philosophical implications on our ethical responsibility, from

a scientific perspective. Being ethically consistent, making good life choices and helping others is a behavior that can be learned and will not only promote well being for others, but for oneself. The very intelligent way to be selfish is to enjoy the pleasure of helping other people. The justification for studying neuroscience as a philosopher is because it helps in making human motivations more transparent. Doing good deeds for others is often deemed as a moral obligation, but it may be our moral nature, considering how pleasant it is to help others. More compelling than preaching for others to good deeds, is to simply do good deeds, teaching by the example.

Let us describe a classic example of experimental psychology demonstrating the phenomena of peer pressure: volunteers could select two lines of the same length from a group of three lines; Asch had lab students collaborators working undercover as "volunteers," who selected the wrong lines on purpose before the real volunteer had to choose. The real volunteer would often choose the wrong answer, at odds with obviously perceptible difference, to come into agreement with what the two Confederate participants stated before him [ASCH 1956]. Truth is relative to the people around.

The activation of a perceptual representation, for example, can influence social behavior [DIJKSTERHUIS and BARGH 2001]. The brain relies on the primitive mechanism of the ventral striatum, which rewards humans with pleasure for acting consistently with peer pressure [CAMPBELL-MEIKLEJOHN 2010].

Mutually reinforcing behavior can be accidental, arbitrary, or for uncertain reasons. On certain occasions the reinforced behavior can be transgressive, that is, it may be in disagreement with an ethical principle. If one of the human dispositions [47] favors group harmonization, a paradox will appear.

It makes evolutionary sense for groups of mammals to move in unison. Unfortunately, herds eventually make their way into a canyon and each member follows the peers in front, falling to their deaths. Even if jumping to their death is at odds with their survival instincts, the instinct to follow the group speaks louder. Moving together constitutes a survival strategy, but no strategy is perfect. Being in agreement with your peers may lead, for example, to a mistake. Better to make a mistake together than to avoid the mistake and be alone.

Relativism is an attractive trap, because it urges to our primal instinct to harmonize with the group. Formalizing the idea into a logical argument:

1. Following the group is a human predisposition.

Suppose:

2. T is an action that is at odds with another human predisposition. Usually practicing T is aversive to us, as it goes against our natural inclinations.

3. All members of a group is taking the action T. At some point the group started

[47] The word chosen is important. Instead of "human nature" , we opted in using "human dispositions". A law of nature strongly constrains possible courses of action. Dispositions, inclinations, tendencies ar e more suitable words when dealing with human behavior. Nature cannot be contradictory to itself.

practicing T and this became the default behavior.

Which leads us to conclude a contradiction:

1. It is a human predisposition for an individual of this group to practice T (obeying 1, given that 3 is the case) and not practice T (obeying 2).

This paradox is one that the theory of moral absolutism cannot escape. We may hold that human evolution and our brain circuitry favor the formation of codes of ethics and conduct, however human predispositions to conform with the group can sometimes lead to such paradox. This impasse suggests that neither the absolutist nor the moral relativist position is completely right. Surprise, surprise human behavior is complex. Thus, there may be little hope to resolve the impasse between moral relativism and moral absolutism theories.

The ability to harmonize with society's values is one of the later stages in human cognitive development, which matures during adolescence. Describing how biology and neuroscience provide the basis for human principles and values is not an easy task, precisely because it must also account for one of the most characteristic inclinations of our species: the harmonization.

We argue that one of the main motivations for ethical dilemmas is harmonization. Laws of nature must not lead to contradictions. Rarely are herds of non-human animals observed acting in ways different from their natural dispositions. This may be one of the reasons why we consider animal behavior to be amoral. Non-human animals did not develop moral systems like ours, probably because of the difficulty they face in suppressing emotions; unlike humans, their prefrontal cortices are not as well integrated and massive as ours.

For animal behaviors that would be considered immoral, in our parameters, there is no evidence indicating that they could act differently. Humans, on the other hand, rely on mechanisms to suppress emotions [GROSS and LEVENSON 1993] and fail to act according to their innate predispositions, either by a rational decision or by another motivation. Human disposition is distinguished from the nature of non-human animals, in our case, our natural tendencies are not as determinant for our behavior as in other animals. There are patterns of behavior that most people criticize.

For example, the act of rape is widely condemned. The physical and psychic suffering caused to the rape victim gives enough reason why human disposition is inclined to reject this behavior. This would be impossible if human beings were incapable of empathizing, feeling the pain and suffering of other people, to synergize with others. In such scenario, it could be the case that popular opinion about rape would be different.

It is grim that there may be cases where habits that contribute to this monstrous practice are socially justified. We presented some neuroscientific evidence supporting that predisposition for human values have some biological causes. We must also incorporate the human inclination to conform to group behavior. Human law tends to be consistent with our neurological foundations. Unfortunately, on certain occasions, clear

violations of our innate predispositions have had legal support in favor of tradition.

Moral naturalism integrates description and prescription with strictly immanent grounds. Offering an explanation of human values aligned with recent scientific investigations into human dispositions.

> [S]ome affective reactions have evolved as a result of the adaptation to life in groups and under the pressure of reciprocal demands, and individuals are not in full control of them. [BRITO 2014].

We are not separating the factual sphere from the moral sphere, rather, we are hoping to bring both spheres together, arguing that moral theories should be grounded on scientific knowledge regarding human dispositions. There are neurological correlates for predisposing ethical behavior, which legitimize the universalization of rights and duties. "Human nature" is too deterministic a concept to address the behavior of our species. Maybe it would be more accurate to say that there are innate human dispositions, which are due to the biological structures shaping the development of our nervous system. Precisely because they are just predispositions, they can be overruled.

Religions have independently arrived at some variant of the golden law. Would it suggest that some basic human values are independent of culture? In our interpretation, there are universal biological human dispositions. Would it not be great if we could understand how God intended for us to behave, by understanding our biological dispositions? Human nervous system is similar enough among people that we have similar dispositions. We feel similar emotions when exposed to the same context. As we share similar emotions, it is more easy to try the reactions other people have. Little matters the culture we belong, watching a hungry child receiving food makes us happy, hearing news of child being raped makes us angry. Those are arguments suggesting in favor of moral absolutism.

When two people are debating, it cannot be the case that the two people are simultaneously winning the arguments. However, most of the time, if you ask them, most people will claim to have won the debate. Not only that, we suspect that, most of the time, the loser actually believe in their victory, this comes from personal experience. As we are always living from our point of view, unable to leave our physical body, we are naturally predisposed for self bias. This may bring danger in advocating for moral absolutism because people hold different values, values that can be self-contradictory. If moral absolutism is correct, some people must be holding wrong moral values. In this sense moral absolutism can be quite dangerous as it may be promoting a witch hunt against the values hold by others that one disagrees with.

We once again agree with George E. P. Box: all models are wrong, but some are useful. It is useful to have models because they allow us to make predictions and analysis, but the more attached we become to a model, greater is the chance that we are

failing to acknowledge the intrinsic errors of our model. Errors are intrinsic to the process of taking any measurement. When it comes to the nature versus nurture / genes vs environment clash, both sides will often draw. The specific gene will not be expressed if it is not exposed to the specific environment, the specific environment will be of no consequence in the absence of the specific gene. Depending on what is the question we may be willing to answer, it may make more sense to look from one perspective or the other.

Human brain circuitry produces similar emotions for certain contexts. An example of an emotional reaction is the fight-flight reaction. Its function is to produce automatic biological changes that decrease reaction time and increase muscle capacity, predisposing the organism to flee or fight. Having this emotion brought an evolutionary advantage to our ancestors. We have inherited the capacity for this emotion, along with many other emotions. Emotions are often involuntary responses. They play a crucial role in our judgment of the morality of our actions. Few people can suppress the feeling of shame for misconduct and pride in benevolent acts. We are incapable of disobeying the laws of physics, but we can disobey civil laws. Few people can act without emotions, however, for better or worse, we can choose to make an effort to ignore our emotions and act at odds with the predispositions brought about by our emotions. If our peers are also engaged in the same behavior, it becomes even easier to suppress our natural impulses.

In the past there were no objective methods for measuring emotions. This was one of the reasons for claiming that emotions are subjective. Recently, analytical methods have been created that can predict which emotion someone is likely to be experiencing and how intensely they feel it. Therefore, scientists are gradually developing techniques to obtain objective knowledge concerning human emotions.

Scientists like Damasio have gathered evidence that corroborates the existence of a brain region that serves as a moral compass (the mPFC) that favors that our judgments regarding ethics are minimally compatible with each other. We are inclined to make moral choices consistent with universal human values. If we did not have such a region, there would be even greater risk that humanity would use its conquests for even greater cruelty.

> We propose that along with the evolution of mammals, a species unique in their need for early nurturance and care, comes a corresponding lifelong need for social connection. [EISENBERGER and LIEBERMAN 2005, p. 110].

There is currently no evidence suggesting the ability to experience social pain in non-mammalian animals. On a superficial analysis, it may seem disadvantageous that loneliness is unpleasant, we can become depressed by the lack of affection, reducing our productivity, income and happiness. However, analogous to the way that physical

pain is an alarm mechanism to protect our bodily integrity, by bringing us closer to others, social pain is advantageous from an evolutionary point of view, because human beings are more likely to survival when they are in a group.

Feeling the feelings of others as our own is a form of empathy and most human beings are prone to experience this feeling by observing the emotions of others. As a rule, we unwittingly imitate another person's feelings as if we were in the same situation they are in. "VMPFC damage was found to be the strongest predictor of empathic deficits" [LIEBERMAN 2007, p. 265]. It appears that a human with a healthy, intact vmPFC will be able to express empathy. The golden rule is significant because of our neurophysiological makeup.

Cause suffering to the other usually ends up hurting the agent causing the suffering, because he cannot avoid feeling part of the pain he causes in the other as his own pain. A person with vmPFC damage will not have as strong a reason to respect the golden rule as a person without such damage. For her, her feelings are independent of the feelings of others.

> Similarly, Botvinick et al. (2005) found greater vmPFC activity when observing another's pain but not when feeling pain oneself, which suggests that this region might contribute to the additional processes invoked by empathy over direct feeling. [LIEBERMAN 2007, p. 265].

This may help explaining why watching a dramatic scene can make us cry. The amygdala passes information from the limbic system to the prefrontal and vice versa. This suggests that our own emotions influence our perception of the emotions of others and that, conversely, the emotions of others influence our own emotions. We are more prone to feel empathy for our own kind, the greater our bonds, the greater our tendency to feel empathy.

The judgment of what is right and wrong in relation to the laws of Physics is simpler compared to the moral judgments of human beings. For example, claiming that a body in free fall at the earth's surface accelerates toward the sky is wrong, while claiming that it accelerates toward the ground is correct. One description is not observed while the other is. Inorganic matter always obeys its nature. We can describe with good approximation what the Earth's orbit will be like in the coming years. Humans have certain tendencies and patterns of behavior that can be explained on the basis of what their central nervous system predispose them to do.

6.6 Telling lies?

Our brain tell us lies all the time. We tend to think that others tend to see the world from a similar point of view to our own, "it is evident that the false consensus effect applies to many types of personal behaviors, feelings, opinions, and characteristics [...]"

" [ROSS, GREENE and HOUSE 1977]. "People's own beliefs, values habits tend to bias their perceptions of how widely they are shared." [GILOVICH 1990]. Apparently we need to activate the right ventrolateral prefrontal cortex (rVLPFC) to prevent our understanding of other people's opinion from being contaminated by our own prejudices.

> Individuals who had TMS [48] applied to the rVLPFC, temporarily frazzling the region, performed worse on the belief bias trials. This finding suggests that when the rVLPFC is impaired, self-control is also impaired, leaving individuals less able to overcome their own beliefs to provide the logically correct answers. [LIEBERMAN 2013].

When we study the world we can test a hypothesis to see if it is true or false. It is intellectual dishonesty to deny the truth of a statement, attesting for it to be false, while actually believing it to be true. We may not know the truth, but we can try our best to get closer to it. Most sacred texts agree upon valuing truth and avoiding falsehood. (Prasna Upanishad 1.15; Sahih Al-Bukhari: Book 73; Hadith 116; al-Ahzab: 33:35; Exodus 20:16-18; Qur'an 2:42). Neurological fMRI studies often lead to the same conclusion.

> Our results show that deception is associated with activation of the limbic system, parts of the frontal lobe that are probably involved in suppressing or inhibiting the truth, and parts of the temporal lobe that might be involved in memory encoding and retrieval. Furthermore, anxiety is presumably associated with deception, which is reflected in the activation of the limbic system. When a subject tells the truth, however, there is far less anxiety, and an alternative cognitive thought process does not need to be inhibited. Thus, fewer brain areas are active in the frontal and limbic system during the truth telling process. [MOHAMED et al. 2006, p. 686].

Telling lies causes a conflict of emotions, a confusion. Our body language may send messages in contradiction to our words – some people touch their necks, scratch their noses, some young children even cover their mouths. It is as if their bodies were struggling to stop their mouths from telling the lie. Many subtly detectable micro-expressions come along with the lies [EKMAN 2009]. Our voice may get higher in frequency and lower in volume. Sweaty palms and increased heart rate are often a symptom of lying. We are fell shame from lying, no culture encourages falsehood per se. We *feel* lying is wrong. On the basis of all the reactions we naturally present when we try to lie, we can postulate a principle: we should always prefer the truth. There are objective criteria that suggest that lying by the act itself is a behavior that causes natural aversion in human beings. It should not be considered subjective, or relative, the immorality of the individual who lies in search of his own benefit to the detriment of others involved.

[48] Transcranial Magnetic Stimulation.

6.7 Eating plants vs. eating animals , North vs. South

Let us briefly look at an example of how current human behavior tends to be less natural and more cultural. Our anatomical and gastrointestinal features do not show a single physiological characteristic compatible with omnivore and carnivore animals [MILLS 1996]. From the point of view of biology, according to the physical characteristics of our species we would be classified as herbivores. The diet of our ancestors was much more about gathering than hunting. The recent abundance of animal products in humans' diet is, on the evolutionary time scale, had not enough time to cause any significant genetic change.

The first known hominid ancestor had a mostly plant-based diet [BEDASO, WYNN and ALEMSEGED 2013]. Although it may have introduced a small amount of insects [SPONHEIMER 2005]. Since then, consumption of animals has only grown over time.

The creation or aggravation of many public concerns came along with the animal products consumption increase: the pandemic threat [PIKE et al. 2014]; chronic diseases [GREGER and STONE 2016]; environmental crisis [SHUKLA et al. 2019].

The movement for animal's rights that may seem to be, at first sight, focused on ethics, has implications over a much broader scope. Some studies suggests the difference in cultural values between cultures. To revenge one's honor would be more common in herding rather than farming societies, explaining the significant prevalence of violent behavior in pastoral areas [NISBETT 2018, FIGUEREDO et al. 2004].

Is it possible to understand ethics as subjective, or should we commit to universal precepts?

> Northerners and the Southerners have, at bottom, the same moral values: They both want to do whatever works best. Their disagreement, then, is just a factual disagreement about what, in fact, works best. [GREENE 2011, p. 119].

The tragedy of the commons suggests that, if we could know what actually works best, we could to avoid many conflicts. Unfortunately, there is no single recipe for what works best for any context, except, perhaps, when it comes to what goes on our plates.

6.8 Discussion

The human dispositions consists on characteristics that are common to the majority of the human population. The human dispositions may give us some hints on what laws are legit and what laws are unfair. Individuals with similar structures, within societies, are more likely to find some consensus on which actions are right and which are not. A prohibition makes more sense when there are justification on human dispositions. On the other hand, a normative rule that violates a natural law (the law of gravity, for instance) would be meaningless.

Going against tradition often pose risk to our lives, and humans are naturally predisposed to value their lives, thus more inclined to stay in line. We examined some of the transdisciplinary literature in neurology and social psychology to probe for the possibility for ethical foundations of neoclassical natural law theory. Our analysis, at light of recent findings, do not corroborate neither in favor of moral absolutism or moral relativism. Our study suggests that the combination of innate human predispositions with social pressures leads to the paradox of moral absolutism/relativism.

7 Linguistic Consciousness

7.1 Introduction

"Don't Panic. It's the first helpful or intelligible thing anybody's said to me all day." [ADAMS 2010]

Here we want to contribute to the debate about the human linguistic capacity. From chapter 4 we discussed the social needs. In the present chapter we will discuss a main consequence of being social animals: language.

The chapter is divided in two parts: our discussion will focus on the cultural context of language, considering the singular example of Pirahã Language; and some considerations on how the evolution of human brain may have set the conditions for the creation and use of written language. We cannot afford to dive on the subject with the proper depth it requires, given our lack of competence. The multifaceted literature regarding the analysis of language may prove to be quite complex and hermetic. The main purpose of the chapter is to introduce us to the interplay between cultural and biological factors that may influence the linguistic aspect of human extended consciousness.

A selection of different studies, from different fields, is reviewed. Highlighting the complexity of human language. According to the Integrated Information Theory, we expect to provide some elements suggesting the interdependence between nurture and nature. Human language is the result of an intricate net of cooperation between a huge set of components. The Pirahã language debate was selected as a case study, as it provides interesting elements that may help us understand human language.

Way beyond the complex interaction between gene and environment. Language goes through a historical and political development. Many brain areas are relevant for learning and using a language, but another vital ingredient for human language is the cultural legacy. Recapitulating chapter 2: the whole holds no more information than the sum of its parts, but is rather constrained by the integration between the parts. We opted to focus on the two main aspects of language that may shed some light to the big picture: nurture and nature.

The linguistic study of Pirahã is suggestive because it seems to provide evidence in favor of the idea that the structure of a language determines the native speaker's perception and categorization of experience. Despite our superficial analysis. By considering the cultural aspect of language we hope to provide some evidence for the influence of the environment factor.

"To be or not to be?" the question posed by Hamlet, written by Shakespeare, summarizes the conflict between life and death, one that has troubled humans for centuries. If there is any question more ontological, our ignorance prevents us from asking it. We have no competence for answering such broad questions about: "Life, the Universe and everything" [ADAMS 2010], our interest is in describing how human brain and human

society have evolved the capacity to formulate such questions.

As far as we know, there is no single cortical area in the human brain, no single network knockout, that selectively impairs the capacity of philosophical inquiry. The endless constellation of philosophical questions seem to come not only from a constellation of different cortical areas, but also from a constellation of different social contexts.

The linguistic network areas are specialized in detecting and deciphering the syntax and the semantic of the linguistic components of the philosophical questions, but the social context fuel its motivation.

Where is the evidence? Evidence may lie on the communication skills developed in children raised by animals. A very rare (and despairing) condition in which abandoned children, having lost or being abandoned by their human parents, end up being raised among animals. Children learn the behavior and language from whoever raises them – bear, wolf, birds [LEWIS 2011, SQUIRES 1927] and, of course, humans. Along the evolution, first mammals develop the capacity for representing the internal intentional states [49], prior to that of symbolic consciousness. The intuition about what the other thinks does not need to be verbalized and we are often unable to report the exact feeling we had about what is going on internally in others and in ourselves.

Depending on our language, we modify our way of perceiving the world [SAPIR and WHORF 1956, EVERETT 1993]. Being part of our context and, generally, not being accessible to the consciousness, its influence on us is easily underestimated. Similarly, the recognized influence of weather on our temperament [PERSINGER 1975, HOWARTH and HOFFMAN 1984, DENISSEN et al. 2008] is also commonly underestimated, given that these are issues that remain unconscious longer than conscious. Subjective issues that influence our behavior without standing out in any way for being everywhere make impartiality in the perception of the world impossible.

A question, which relates to the original question about existence, is expressed in the first sentence of the Bible, which seeks to answer: "What is the origin of Heaven and Earth?" The editors of the Bible had special interest in the subject, otherwise they would not dedicate the first sentence, which usually has the most prominent place in the entire text, to present an answer.

Thanks to a complex philological effort we have access, even if indirectly, to part of the content of the oldest texts written by man. The earliest texts, dated between 3200 BC. and 165 BC, offer us creation myths. They are: Egyptian hieroglyphics on tombs [GARDINER 1957, BUDGE 1969]; Hebrew papyri with the Old Testament [REBENICH 2013]; Sumerian cuneiform features marked with stylus on clay tablets; Chinese characters of oracles engraved on animal bones or tortoise shells. We cite just a few of the early texts that, in general, demonstrate the human capacity for imagination, linguistic articulation, a strong inclination toward the mystic and a height-

[49] Chapter 4 has discussed the Mentalizing Network at some extent.

ened state of consciousness. We clearly see, in the fragments of the origin of human writing, the desire for contact with the unknown. As if we were trying to guess the intentional states of the universe around us, wondering what would be going on God's mind.

The concept of inscrutability, or indeterminacy of reference [QUINE 2013] renders a complete translation to be impossible, which constitutes a strong criticism toward correspondence theory. According to this reasoning, no translation, especially the translation of the ancient texts, has identity with the originals. They are "free" (sense-for-sense) and not "literal" (word-for-word) translations [MUNDAY 2013].

A process analogous to what has been named incommensurability [KUHN 1970, FEYERABEND 1970], in which the scientific language that structures concepts makes it impossible to translate a concept from one paradigm to another. E.g., the term "time" used in relativistic mechanics is interdependent with other variables, which is not the case in Newtonian mechanics, so there is no identity between relativistic and classical time. The only way to "translate" would be to modify the classic time paradigm in order to enable its incorporation to the relativistic concept, i.e. in this case, the translation is not possible, thus the two concepts are incommensurable.

It seems that our obsession with what we do not know drives much of the research. We set up creative explanations to fill in the gaps in our knowledge, observing the phenomena and raising hypotheses about the workings of the universe. E.g., Hubble looked at the sky at night – one that has fascinated us since ancient times – and described another narrative about its origin. Hubble had more analysis' tools: the best telescope of its day, sky charts and its Cosmic Redshift measurements; as well as astronomical estimates of the size of galaxies that he himself had calculated. With all this in hand, there is enough data for estimating the age of the universe, based on his expansion rate[50]. From the evidence that the Universe is currently expanding, one may suppose that the galaxies where closer in the past, considering this expansion has been going on since the beginning of the Universe, there must have been a time in the past when the Universe was very small.

The comparison between Hubble's hypothesis for the beginning of the universe and the ancient civilizations' creation myths is only natural. "Concerning the age of the Earth, the Bible's genealogical records combined with the Genesis 1 account of creation are used to estimate an age for the Earth and universe of about 6000 years" [BALL 2003]. Pondering over the age of the Universe requires a degree of imagination that, as far as we know, is uniquely found in humans. Regardless of one's belief, the subject remains as intriguing as ever. Another interesting question: "When was the mythologies' birth?". We may be able to track down the oldest archaeological evidences for human myths, but would there be a way to pinpoint the exact moment our minds began

[50] Hubble's prediction is one order of magnitude off when compared to more recent calculations. Hubble's estimate: 1.8 billion years. Current estimate: 14.4 billion years

to stretch that far? Hubble looked at the spectral lines of stars and galaxies in the sky and our Sun was the only star untouched by Redshift. By doppler effect, a racing car, for example, has its sound shifted to higher frequencies when approaching and low frequencies when moving away. For starlight and galaxies an analogous phenomenon is at play. Looking to the light from the stars one can find out that (except for the Sun) the spectral lines the stars emit are out of phase for lower frequencies (toward the red frequency) indicating that the stars are moving away from us. This finding raises the question: "What are the stars moving away from?". The universe is expanding, concludes Hubble. Have been expanding for how long?

The Cosmic Redshift (an average of the velocity the stars move in relation to the solar system) enables calculating Hubble's constant. Hubble estimated the size of the universe, and calculated how long it would have taken the universe to get from a small explosion to its current size, growing at a constant rate – extrapolating the Redshift has remained the same since then.

Genesis chapter 1: verse 1, one finds records of an answer to a similar question that Hubble asked: "in the beginning God created the heaven and the earth". Our origins are fascinating, the origin of our fascination is also fascinating. The biblical verse answers why the Universe began. Hubble's work, on the other hand, gives a description for how was the Universe at the beginning.

A series of experiments were carried out with the chimpanzee named Sarah, in which Sarah was able to point out with good precision, among alternatives presented to her, what card better predicted the probable behavior that would follow in short videos showing humans troubled with some simple puzzles [PREMACK and WOODRUFF 1978]. During human history, trying to read God's mind has been a puzzle that fascinated our imagination and faith. As for the former, we are probably in a better position than Sarah to tell if she figured us out correctly or not, as for the latter, God is probably in a better position to tell if we figured Him out correctly or not.

> Even so, the biggest stumbling block for evolutionary biologists has been recognising that religion might have a functional advantage. If a biological trait has evolved, we want to know what use it is – and by that we mean how its possession makes an individual better adapted to survive and pass their genes on to the next generation. [DUNBAR 2022]

Faith in God is an universal human behavior. The ultimate act of faith is martyrdom: sacrificing one's own life in the name of God. From a biological perspective, martyrdom is a maladaptive behavior. Maladaptive behaviors, according to evolutionary theory, should be negatively selected over generations, but this was not the case for religious behavior in humans. Against such puzzle, the authors have no competence to go any further.

7.2 Learning about the unknown

"The final frontier ... To boldly go where no man has gone before." [RODDENBERRY et al. 1966].

The first question. The question from which all the other questions arise. The predisposition to make questions, evoking the inquisitive behavior, from which all subsequent questions arise. We suggest that at the heart of the existential anguish, so characteristically human, lies the Theory of Mind. Although we are unable to prove this hypothesis nor express it more clearly, Sartre seem to have nailed it, the desire for knowledge comes, according to him, from the look from another person and not knowing what that other person is thinking. We crave for being loved and nurtured. The idea of being rejected is disgusting. Not knowing what lies behind the eyes of the other person drives us crazy. Following Sartre, all the other questions seem to arise from this primordial anguish [SARTRE 1943].

Hubble's question is somewhat close to the first question the Bible provides an answer for: where did it all started? The question seems relevant, otherwise it would not be on the very first sentence of the very first page of the most read book in the World. Our humble interest lies in what leads humans to formulate questions.

The greater our ability to find informed and coherent answers to undo the ignorance about what is going on internally, the greater our ability to meta-cognition, i.e. to produce knowledge about knowledge, thoughts about thoughts, feelings about feelings. The ignorance of our own ignorance (meta-ignorance), on the other hand, incline us to have greater confidence on our own knowledge [DUNNING 2011], enabling cognitive networks to stop wasting resources and rest.

Without consciousness, there would be no knowledge acquisition. The better our understanding of consciousness, the better would be our understanding of knowledge acquisition. Unfortunately we are far away from having a solid theoretical base, with good answers to the most fundamental questions about consciousness. We have no way to measure consciousness directly. Having only access to the neural imagery activation over time, it may be possible to predict whether the subject was conscious or not. The integration of specific brain regions is required for consciousness, as well as the activity of neurons in specific areas of the cerebral cortex [TONONI et al. 2016]. Nonetheless, even if we consider the images of neuronal activity and the values of the integration between brain regions can be correlated with consciousness, yet this method gives no direct access to consciousness.

This intricate process easily leads to illusions. Bayesian theory proposes that the brain is involved in sophisticated probabilistic reasoning [HOHWY 2013]. In order to know what is outside a closed box (the thing itself) we, inside the box, can only make assumptions about what is outside by the phenomena that come to us. The calculation to find the hypothesis that has the greatest chance of being true is the one with the greatest

a posteriori probability P(hi|e). The posterior probability is equal to the multiplication of *likelihood* P(e|hi) with *prior* P(hi). *Likelihood* is the probability that the evidence will occur given the hypothesis being true; *prior* is how common the hypothesis is (how often the event described by the hypothesis has been observed in the past). In summary: P(hi|e) = P(e|hi)P(hi).

Let us say there is a humanoid silhouette behind a translucent curtain. If the assumption that there is a person behind the curtain would likely result in such observation – P(hi|e) is closer to one than zero – and we observe people often – P(hi) is more closer to one than zero – I can plausibly conclude there is a person behind the curtain.

The theory also predicts hierarchical processing levels. At the base are neurons sensitive to external stimuli, these subordinate networks stimulate the upper layer only when one of the following conditions is satisfied: 1- there is no previous prediction (non-existent model) or 2- there is a difference between the signal coming from below and the expectation from the upper level (prediction error or model error). This recursive process repeats, passing on information to higher levels. The predictions of the level immediately below will raises information to the higher level in the case when one of the conditions 1 or 2 is satisfied. This model is based on the principle of least information, or maximum entropy. Model that seeks to optimize the energy expenditure of the system, a law that regulates any living organism or cell. If the lower levels always sent electrical signals to the higher levels, even when the higher level had already correctly predicted the information coming from below, there would be a huge waste of energy and inefficiency.

At the top of the hierarchy would be the processing set that produces hypotheses about the lower levels. This set is fed with all the information coming from the errors of its predictions, it makes the predictions to be passed on to the lower levels, level by level. For an organism that works according to the Bayesian theory, it would be very efficient to be capable of metacognition. If the higher level discerns about the very process that it and the lower levels perform, it can improve, redo the connections that get it wrong most often and strengthen those with a high level of success.

Our model of the world can contain errors that contaminate, from top to bottom, the perception of the world. On the other hand, if our senses do not receive any information to pass to the higher processing levels, the ability to update the model would be weak, as the lower levels would no longer feed the higher levels with prediction errors. tion. If our senses pass on incoming information but distort it in the process, our mind map will incorporate that distortion into its description of the world.

The struggle to find meaning in things that we are not yet able to predict correctly accompanies us on our journey through this world.

7.3 The oldest recorded questions and their relation to the social brain

Modern *Homo sapiens* have their oldest burial ritual 115 $\pm$ 15 [51] thousand years ago at Qafzeh in Israel [SCHWARCZ et al. 1988] as shown by the archaeological records. This date coincides with migratory movements from Africa toward other continents. The bones at the site were stained with red ocher, the use of red ocher in rituals increased from this date to 50,000 years ago. Its use suggests that such associations are the origin of a symbolic referential and are consistent with the existence of the symbolic culture [HOVERS 2003]

The Creative Explosion, during the Upper Paleolithic Revolution, can be taken as an evidence hinting for the birth of philosophical questions being formulated by our ancestors. We cannot name what the exact question was, but having the capacity for social pain (discussed in chapter 5), the ritual burial of another person suggests grief for losing a relative. The social pain one feels at such circumstances is biological, but the symbolism and liturgy employed (shown by the regular use of red ochre on the mortuary customs at the time [Wreschner et al. 1980]) is cultural.

The structure and volume of the human skull changed considerably during the Pleistocene period "Early to early Middle Pleistocene (1,800 - 600 kya) Homo was about one-third less encephalized than Recent humans, and there was no increase in encephalization quotient (EQ) throughout this period." [RUFF, TRINKAUS and HOLLIDAY 1997]. In the last 90 thousand years, however, little variation was observed in the encephalization quotient in our ancestors, with even a slight drop when comparing human fossils from the last 10 thousand years with the current records [HAWKS 2011]. Between 600,000 and 200,000 years ago the encephalization quotient of our ancestors tripled.

There is no evidence for a change in cranial structure and brain volume over the last 90,000 years. The oldest "anatomically modern" *Homo sapiens* bones, dated approximately 196 $\pm$ 5,000 years ago, contain the same cranial structures characteristic of modern humans [HAMMOND, ROYER and FLEAGLE 2017]. If there were no structural changes nor in the encephalization quotient during the Upper Paleolithic creative explosion period, what is the reason for the change in human behavior during the Upper Paleolithic creative explosion? Another question we are not competent to answer.

The module responsible for linguistic meaning present in modern human beings is primarily responsible for our capacities for expression. The stages of child development bear some resemblance to the changes in behavior observed in different stages our common ancestors went through. The study of child development, archaeological findings and indigenous language, drawing some similarities that may be found up to a point, may shed light on the birth of human consciousness. Problem solving,

[51] The carbon swimming technique used accuracy admits a maximum margin of error of 15,000 years.

creative thinking and children's make-believe play are abilities to reason and create assumptions [CARRUTHERS 2002]. Along with cultural aspects passed on from one generation to the next.

Neuroscience points to two fundamental mechanisms that suggest the motivation for burials of mortal remains. One of them is the activation of the dorsal anterior cingulate cortex, a region that makes pain unpleasant, during the loss of social relationships. The other mechanism is located in the areas of the Default Mode Network which overlaps the areas of the mentalizing network [MOLNAR-SZAKACS and UDDIN 2013, HYATT et al. 2015, SPUNT, MEYER and LIEBERMAN 2015, LIEBERMAN 2013, MARS et al. 2012]. In short, we grieve over the loss of a loved one, we wonder what happened to the mind of the person who died, both processes are corroborated by the neurological evidence. These two mechanisms alone do not explain the ability to use the burial as a symbol (a short discussion over linguistic aspects of consciousness on chapter 7), but justify the mourning for the emotional bond that was lost. The linguistic aspect of extended consciousness is crucial for language acquisition and use. Social animals in nature develop some language skill. We suggest that, in human species, much of our biological apparatus for linguistic processing is due to our natural dispositions for social life. However, lack of exposure to an environment where a natural language is spoken during early development can be almost as detrimental to language acquisition as the absence of the proper genetic makeup.

In mammals, social pain in mother and child is an essential characteristic that increases the survival chances. Social pain predisposes maternal behavior in the mother and learning of healthy coping mechanisms and social behavior. Social pain, like physical pain, activates the dorsal anterior cingulate cortex. In the laboratory, rodents that were injured in this specific area display serious deficits in maternal aspects, compared to controls. The contribution of this area to the vocalization of the baby and maternal care is important [NEWMAN 2007]. In our case, activation in this region can, for example, make the death of a loved one painful. During grief, human beings usually seek comfort. Ceremonial rites of passage can help to cope with loss. The evolutionary moment in human prehistory in which the social behavior accompanied with grief becomes more complex coincides with the end of a stage of more crude and slow development and the beginning of a more refined use of tools and territorial expansion. The early burial sites and how this practice changed over time concern to the how we draw the time lines dividing the Upper Palaeolithic age [RIELSALVATORE and CLARK 2001].

Carruthers points out that mentalizing contributes to consciousness [CARRUTHERS 1998]. By creating hypotheses about what goes on in the minds of others and in our own minds, we are at the meta-knowledge level, we perceive ourselves as beings capable of experiencing intentional states. The fact that we observe the first human burials during the same period when there was a great cultural change is suggestive, to say the

least. An important distinction of the human mind is its enormous capacity to care for other minds.

The mentalizing network appears in primates and is strengthened in our species. One of the functions it fulfills is to create strategies to avoid isolation, generating hypotheses about what is going on in the minds of others and in our own minds, seeking to minimize the prediction error. The ability to reflect on other others' mental states – intentions, beliefs and desires – helps us to achieve our own interests or those of others, if we wish to do so. The mentalizing network activates the same areas as the network by default. The default mode network is turned off when solving a math exercise, for example, but as soon as there is a break between exercises, it turns back on. Whenever the brain finds idle time, it activates the same areas of reflection on the person and on others. In that sense, the brains of the vast majority of human beings look alike.

From a neurological point of view, it seems plausible to say that we are strongly inclined toward the social world. As the Default Mode Network is often activated, we start to create all sorts of hypotheses about the mind of the dear person who passed away. One of the questions a person may ask is: "Where goes the mind of the person after death?"

There is nothing to show that the lion reflects on the death of a zebra. She needs to recognize the zebra, she needs to identify it from a distance, but we have no evidence to suggest that she is aware of it in the sense that no lion was observed to be in doubt about its course of action. Once a lion identifies a zebra, is hungry and recognizes an opportunity to capture the zebra, the lion attacks and kills the zebra. No hint of remorse, no hint of doubt.

We have little access to the mind of lions. Humans, on the other hand, can give verbalized reports about what happens internally. We also have internal access when consciousness is less active, during sleep. Three types of non conscious and semi conscious states during sleep: dreamless sleep, normal dream and lucid dream. During dreamless sleep, consciousness is completely shut down, we completely lose the perception of the passage of time. During normal dreams, we have a loose perception of the passage of time, but no control over our dreamed actions and contents of the dream. During lucid dreams, we have some control over the content of the dream and we may guide the actions we "perform" during the dream.

We can only conjecture to what happens to the mind after death. Arguably, the "experience" may be the similar to the "experience" of a dreamless sleep. But the idea of death as a dreamless sleep that never ends is not enthusiastically accepted. This dreamless sleep "theory" is painful for the grieving relatives. Mourning our losses is painful enough. We fill the void of ignorance with beautiful tales of heaven, frightful tales of ghosts, fearful images of hell. Our mentalizing network keeps on creating hypothesis, it does not check the obituary.

7.4 Talking neurons

To picture the mind as resulting from the parallel activity of neuron cells in the body is not intuitive, as we do not live at the scale of neuron cells. Our awareness is related to macroscopic events, observable with the naked eye, the cellular scale is alien to us. On top of that, the stream of consciousness is usually perceived as an unified process for the conscious person. The whole concept of consciousness as a compositional mosaic from the contributions of many parts is a fragmentary concept. A good analogy is usually one made with something one is quite used to. And computers are something we have grown to be quite used to nowadays. The computer analogy to the mind was almost inevitable.

> This article presents one alternative to the computer analogy that suggests brains are organized into independent modules. Evidence is reviewed that brains are in fact organized into parallel processing streams with complementary properties. Hierarchical interactions within each stream and parallel interactions between streams create coherent behavioral representations that overcome the complementary deficiencies of each stream and support unitary conscious experiences. [GROSSBERG 2000]

The parallel processing theory is gaining academic momentum [ZEKI 2015, WHITE and MCDONALD 2002, SIGMAN and DEHAENE 2008]. Roughly speaking, the information is simultaneously processed into its different domains (perception, learning, cognition, action, etc.) enabling competition, cooperation and interaction between networks. Not only there is plenty of neurological evidence supporting the idea, the concept is seductive. As in Dennett's motto "One discharges fancy homunculi from one's scheme by organizing armies of such idiots to do the work." [DENNETT 2017].

The parallel processing theory is opposed to the encapsulated modularity theory for neural processing, such as supported by a computationalism à la Fodor [FODOR 1983]. It seems plausible that, from parallel networks, the nodes and ramifications of the different areas of the cortex, with their respective specialties and deficiencies, organize themselves in a democratic hierarchy [NICOLELIS 2011], even though connections have different weights, the number of "voices" stimulating (or inhibiting) the activation potential for it to be triggered (or not) tends to be a determining factor. A similar analogy is made by comparing the neurons to a pandemonium.

> The constant interplay of bottom-up and top-down connections provides a neuronal implementation of Selfridge's "pandemonium," (...). Populations of neurons literally act as an assembly of daemons that constantly send messages in all directions, thus passing on the fragmentary data at their disposal to each other until the whole group converges toward an agreement.

Not much different than an academic debate. A single scientist does not hold all the scientific knowledge available, but the accumulated efforts from scholars of many different fields and backgrounds (past and present) will more likely be capable to generate ideas with less and less errors after each generation. This comes not from as a simple linear addition of the many contributions, as independent researchers in parallel projects may diverge or make mistakes. A conclusion can only come through disputes and coalitions between groups of scientists, until one group is able to become a majority and convinces, silences or waits for the defeated opposition to grow old and eventually die. Otherwise, simply adding the claims from all the different scientist over history would result in contradictions, as members of the scientific community often disagree. If, on the other hand, we take the contrast between the plurality of different perspectives as constraining the possibilities, we may take the less considered interpretations to be the less plausible ones.

Arguably, the scientific endeavor resembles the neuron cells activation in the brain, in a coarse analogy. A complex structure with a huge number of component parts working in parallel, none having access to the whole picture, but each one having a small contribution to give, fighting to join his voice to its neighbors.

The ideas we hold are fragile, open to revision and change. Even good indicators: solid and numerous evidence and researchers' community endorsement; do not necessarily imply the veracity of any held belief, after all, one should not expect indicators to do more than what their name suggests. Also, scientific hypotheses are not candidates to the ultimate truth, but can only serve as provisory conjectures among many others. A hypothesis may be more likely than others, yet it does not follow from that the more likely hypothesis is the true hypothesis.

According to a strong relativistic approach, one should consider the possibility that a plurality of hypotheses may be correct. But, if the plurality of hypothesis is not constantly checked and monitored, it may simply become a cluster of disorganized information – the academic analogous to what biology names "cancer".

In the linguistic debate over Universalism vs Relativism, the dissent over the language influence over perception cannot be resolved only with linguistic theories without analyzing the neuronal functioning of the perceptual system [DAL'PUPPO and AMARAL 2021].

A balance has to be reached. In order to explore a wide range of diversified possibilities, scientists enjoy some freedom to present any theory, no matter how bizarre. Having said that, it comes with a caveat: scientific theories can be falsified. To hold true a theory that has been falsified throughout is considered intellectual dishonesty and not welcome anymore, until good evidence is provided.

The paradox Plurality vs. Universality poses us a problem: is it possible to find an unified set of rules that can describe the diversity? We may now enter the arena of the linguistic turn. 'Linguistic turn' is an expression used to refer for the impact of the

relationship between philosophy and language, which began to be significant in the early 20th century.

Universal grammar, in modern linguistics, is the theory of the genetic component of the language faculty, usually credited to Noam Chomsky, a major author during the linguistic turn. Chomsky proposed his generative theory of language highlighting how common principles, underlying all natural languages, can structure the language acquisition mechanism found in the human brain.

Unfortunately, we cannot cover the matter at length, but only hope to provide some superficial ideas regarding two topics: first, how the study of Pirahã language poses some challenges to Chomsky's universal grammar; second, the possibility of describing the diversity of the world coded through written letters and words.

7.5 Pirahã language and Chomsky's generative theory

In the Thesis Everett presented at the Department of Linguistics of the Language Studies Institute at the State University of Campinas – "A Lingua Pirahã e a Teoria da Sintaxe". In his Thesis he proposes, first a theoretical analysis of Pirahã from sentences to phonemes, . 4). He deepens a discussion of the epistemological implications of development of Chomsky theory and the importance of an epistemological perspective in research. He presents a general insight of the generative grammar of Pirahã, analyzing especially the problem of co-reference between dependent terms and its antecessors. Including two appendices to help understand the Pirahã language and Chomsky's theory, according Everett's abstract: [52]" [EVERETT 1983]. Everett applied scientific methodology in collecting data about Pirahã language, his wife played a critical role as Pirahã women do not talk with males that do not belong to their people. Their detailed analysis of the Pirahã language afford a deep analysis of the roots of human language.

"The generative theory has, for me, the most beautiful 'package' of all mentalist theories"[53] [EVERETT 1983, our translation]. Everett made an effort in his analysis to follow the methodology of nuclear grammar and to follow a deductive structure, as proposed by Chomsky:

> I would like to make an application of the current Chomskyan theory (...) to the Pirahã language, in an attempt to show that it is extremely promising, empirically and, theoretically, serves as a model of human linguistic competence. [54] [EVERETT 1983]

Everett's promise was received as threat to Chomskyan theory, as it exposes some critical issues Universal Grammar seems unfit for answering. There is a gap between

[52] uma série de definições e discussões de mais de cem termos técnicos da teoria chomskyana

[53] A teoria gerativa tem, para mim, a 'embalagem' mais bonita de todas as teorias mentalistas

[54] gostaria de fazer uma aplicação da atual teoria chomskyana (...) à língua pirahã, numa tentativa de mostrar que ela é extremamente prometedora, empírica e, teoricamente, serve como modelo da competência lingüística humana.

Pirahã grammar and Universal Grammar. The gap is that Universal Grammar presupposes recursion – sentences embedded inside sentences, for example – but Everett presents evidence that Pirahã language forbids the building of sentences inside sentences.

> The deductive structure (...) is a starting point. It has to leave out social, pragmatic information, etc. according to Chomskyan idealization, because the nature of what we study is purely grammatical (...). I.e., in order to reach an understanding or, at least, a characterization of the competence of the native speaker, we have to propose a deductive structure free from the interference of the heterogeneous community, precisely because our initial idealization presupposes that in order to solve the problems in which we find ourselves, this heterogeneous information is irrelevant and will confuse us. [EVERETT 1983, our translation] [55] [EVERETT 1983]

When we ask about the notion of the "scientific idealization", as a necessary question to understand the nature of the nuclear grammar and as a basic principle of scientific inquiry, Everett seeks, in the perspective of his research new alternatives, in the sense of ontology. While asking himself about the notion of "scientific idealization", as a necessary question to understand the nature of nuclear grammar and as a basic principle of scientific inquiry, Everett seeks, in his research alternative perspectives, in the sense of ontology. The core grammar is defined by Chomsky referring to recursion and lexical terms.

Quoting Feyerabend about the "observer" has an a priori perspective that affects his observations. In even stronger terms:

> A comprehensive theory, after all, is supposed to contain also an ontology that determines what exists and delimits the domain of possible facts and possible questions. [FEYERABEND et al. 1993].

From this point of view epistemological considerations are linked even with a "description" of an indigenous language. What is the "ontology" we seek to describe? Conversational structures? Innate linguistic competence? Constriction of the pharyngeal walls? [EVERETT 1983].

As we understand, the domain of Everett research when studying the indigenous language of Pirahã is primarily questioning the innate linguistic competence, entering in the debate of nature versus nurture.

[55] A estrutura dedutiva (...) é um ponto de partida. Ela tem que deixar de incluir informação social, pragmática, etc. segundo a idealização chomskyana, porque a natureza daquilo que nós estudamos é puramente gramatical (...). Isto é, para chegarmos a um entendimento ou, pelo menos, a uma caracterização da competência do falante nativo, temos que propor uma estrutura dedutiva livre da interferência da comunidade heterogênea, justamente porque nossa idealização inicial pressupõe que para resolver os problemas em que nós nos colocamos, esta informação heterogênea é irrelevante e nos confundirá.

7.6 Learning Pirahã

Everett in his text "What does Pirahã grammar have to teach us about human language and the mind?" highlights:

> I believe that the most important lesson of Pirahã for theories of the mind and language is that culture may exert an architectonic effect on grammar. The cultural constraint on Pirahã grammar, which I have termed the 'immediacy of experience principle' (IEP), is based on the deceptively simple fact that the Pirahã require evidence.
>
> Grammar and other ways of living are restricted to concrete, immediate experience (where an experience is immediate in Pirahã if it has been seen or recounted as seen by a person alive at the time of telling), and immediacy of experience is reflected in immediacy of information encoding one event per utterance.3 Less explicitly, the chapter raises the possibility, subject to further research, that culture constrains cognition as well. If the assertion of cultural constraint is correct, then it has important consequences for the enterprise of linguistics. [EVERETT 2005].

The concept of language as a cultural tool makes it easier to understand why, after nearly 100 years of modern linguistics studies and field research we are still lacking a non-controversial proposal on the nature of universal grammar [EVERETT 2012].

Daniel Everett arrived in Brazil sponsored by the Summer Institute of Linguistics, as one of the many missionaries translating the Bible into various languages. Little was known about the Pirahã language previous to his arrival, because the documentation about this language was very scarce and incomplete. The previous attempts from the Summer Institute of Linguistics had failed after 20 years studying the Pirahã. Learning Pirahã language was uncharted territory, so to speak, the only way was to live among them, learning directly from native speakers. This experience dramatically changed his world view. He understood Pirahã were happy, even facing all the hardships posed by their lifestyle and constant menace from external invasions to their territory, they were not saddened nor troubled. Everett did not expect this scenario before his arrival, he imagined they would welcome the teachings of the church in a similar way he experienced during his adolescent years when he got initiated in substance abuse and found in the church a way out.

The absence of a christian God in Pirahã culture was no obstacle for their happiness, as he once believed would be the case. Somehow getting to know the Pirahã changed something deep inside Everett's mind. Later Everett lost his faith in the christian church, becoming an atheist. He had to acknowledge much of his prejudice concerning the Pirahã was unfounded, after the time he spent with them. It could be said that, instead of Everett converting the Pirahã, as was Everett's initial goal, the Pirahã ended up converting Everett, which was never their intention.

It is no secret that our society is biased by language. The 1988 constitution forbids illiterate citizens to run campaign for any position of political power "§ 4º illiterate persons are ineligible." [56] [BRASIL 2010, our translation]. It took more than two decades for a complementary law to establish that eligible candidates must present a clean criminal record[57] [BRASIL 2010]. From Brazil's legal perspective, it was only recently that having a criminal record became as forbidding for running a political campaign as being illiterate. Pirahã people live in Brazil territory, but, even so, they are not granted the same rights to partake on Brazilian democracy as other citizens enjoy, because Pirahã are not only illiterate, but do not speak Portuguese. If such bias is to be found in the supreme law, what not to expect from its citizens?

Bearing that in mind, Everett's paper title: "What does Pirahã grammar have to teach us about human language and the mind?" seems provocative, to say the least. Not only the study of Pirahã language defies the Universal Grammar theory, it defied Everett's faith.

The Universal Grammar defended by Chomsky is criticized by Everett:

Universal grammar has emerged as the most prominent hypotheses in the past 50 years on the nature of language. It is of the more simplistic variety of the nature versus nurture hypothesis, in that it hypothesizes a single 'core' grammar of human languages at the far end of the continuum, deriving strictly from nature. Pirahã language, and other examples that are beginning to come to light, teaches us that universal grammar should be seriously re-evaluated. [EVERETT 2012, p. 556].

Everett, while talking about his religious teachings with the Pirahã, describes the difficulties he dealt in translating the recursive sentences in the Bible to the Pirahã:

> The Bible is full of recursive examples, such as the following, from Mark 1:3:'(John the Baptist) was a voice of one calling in the desert...' I initially translated this as: 'John, the man that put people in the water in order to clean them for God, that lived in a place like a beach with no trees and that yelled for people to obey God'. The Pirahãs rejected every attempt until I translated this as: 'John cleaned people in the river. He lived in another jungle. The jungle was like a beach. It had no trees. He yelled to people. You want God!' The non-recursive structure was accepted readily and elicited all sorts of questions. [EVERETT 2012, p. 558].

Recursion enables building phrases of theoretical unbounded length. Without recursion, to create sentences of unbounded length in Pirahã should not be possible. From Everett studies, the idea that recursion serves as an fundamental feature for the universal grammar may require some revision:

"Assuming that my analysis of Pirahã is correct here, then the first lesson to draw from Pirahã for human language and the mind would be that, contra HCF [Hauser,

[56] § 4º São inelegíveis [...] os analfabetos.
[57] Known as "Lei da ficha limpa", complementary law number 135, 4th of june 2010.

Chomsky and Fitch], recursion is unnecessary for human sentential syntax."

Everett's perspective holds that the human language does not need to rely on recursive capacity. The faculty of human language was considered to be grounded upon recursion. Unbounded language is only found on the human species and the recursive capacity was considered to be its key. [SILVA 2014, p. 35]

> Now, I agree that recursion is crucial, but I do not think that sentence recursion per se is all that important. Rather recursive thinking is what is crucial. One way to approach this issue is to think of recursion in thought and language as tools, but that recursion in language shows up when and where a culture desires it, if it does at all. [EVERETT 2012, p. 286].

Even though there are evidences that Pirahã does not show recursion on their speech, Everett is not arguing the Pirahã do not think recursively. Quite the opposite, he claims the Pirahã do have recursive reasoning:

> I have argued that Pirahã discourse shows clear evidence of recursive reasoning. If this is correct, then can't we simply concede the I-language point, namely, that Pirahãs clearly do recursion, but that a stipulation some sort on Merge prevents us from seeing the results in their actual utterances [EVERETT 2012, p. 559].

According to Soares, the recursive thought may show itself in other ways, even if it does not show itself on the form of sentences with recursive syntax. There may be stories that possess recursion in its plot. According to Everett this is what happens in Pirahã language.

> A language could eliminate recursion from its sentences by restricting recursion to stories, developing recursive relationships between, rather than within sentences. It seems that all people not only reason recursively, but that they need recursive language as a tool to express recursive thoughts. However, if the recursive thoughts a culture wishes to express can be expressed adequately without recursion in the syntax, then the tool of recursion are unneeded outside of discourses. This would be reinforced if there were other cultural principles that made recursion less desirable for that language, as has been claimed in several publications about Pirahã. [EVERETT 2012, pp. 287-288].

In general, Everett keeps the position that Pirahã do not have embedded sentence structure and absence of counting system. But these differences may be a reflex of cognitive differences. Everett claims that Pirahã people have a vast knowledge about the jungle. They know when and where to get more fish and nuts. The seasons are more important in their lives, naming the trees, whistling instead of talking not to scare the prey. Language is the cultural tool [EVERETT 2012], it serves for guiding our lives across its many dangers and opportunities.

> (...) if the Pirahã show additional cognitive deviations from Western expectations with regard to, for example, color identification, ability to interpret multiply embedded structures, or relative tense concepts (all matters that require careful, culturally appropriate psychological experimentation), then these would seem most economically understood in terms of cultural constraints as well. Thus what the paper has labored most intensely to establish, namely, that Pirahã culture constrains Pirahã grammar, also predicts that the effect of this constrain could eventually affect cognition as well." [EVERETT 2005, p. 27].

The exceptional character of Pirahã language is evident. Everett claims their grammar is constrained by the culture. As they only speak about what is observable and what they experience (actions) it models the way they speak. At light of Chapter 2, the interface between grammar and culture imposes a limit to the possible utterances.

> With respect to Chomsky's proposal, the conclusion is severe – some of the components of so-called core grammar are subject to cultural constraints, something that is predicted not to occur by the universal-grammar model. I argue that these apparently disjointed facts about the Pirahã language – gaps that are very surprising from just about any grammarian's perspective – ultimately derive from a single cultural constraint in Pirahã, namely, the restriction of communication to the immediate experience of the interlocutors. [EVERETT 2005].

Here Everett is questioning, once again, the core of Universal Grammar. Everett's reasoning is that the IEP imposes a radical change on grammar. If all human beings are born with a innate grammar, then why are the Pirahã grammar so different from the grammar shown in other languages?

7.7 Evaluating the Sapir/Whorf hypothesis in the scope of Pirahã language

Deutscher speaks of two different views: "primitive people speak primitive languages." and: "All languages are equally complex." Deutscher places himself more closely to the first view. "I'll try to convince you that neither side has got it quite right, but that linguists have fallen into the more serious error." [DEUTSCHER 2010, p.99].

While learning our mother language, we indeed acquire certain habits of thought that shape our experiences in a significant manner. According to Deutscher the mistake of Whorf was presuming that the mother language restricts our mind and inhibit our capacity of thinking certain thoughts.

Pirahã language suggests by the IEP that there are ideas that cannot be expressed in a given language because the language itself may present an insurmountable obstacle to express the idea. Pirahã only enables to express: what one have seen by themselves, that a known person have seen, or that they have evidence to believe. An abstract idea,

such as God, present a difficulty when translated to Pirahã language. Pirahã culture is influenced by the language, for example, in order to talk about Jesus, they would have to either see Jesus, or know somebody that has seen Jesus. Everett's efforts to explain Jesus to Pirahã people were met with a language obstacle that prevented any chance of successful translation.

Evaluating the Pirahã language using Sapir/Whorf hypothesis seems to suggest the linguistic constraints may impose limits to what can be perceived or expressed. As in the Following this interpretation, the same reasoning could be applied to any language. Nonetheless, when a native speaker of English met the native speakers of Pirahã, in order to parse sentences from English to Pirahã, the information loss due to the translation is more dramatic. Suggesting that languages vary in complexity in such a way that it stresses the possibility for an Universal Grammar. "There is no need for an advanced course in logic to realize that the two statements 'there are no primitive languages' and 'all languages are equally complex' are not equivalent, and that the former does not imply the latter." [DEUTSCHER 2010, p. 103].

"As it happens, the dogma of equal complexity is based on no evidence whatsoever." [DEUTSCHER 2010, p. 105].

Language influences culture; 2. All languages are equally complex. The IEP proposed by Everett corroborates the first statement. Those two statements together can be expressed as a relativity principle. There is an example in Deutscher explaining the role of language to mental cognition. "There is no verb in Nootka that corresponds to our general verb 'fall' and that can describe the action independently of a specific falling object. Instead, a special verb, 'to stone,' is used to refer to the motion of a stone in particular. To describe the event of a stone falling, this verb is combined with the element 'down.' So the state of affairs that we break up into 'stone' and 'fall' is described in Nootka as something like 'stones down.' Such concrete examples of 'incommensurable analysis of experience in different languages,' Sapir says, 'make very real to us a kind of relativity that is generally hidden from us by our naive acceptance of fixed habits of speech . . . . This is the relativity of concepts or, as it might be called, the relativity of the form of thought.' "

The "universalist" reaction of Nevins, Pesetsky e Rodrigues (2009) presented on the Language magazine, analyzes and debates Everett's proposal and seek to confront the very evidences provided from Everett's studies of pirahã language against the hypothesis forwarded by Everett.

> Relying on the available documentation and descriptions of the language, especially the rich material in Everett 1986, 1987b, we argue that many of the exceptional grammatical 'gaps' supposedly characteristic of Pirahã are misanalyzed by Everett and are neither gaps nor exceptional among the world's languages. We find no evidence, for example, that Pirahã lacks embedded clauses, and in fact find strong syntactic and semantic evidence

> in favor of their existence in Pirahã. Likewise, we find no evidence that Pirahã lacks quantifiers, as claimed by Everett [NEVINS, PESETSKY and RODRIGUES 2009].

The very concept of recursion may further cloud the debate. Fitch analyzes the recursion concept as used in mathematics, computer science and linguistics. Suggesting that recursion is a grammar property, not a language property. Suggesting an open concept of recursion, to be constrained depending on its context.

> A definition of recursion focused on which kinds of information individuals can represent and use it to make specific predictions about behavioural responses associated with the representation(s) of recursion. Furthermore, we suggest that recursion should not be assumed as a monolithic and encapsulated domain-specific module in absence of evidence to the contrary. Instead, empirically relevant definitions of recursion should be compatible with either domain specificity or domain generality, and further conclusions should follow and not precede empirical results.

At risk of boring our readers to death, it is time once again to repeat the motto of our thesis: consciousness is complicated, composed of many parts, constrained, by its turn, to the context they belong. Parts embedded into subgroups, subgroups embedded into groups.

7.8 Reflections on Pirahã language

There is a personal reflection that Pirahã shows a very esoteric behavior. Often Pirahã avoid contact with foreigners (a reason why it was hard for accounting the total number of Pirahã people). Pirahã's esoteric behavior probably kept Pirahã people alive, despite all the efforts europeans went through in changing that.

When we look on western history the more a civilization displayed exoteric behavior, the more knowledge they collected. The Egyptian and Roman culture in ancient history; the Italian at the Middle Ages; the Portuguese and Spanish on renaissance; the French and English in the industrial revolution. The other way around can be considered: the more knowledge they collected the more expansion they were able to do. The more a cultural group get in touch with different communities, the more ideas they are exposed to. Ideas are exchanged from different cultures (the most complex and rich cultures were often found near the most transit, such as in a busy commercial trade route). One example is gunpowder: it was brought from China to Europe, not to be used during festival in fireworks, but in a much more deadly fashion. A good example of how the exoteric behavior can be dangerous as well.

Pirahã language – using only simple tenses, not using embedded structures, not having numerals, etc. – does not require a complex grammar. The simple grammar rules does not compromise the expressive power of the language. It may be interesting

Table 4: Table of som Pirahã language characteristics

Absent features	**characteristics of Pirahã language**
No discrete infinity	Rudimentary drawing and absence of other manual artwork.
No recursive possessives	Rudimentary fiction and creation myths.
No long-distance dependencies	An example of Amazonian worldview [EVERETT 2005, p. 636]
No words for numbers	People and things represented by names.
No sub clauses	Recursive thinking / recursive reasoning.
No color terms	Light and dark terms to differentiate shades of color.
No complex tenses	Simple past, simple present and simple future.
No stacking of modifiers	The verb, its arguments, and one modifier for each of these.

Source: author.

to look for formulaic structures in Pirahã language. According to Wray a formulaic language is present in esoteric and oral languages and benefits the speaker:

[WRAY and PERKINS 2000]. As a small group it would be very productive to Pirahã to use formulaicity. It would be a surprise if they do not use it. Everett, from Chomsky's postulates, concluded in his thesis a great number of absences. The differences from Pirahã language, compared to western languages, are dramatic. The cultural elements preserved by the Pirahã people, even its simplicity, is a endangered heritage we should treasure. The history of threats of violence endured by Pirahã people is not a novelty, but it escalated dramatically in recent years.The loss of Pirahã language would bring great harm to the understanding of human language.

Pirahã do not have words for the levels in their cosmology. They admit not to know if there are more layers. There is also some uncertainty of what composes each layer. Some reduce the complex structure to a simplified version. In that version there are five levels, this version retains the details and impressions of the larger version. The five levels are as follows:

- abaisi e ibiisi
- abaisi e ibiisi
- ibiisi
- abaisi, kaoaiboge, toipe, ibiisi
- abaisi e ibiisi

Each line correspond to a cosmic level. Each level is inhabited by different beings. Their version of the Universe consist of those levels. We should note such description

of the universe does not mention any creational myth. Nevins et al contest Everett regarding the question of creation myths. “the Pirahã do have narratives about the mythic past. [NEVINS, PESETSKY and RODRIGUES 2009, p. 392]

The controversy has accumulated systemized data, studies and research surrounding the linguistic proposal by Everett. It would be interesting not to focus only on the controversy between the generativist (Chomsky theory) against the position defended by Everett. Perhaps Everett was hasty by saying that he had falsified the Universal Grammar, as the enemies of Everett were hasty by overlooking the data brought by Everett's research.

Everett claims have fired up a heated debate between two sides. At one side Everett defended his ideas; at the other the Universal Grammar defendants attacked Everett's authority and his collected data.

The Pirahã's power structure is quite different. The social hierarchy in Pirahã society is horizontal. Even though their borders are often threatened, the violence witnessed by Everett came from within. An outsider gave sugarcane liquor to Pirahã as payment for collecting brazil nuts for him. Everett forbid them to drink, they ignored him and drank anyway, gathering courage to threaten Everett and his family. Taking preventive action, Everett stole all the bows and arrows from the men and hid them in his hut [EVERETT 2009]. Other than this isolated episode, Pirahã people have endured many dangers with undeniable resilience and peacefulness. Quite astonishing how Pirahã people can live happily, considering the amount of perils they face. Illegal mining and lumbering activity endangers this precious living link to the mysteries of human language to be lost forever.

Human language is a crucial tool for organizing politics. To separate our discussion of language from the political implications is quite hard. The language serves as one common ground for creating an identity among a nation.

As an heritage from Brazil's colonization, a strong prejudice against illiterate people may still be present. A bias reinforced by law, as the illiterate people are excluded from politics as ineligible. For example, the constitutional right to run a political campaign are only granted to a portuguese literate speaker, but not to a Pirahã person.

There are many examples of prejudice against foreign language speakers. Not even European languages are spared, such as the historical negative prejudice against French Canadians [IGARTUA 2008, BOURHIS 1997]. There seems to be a close relationship between language and group identity. The minimal requirement for belonging to an ethnic group is to speak its language. Regarding this complex theme, the reader may complain about some lack of objectivity of political science. We believe the reason for the loss of objectivity is due to the difficulty in isolating the variables that are relevant for the political scenarios. Ideally, analyze the linguistic component of extended consciousness as completely insulated from the other components would be much more easy. Unfortunately, as we have discussed in chapter 2, attention must be paid to the

integration between the parts, if we intend to understand how the whole is built bottom-up from its parts. The science of consciousness is permeated with complexity, hence its subjectivity.

7.9 History of science as an analogy to science of consciousness

From a kuhnian perspective, history of science goes through periods of normal science and periods of crisis, during the period of crisis paradigm shifts may occur. According to his interpretation of the history of science, its growth is not linear, but much more convoluted.

> Paradigms are not corrigible by normal science at all. Instead, as we have already see, normal science ultimately leads only to the recognition of anomalies and to crises. And these are terminated not by deliberation and interpretation, but by a relatively sudden and unstructured event like a gestalt switch. Scientists then often speak of the 'scales falling from the eyes' or of the 'lightning flash' that 'inundates a previously obscure puzzle, enabling its components to be seen in a new way that for the first time permits its solution. [KUHN 1970, p. 122]

According to Kuhn, science is not an impartial method, a linear construction. The paradigm shift takes a long time, because scientists holds their own beliefs. One does not simply completely change his mind after being confronted with evidence.

Kuhn was inclined to reclaim the political forces during scientific revolutions. The revolutions take place when the normal science gets as far as the current paradigm could go. The current paradigm finds anomalies, in conflict the paradigm itself. They would not have been observed without the greater accuracy and better observational tools brought by the progress of normal science. If the paradigm was not there in the first place, there would not be any anomalies to study. The anomalies show weaknesses in the normal science.

> Lifelong resistance, particularly from those whose productive careers have committed them to an older tradition of normal science, is not a violation of scientific standards but an index to the nature of scientific research itself. The source of resistance is the assurance that the older paradigm will ultimately solve all its problems, that nature can be shoved into the box the paradigm provides. Inevitably, at times of revolution, that assurance seems stubborn and pigheaded as indeed it sometimes becomes. But it is also something more. That same assurance is what makes normal or puzzle-solving science possible. And it is only through normal science that the professional community of scientists succeeds, first, in exploiting the potential scope and precision of the older paradigm and, then, in isolating the difficulty through the study of which a new paradigm may emerge. [KUHN 1970, pp. 151-152]

In that case we can turn our minds to the Pirahã. Everett resistance from his western education crumbled over. His paradigms, his religion, his marriage (and also the way he understood language), it all changed dramatically from his contact with Pirahã people. Everett put a question mark in the Universal Grammar proposed by Chomsky, causing a revolution inside the revolution known as the linguistic turn.

What is the relation between languages and thought? Sapir & Whorf present a hypothesis that presents a case in which languages form cognition and so they keep an interrelationship.

7.10 Social animals require social coordination

Studying the works by Daniel Everett we highlighted the controversy in the field of Linguistics. The Pirahã is an indigenous hunter-gatherers language debated and studied by scientific community, providing a vast material for research as it seem to defies the Universal Grammar theory. The thesis presented at the Department of Linguistics of the Language Studies Institute at the State University of Campinas – "A Lingua Pirahã e a Teoria da Sintaxe" and some others [EVERETT 1983] was crucial for the present study. At the end we reviewed Nevins, Pesetsky and Rodrigues as they are discussing Everett's ideas.

Theory of Mind helps in understanding what goes on inside our own heads and in the minds of others enables us to better navigate relationships, Theory of Mind can recruit language skills in order to more accurate guesses on what is going on on other people's minds. There are many social animals in nature. Many examples of social animals in almost every evolutionary branch: insects (bees, ants, termites); some spiders (arachnids); birds and mammals. Pushmi-Pullyu representations serves to coordinate social behavior. Exchanging information is vital for social animals. The efficiency in expressing information through language and the vastness of its vocabulary can be the difference between life or death. "food" does not carry as much information as "food can be found in moderate quantity by traveling in such and such direction". Mastering language is a crucial skill for coordinate behavior, sending and receiving messages. This aspect relies on the core of linguistic consciousness. Language is the social animals' main tool for expressing and sharing information.

8 Temporal Consciousness

8.1 Where were we?

Let us refresh our memory with a brief summary of the main points of previous chapters.

The chapter 2 introduced the equation expressing how parts and the whole relate to each other. Namely, the information contained by the whole is equal to the information of the sum of the parts minus the integration between the parts. On one hand, the description suggests limitations to the reductionist method. On the other, it offers a palliative circumvention strategy.

The chapter 3 suggests the bodily aspect of consciousness to be at the core of consciousness. The evidence in favoring this interpretation lies in the central importance of the subcortical areas of the superior pons and anterior midbrain, whose functions include, control and regulation of homeostasis, and, when these areas suffer impairment, consciousness is extinguished into a deep coma state [PARVIZI and DAMASIO 2001].

The aspects of extended consciousness are not as critical as the core consciousness, because if one aspect is selectively suppressed, it produces only partial impairment in the faculties of consciousness, preserving the functioning of the unharmed aspects [JOHNSON 2001]. The social aspect of extended consciousness is the first aspect of consciousness we analyze 4. Mammals are social animals, being social is an intrinsic human disposition. The capacity for social pain motivate our social behavior. The capacity for Theory of Mind enable us to have theories about our own minds, hence consciousness the Theory of Mind module would be responsible for the awareness of our emotions and feelings.

We analyzed the perceptual aspect of consciousness next, in Chapter 5. To collect information from the environment is not an unique human feature, we share this ability with most animals. What makes the perceptual information special for humans is that not only it guides our behavior, clustering the perceptual information into categories requires modeling theories about the objects in the external world. One is capable not only of perceiving the external stimuli, but of being aware of the external stimuli. Two different neural routes are established: one for detecting the information from the senses, another for raising awareness about the gathered information.

Ethical consciousness constitutes another aspect of extended consciousness, in Chapter 6. Our powerful social nature allowed us to compose bigger groups. In order to navigate such complex societies, evolution selected our ancestors capable of better decision making. The moral compass predispose us to prosocial behavior. The downside of belonging to bigger groups is that we are also predisposed to harmonize our values to the values of the group we were raised into. Unfortunately, every once in a while communities with anti-social values appear. This raises a paradox. Humans are predis-

posed to prosocial behavior and to follow the group values. A contradiction appears When the group values are opposed to prosocial behavior.

All social animals have developed the means to share information. Humans have developed complex languages in order to better communicate with others. The linguistic aspect of extended consciousness, in Chapter 7 enables a better description of the external and internal world. Linguistic consciousness relates to symbolic experience. The internal talk, considered to be uniquely found in humans, is an integrating feature of our inner life. Compared to core consciousness, linguistic consciousness is at a much higher level of complexity. The brain orchestrate several modules in order to manipulate speech and written text. One reason for this complexity is the intersection between innate capacity for language and cultural constraints.

Finally, we will now analyze the temporal aspect of consciousness, in the present Chapter 8. Otherwise, the consciousness we are describing would be trapped in the present. The flow of consciousness can anchor itself to a particular time, either remembering the past, registering the present or predicting possible futures.

The combination of the multiple aspects of extended consciousness may help explain the uniqueness of human experience. The same types of neurons present in our brains are also present in the brains of mice, sharing the same Brodmann areas of the mammalian brain. Why human behavior seem to be unique among other animals?

8.2 Social memory

A recurrent theme is to find that the specialized modules are themselves divided into subgroups. Memory is no different in this aspect. According to the standard model, memory can be divided into, at least, two big categories: working memory and long-term memory.

Working memory will handle the information immediately available, it will store information for a short period of time, usually for performing some task. An example of working memory is when someone is writing a sentence and has to remember the context of the words previously written. This memory is not capable of holding a huge amount of information nor for holding it for a long period of time, but it is faster and more accessible. In contrast, long-term memory is latent memory that can be accessed multiple times and can be stored indefinitely. Ideally, a long-term memory can be easily accessed or created by the working memory. Creating memories takes some time, the more frequently a memory is used, the more strengthened its neural pathways becomes.

Working memory is a unique type of memory. It is now thought of as a mostly active system, during waking hours. Stores data on the key characteristics and the context of what we are learning and retrieves it for a short time span. We briefly “remember” the information so that we may use it for the next few minutes, before completely forgetting it. Declarative memories are created and acquired mostly in the region of the

temporal lobe called hippocampus. Working memory allows verbal information to be immediatelly recalled.

Long-term memory formation ultimately relies on changes in synaptic pathways, such changes depend on a series of biological events: synthesis of macromolecules; metabolic events; morphological change. Each of these biological steps can theoretically be further broken down into minor processes [SQUIRE 1987]. For example, the NMDA [58] receptor controls brain synaptic plasticity and is essential for memory and learning [LYNCH 2013]. A rare condition of anti-NMDA-receptor encephalitis causes dramatic psychiatric consequences. A postulated underlying mechanism for epilepsy, dementia, and stroke is excitotoxicity caused by overactive NMDA receptors, whereas low activity results in symptoms of schizophrenia [DALMAU et al. 2008, KRISTIANSEN et al. 2007]. A person's identity can change over a few months due to such autoimmune condition and this is but one example.

Short-term synaptic alterations are those that start occurring at the moment of learning and end rapidly (up to 6h). Long-term synaptic changes are those that start later and support long-term memory (24h or more). More frequently used synapses are strengthened, the emotional context in the amygdala can dramatically suppress stimulate or memory creation, as in early traumatic experiences or childhood affection.

A theory has been proposed for working memory to operate at a non-conscious level. By training a decoder to distinguish seen trials from unseen trials in a perception task and applying the results to unseen correct and incorrect trials in the working memory task, the authors directly assess the classifier's ability to generalize correct trials from what was not perceived. [TRÜBUTSCHEK et al. 2017].

Working memory is quite useful for a great range of tasks, it would be sub optimal, for efficiency sake, if working memory would require the burden of activate awareness. The evolutionary drives constrains working memory to be light on resource usage. Introspectively, it is possible to pause for a moment and explicitly think about the content of working memory, but most of the time the conscious recall is unnecessary, takes a longer time and may impair performance.

What was the main evolutionary use that drove the adaptation for the learning capacities? A possible answer may lie on research on what type of context enhances human learning.

> Participants read statements about everyday behaviors. Some participants were told to memorize the information because there would be a recall test later on. Other participants were told "to form an overall impression of what the person who performed these various actions is like" and were not informed about the later recall test (memorization was explicitly discouraged). Contrary to what we might intuitively expect, the social encoding

[58] N-methyl-D-aspartate.

> group demonstrated significantly better recall of the facts than those with full knowledge of the subsequent recall test. [LIEBERMAN 2012, p. 7].

Learning is not a lonely endeavor. The knowledge about what might be the overall impression of the person performing the actions is irrelevant for answering the recall test, yet it significantly enhanced the memorization. Suggesting the role of the social factor for memory. The social modules are integrated with learning, pre frontal activity is required for tasks involving focusing attention for a longer time. Focusing attention is easier when the target of our attention is of social nature.

8.3 Roses are red. Quantity is quality. Or maybe not

> What I discovered yesterday was that we are now seeing for the first time what happens when quantity becomes quality.
>
> *Gary Kasparov,*
> Interview for The Times on his first match against the Deep Blue chess engine.

Ramon y Cajal spent much of his career pursuing the type of neuron cells that was uniquely found in humans, eventually he gave up, admitting to have found no evidence for it [CHANGEUX 2006]. Human brain neurons are generally of the same type, they differ in the numbers.

> Imagine a hippocampal neuron receiving synaptic inputs from three sources: A, B, and C. Initially, no single input is strong enough to evoke an action potential in the postsynaptic neuron. Now imagine that inputs A and B repeatedly fire at the same time. Because of spatial summation, inputs A and B are now capable of firing the postsynaptic neuron and of causing [Long Term Potentiation]. [...] In this way, the sight of a rose could be associated with the smell of a rose (they often occur at the same time) but never with the smell of an onion [BEAR, CONNORS and PARADISO 2020, p. 779]

A recurrent theme in the present thesis; cooperation. Cooperativity is neuroscience jargon for neuronal synapses being active simultaneously. Joining forces There is evidence supporting this idea from studies on Alzheimer disease. The main symptom of Alzheimer's disease is the rapid deterioration of memory along with psychiatric disturbances. [CASTELLANI, ROLSTON and SMITH 2010]. A model for describing the loss in the patient's memory is the theory of 'cognitive reserve'. Cognitive reserve can be defined as the resilience of the cognition, the ability to cope with increasing damage yet preserving proper function. This passive threshold model presupposes the existence

of a limit that, once reached, inevitably lead to the onset of clinical manifestations of dementia.

The number of neurons in the brain can decline, while preserving function. When the passive threshold is is reached, however, the quantity loss will result in a quality loss. The difference in the quality of human mind versus other animals' mind may be quantifiable through the Encephalization Quotient. Dunbar's number is an indirect measure of social network complexity [GRUETER 2015], as a consequence it also correlates with learning and intelligence [JOFFE 1997].

A recent study require us to mention a brief caveat to the quantity/quality symmetry theory we were just mentioning. It took a long time of research, but the picture drawn for the types of neurons in mice and human brain to be the same may prove to be false. Maybe Ramon y Cajal was not completely in the wrong path after all, only he lacked the proper tools.

> Comparison to similar mouse cortex single cell [...] revealed a surprisingly well-conserved cellular architecture that enables matching of homologous types and predictions of human cell type properties. Despite this general conservation, we also find extensive differences between homologous human and mouse cell types, including dramatic alterations. [HODGE et al. 2019]

Finally a candidate cell type to be uniquely human was found: the rosehip neuron cell. Further research may tell if this is unique among primates or if it is exclusively human cell type. Often when the science of consciousness presents any hint of simplicity, it is only a matter of time for complexity to lurk back.

8.4 When memory meets culture – let us not forget to wear our pants

> If I have seen further it is by standing on the shoulders of Giants.
>
> *Isaac Newton*

As we have seen, memory is constrained by the number of neurons. Fortunately, human culture came up with a powerful tool for enhancing memory capacity. By turning sounds into symbols (writing), it is possible to save information, storing it for future use. By turning symbols into sounds (reading), the stored information is recovered from the past. Written language is a cultural tool that expands the limits of our consciousness beyond the limits of our bodies [NOË 2009].

History before written language is called pre-history, as if written language technology drew a line separating our animal self from our civilized self. We created the

amazing capacity to record our thoughts into stone and bones, saving it for future generations a gate to access the mind of their predecessors. As a byproduct, writing gave much more reliable material for historians to dig into. It is not the case that historians have little interest in the history before any writing system, historian would love to research pre-history more deeply, but the lack of any writing system forces them to rely on much less accurate and troublesome information about their lives such as guessing it from archaeological excavation sites.

> History is much deeper in time than the temporally shallow period since the emergence of (systematic) writing in the fourth millennium BCE, traditionally associated with the emergence of states and 'complex' societies and commonly considered as the starting point of ordered human progress. [SOUVATZI, BAYSAL and BAYSAL 2018, p. 1]

At the scale of evolution, there is not enough time for natural selection to have specialized our brains for writing and reading in such a short notice. Writing and reading circuitry has been selected to perform different tasks, but got exapted (or recycled) in order to code and decode text. Human evolution constraints allowed for this possibility, even though other social animals have language systems their capacity to store information is constrained within their nervous system. By creating written language, our information capacity storage skyrocketed. Generations of readers and writers added small improvements over the years, in order to better accommodate the writing system to our nervous system. The other way around: to natural selection to match our cognitive reading needs would require a longer time span.

> But writing was born only fifty-four hundred years ago in the Fertile Crescent, and the alphabet itself is only thirty-eight hundred years old. These time spans are a mere trifle in evolutionary terms. Evolution thus did not have the time to develop specialized reading circuits in Homo sapiens. Our brain is built on the genetic blueprint that allowed our hunter-gatherer ancestors to survive. We take delight in reading Nabokov and Shakespeare using a primate brain originally designed for life in the African savanna. Nothing in our evolution could have prepared us to absorb language through vision. Yet brain imaging demonstrates that the adult brain contains fixed circuitry exquisitely attuned to reading. [DEHAENE 2009, p. 12]

The natural constraints in the landscape had to be reorganized in order to better serve our needs, through agriculture and pastoral activity. Farming the land created the possibility of permanent and bigger settlements, this effervescent large number communities created "a new neuro-physiological ecosystem the sorts of customs and habits that generate new neural configurations or alter brain-body states could evolve in unpredictable ways." [SMAIL 2007, p. 155]. Determinism was swept away because not only our brains have a large number of neurons, but our brains were collected in larger numbers.

The economic activity increased the need for registering and organizing the exchanged goods in the comercial harbors. Writing offered a very practical tool for accurate records merchants were so desperately in need for.

> We now have a radiometric timescale for the period of at least two and a half million years from the first appearance of species that have been defined as members of the genus Homo to the boundary between the Pleistocene and Holocene periods approximately 11,600 years ago, the conventional end of the Palaeolithic. Against that background, cultural change between the Neolithic and the earliest cities and states where writing was beginning to be used seems rapid. But when we enter the periods documented by written texts, historians can discuss events within the reign of kings. The pace of evolutionary change has been quickening through-out human history. [SOUVATZI, BAYSAL and BAYSAL 2018, p. 101]

Very little people were able to write and read at that time, merchants would certainly fight against each other to get their hands on a decent scribe. Fortunately, illiteracy has declined over the centuries, providing an ever growing collection of textual evidence for historians to dig into. The study of human culture focuses more on writing text, not only because the records are more accurate, but because writing accelerated the change in human history. Not only our memory in the present is enhanced with the use of writing language, it enhances our collective memory of our past as well. The human history is intrinsically connected with the history of writing. This is of great consequence to the study of consciousness as well. If the Sapir-Whorf theory is correct, it means that culture influences perception. It means that language can shape the way we see ourselves and the world. For instance, the use of temporal tense introduced a more clear distinction between past, present and future.

> The reason why speech is based on sound, rather than gesture, is probably because sound is the sense most closely related to time. Nevertheless, although sound is transitory, the development of language originally depended on man's recognition of long-enduring objects to which names could be given, for there is good reason to believe that the introduction of verb-tenses was a comparatively late development. Our knowledge of the evolution of language is necessarily confined to written records, but they support this conclusion. For example, in Middle Egyptian of about 2000 BC, the 'tenses' were concerned with the repetition of the notion expressed by the verb rather than with the temporal relation of the action concerned to the time associated with the speaker. This was not just a peculiarity of Middle Egyptian, for we find that in other ancient forms of language the dominant temporal characteristic was duration rather than tense. Indeed, it is only in Indo-European languages that distinctions between past, present, and future have been fully developed. [WHITROW 1989, p. 13]

We can witness at first hand the change in the development of little children learning to speak. The focus of their attention changes dramatically. Compare a six year old cat

playing with a string to a six year old children playing with a string. When the string moves, it catches the attention of the cat, if the string vanishes, the cat holds the breath and moves the head up and down, left and right, attempting to see where the string went, hold the string almost outside reach and the cat will jump and extend its paw, it is as if the string plays the cat. The six year old child is different, the string does not tell the child what to do, it is the child who decides what the string will serve as in the child's play. The behavior of children raised among animals will be much more similar to the behavior of the animals who raised the child than to human behavior. Evidence in support to the claim that child raised by animals mimic their non-human animal caretakers' behavior comes from the observation of the behavior of children that were found in this unfortunate scenarios [LEWIS 2011, SQUIRES 1927]. The perception of children raised in such circumstances is quite differentiated, some develop highly accurate sense of smell, some can hear very subtle noises. Human perception is not neutral, it is biased through social context.

The aspects of extended consciousness are not insulated modules. We may have categorize them in different labels, image studies may focus on a specific cortical area, etc. However, this is due to the methods we applied, not due to the object of our study. Scientific method requires us to isolate variables, otherwise we would be facing the possibility of spurious findings [59]. It is much easier to understand and describe idealized models, the problem comes when we start to think that our idealized model correspond to the real world. Social context affects perception, perception affects memory, etc. All modules are interconnected.

For instance, it is hard to distinguish temporal consciousness from linguistic consciousness. The integration between memory and language constrains the way we understand ourselves. The reductive approach forces us artificial divisions. As one theory just cannot simply describe everything, branches in different areas of knowledge specialize into a certain niche. Way before Cartesian analysis, the natural selection was already shaping our cortical regions into specialized modules. The efficiency constraints forced the brain away from generalization, one reason why its surface it is not smooth. The wrinkles not only increase surface area, but also increase insulation between modules into clusters. An equilibrium had to be reached between integration and independence. The evolution of the symbolic images we created to express ideas is not free to express information, but constrained to our neural structure.

The linguistic and temporal aspects of extended consciousness are derived from our social nature, which is deeply embodied on our biological constitution. Each neuron cell in the brain connects to an average of 6250 to 15000 synapses [BOLAM and PISSADAKI 2012], it is no surprise it is a convoluted and complex system.

[59] Spurious findings can occur due to the influence of other variables, coincidences or other unknown factors, the two or more observed events or variables appear to be associated, but no causal relation can be drawed, as it is only possible to pinpoint the consequence, but not the cause.

8.5 Integrated memory

In the case of written language, decoding the visual information into speech goes through a series of steps performed by different cortices. Unfortunately, we cannot afford to go through a complete review of the module cooperation required for the reading and writing tasks. Our focus here is merely to outline how integration is crucial in this complex matter. To integrate a whole combination from multiple parts is indeed a remarkable feat.

> Elizabeth Spelke['s] work suggests that, before the age of five or six, children's search behavior is modular and poorly integrated. Younger children can use the color of a wall to guide their search for a hidden object, and their sense of location to tell them on which side of the room to look – but it is only around the age of six that children represent a combinatorial concept such as "left of the green wall." Other species like rats never attain this integration stage, even as adults. [DEHAENE 2009, p. 207].

Combining the multiple pieces of the written language puzzle requires a patience we soon forget once it becomes an automatic task. Working memory can assist us with its almost magical touch. Rendering writing and reading an effortless job, we are allowed to focus our attention exclusively on the information expressed, while ignoring its vehicle. Written language can store the information for us, our limited resources from long-term memory becomes free to be more efficiently employed. Human memory piggybacks on the natural selected nervous system apparatus plus the technological tools created for easing the task. The communal fight for stretching our possibilities as far as the constraints allow us to go is a constant in the open science. A great obstacle we now face are the paywalls blocking the access for information that should be free [MONGE-NÁJERA]. Our pre-writing ancestors would probably frown upon the idea of denying knowledge due to copyright, knowledge they would probably be immensely happy to share. A downside for our complex rich society is that its greed spoils much of the results it blossoms.

A somewhat obscure memory condition was mentioned, it only makes sense to mention the most famous ones.

To circumvent the constraints is not always a possibility. Fortunately, written language is an artificial tool that reduce the tax on our memory. Learning to write and read is a human activity that requires the cooperation of both social and biological aspects. The small contributions from the multiple parts join forces. The ventral temporal visual cortex can act as a visual interface for reading, as a result of its proximity to the temporal language areas that encode spoken words and speech sounds [DEHAENE 2013]. A crucial skill literacy yields is the ability to translate graphemes into phonemes, learning to read improves speech processing. A rich interplay exists between memory and language.

> The visual word form area – the brain's letter box – is a small region of the human visual system that systematically activates whenever we read. It shows a stronger activation to words than to many other categories of visual stimuli, such as pictures of objects, faces, or places. In all of us, it is systematically located at the same place within a "mosaic" of ventral preferences for various categories of objects. And, if it is destroyed or disconnected, as in the patient whose brain scan is shown at right, we may selectively lose the capacity to read. [DEHAENE 2013, p. 2]

Word blindness is called alexia. The eyes are unharmed, vision is unharmed, speech is preserved, yet the capacity for writing and reading is lost. This is just one more evidence for mind's modularity. Arguably, interpreting the neuroscientific findings, suggests that one could settle the issue through reductive approach [GELL-MANN 2001]. The temptation is real. To decompose complexity into simple parts and describe emergence simply as the result from the combination of the parts would lessen the onus of dealing with the unsolvable problem of ineffable phenomenal experience. To postulate new entities requires extensive proof.

That being said, it is crucial we establish a solid conceptual grounding for our speculations. The reductive method is unfit, we can never stress this enough, for it can only describe deterministic phenomena. The more we study the human mind, more it reveals its complexity. The Cartesian analysis is only fit for solving equations with independent variables. There are two possibilities: our work got it all completely wrong, the nervous system is modular, its multiple parts work completely and utterly freedom, therefore the reductive method is fit for describing the whole nervous system phenomena by exhaustively describing the simple and deterministic mechanisms ruling over each independent component; or maybe the human nervous system complexity is of the intertwined type, by ignoring the integration between the parts and how integration constrains the behavior of each part renders a simplistic and idealized model that can, at best, be partially correct about specific issues, but will never exhaustively describe nervous system phenomena as a whole.

To prove that two neurons can oscillate for a long time in deterministic fashion is sufficient to completely refute our hypothesis. Being more realistic and less indulgent, it suffices to show that the embodied, social, perceptual, ethical, linguistic and temporal aspects of consciousness are completely independent modules. If the insulated modularity of the brain will turn out to be the case, we will gladly accept our mistake and partake on the profitable efforts the reductive framework in order to portrait a better description of human consciousness.

8.6 Neural democracy analogy

> "There are many wars, comrades" he shouted "some, we fight alone!" [a]

[a] – Há muitas guerras, companheiros – bradou – algumas a gente luta sozinho!
Moacyr Scliar,
The One Man Army.

Memory is a stimulating topic for research and debate. By no means, this chapter could ever pretend to exhaust the topic on the multiple scientific fields it comes across. The author's technical and conceptual ignorance constitutes an obstacle for drawing conclusions from the brief review presented. The main philosophical motivation behind the efforts was to connect some dots between the far fetched components integration regarding the modules responsible for enabling temporal consciousness, and consciousness in general. Starting with the fact that "memory" in the singular, is an underestimation. "Memories" in the plural would be a more accurate concept. Maybe the same reasoning should be applied to the concept of consciousness. A possible ambiguity may lie on the fact the "consciousness" noun commonly remains the same for both expressing the singular and the plural form. Consciousness in singular is a solipsistic concept that does not do justice to the human social nature. Fortunately, we do not have to fight the war against ignorance alone, we would definitely lose it if that was the case. The fight for knowledge about consciousness is fought by a single army of little neuron cells, but by armies of armies of little neuron cells. Team of scientists cooperating to describe the neuronal hierarchy and integration.

The study of consciousness is not a neutral ground for objective methodology. The science of consciousness and madness is social and political. Chronic stress, poverty, hunger and ostracism are the main causes for the apathy of consciousness. The anguish caused by ignorance is silenced by the threat of solitude and death. The history of humankind is stained by the oppression of the voiceless, the memories that were intentionally forgotten. Memory is not neutral, it selects what should be remembered and most importantly, who should be remembered.

A quixotesque lonely war against ignorance is probably lost before its beginning. The fight against ignorance requires social and political efforts. A fight desperately in need for more allies (one is the loneliest number). A handful of voices with high confidence can be overruled by a swarm of voices with average confidence. Can the one neuron cell army hold out against the swarms of disagreeing neurons?

The lifetime of authoritarian intolerant neurons is short, they are pruned as soon as their harm to the collective of neurons is identified. The neural democracy may teach us some lessons. The antonym for neural democracy is dementia. Dementia occurs

when the number of voices is gradually, but unceasingly silenced. For free speech to occur, the few intolerant voices have to be silenced in order to give space to a greater number of voices to be heard. Giving space to a small number of voices, while silencing the others allows for the rise of dementia. Free speech is only be possible, not when any voice can overrule the others, but when the greater number of neurons is heard, preventing the number of voices to gradually decline. Democracy is plural, if there is to be room for the majority of voices to be heard, the few intolerant voices must be silenced. Unconstrained free speech predisposes the number of voices to gradually decline, because it allows intolerance and intolerance is the end of democracy.

Our writing suggests that consciousness is not singular, but plural; not unified, but spread over many cortical areas; not reducible, but integrated.

9 Conclusion

We reached a conclusion: consciousness is complicated. We focused on the problem of consciousness. We had two choices: we could broaden our scope, compromising depth; we could reduce our scope, increasing depth. Driven by our pursuit to tackle consciousness as a whole, we tracked down consciousness over different branches of scientific research. The shortcoming of such strategy is the superficiality of our research.

Information theory served as a compass, guiding our path in making a general sense of the brain's maze. No neuron is an island, the convoluted inextricable neural networks in human consciousness were analyzed, for the sake of simplicity, in aspects. Such analysis forcefully ignores the interdependence between the parts, but was a necessary step in order to allow for applying the reductive method. It would be quite cumbersome to proceed without isolating the relevant variables to human consciousness. Our analysis led us to into dividing consciousness into embodied core consciousness and five aspects of extended consciousness: Social; Perceptual; Ethical; Linguistic; and Temporal. The root that connects lower body and neocortical areas lies on the basis of the brain. Of focal importance to embodied core consciousness, humans share this structure with reptiles, birds and mammals. The difference from core consciousness to extended consciousness is that lesion to the area responsible for core consciousness results in complete loss of consciousness.

Even though the aspects of extended consciousness may be selectively knocked down, they are not completely independent. The information theory was useful in understanding how the parts fit together. The information of each component is constrained due to its embedded context. At the same time, the theory suggests problems for both dualism and reductionism. As the whole is the result of the sum of its parts subtracted by the integration within the parts: there should be no room left for a distinct entity; while also suggesting that reducing the whole to be the sum of its parts is ignoring the dependence between the parts.

According to the framework of information theory, we described analogies for how neurons cooperate together. One analogy we drawn was the picture composed of pixels. The information each pixel can express is constrained by the remaining pixels. Pictures composed of unconstrained pixels are free to act randomly, can hold the maximum amount of information, the downside is that the information pictured is chaotic. Pictures composed of rigidly constrained pixels hold minimum information – it will only display solid colors. The intermediate scenario is the most interesting, a mixture of integration and independence. The latter picture can hold a moderate amount of information, the pixels are somewhat constrained by the neighboring pixels. Such pictures are organized in such a way that they are constrained by the immediate neighbors, but loose enough that more distant clusters will diverge.

A picture comes as the result from the pixels cooperation. A digital display composes a picture by adjusting the color and brightness of each pixel in the screen, no need for extra ingredients. Screens more densely populated with pixels can display greater definition because in the same region occupied by a single pixel makes room for more pixels to express finer detail.

We drawn the pixel analogy to describe how human consciousness may be understood as the result from the cooperation of many small building blocks. The relation of the aspects of extended human consciousness is analogous to the picture with intermediate integration, with a mixture of independence and integration between the parts. To lose one aspect of extended consciousness would be analogous to a cluster of dead pixels in a malfunctioning monitor. The monitor displays a blotchy picture, a portion of the information in the picture was lost, but the remaining pixels are still working.

With this framework at hand we may proceed to the study of each component of consciousness in more detail.

Embodied core consciousness is the foundation of consciousness. Keeping the flow of information from brain to the body and from body to the brain is fundamental for consciousness. Acknowledging that the human body has influence over consciousness may seem obvious, yet this interdependence is often overlooked. The basic biological characteristics of our bodies – sex, age, skin pigmentation, etc. – can influence behavior. Violence, for example, is exacerbated by testosterone levels. Testosterone does not cause violent behavior, it aggravates violent behavior. Not surprisingly, for every culture and continent on Earth, the majority of crimes are statistically committed by men. Over time, the body matures and grows old, but other than that, it does not change much. Being part of the background, embodied core consciousness is ubiquitous and we can easily grow used to it, underestimating its influence. Yet, embodied core consciousness can drastically change one's life. Consciousness is lost if this bridge connecting the brain with the body is lost.

Extended social consciousness was possible due to the mammal adaptation predisposing social contact. We are born inside our mother's womb, as babies we drink our mother's milk. Mammals are helpless without social connection. To lose a mother or a baby is a pain I am fortunate enough to have never felt. Our mammalian brain is wired with an alarm to detect the loss of social relationship. The same cortical area responsible for feeling physical pain was recycled to feel social pain. Furthermore, the same areas that are activated for default are also recruited for creating hypotheses about what other people is thinking. Being rejected causes an aversive sensation and we are often thinking what others are thinking in order to predict optimal strategies for strengthening our social bonds and preventing rejection. A baby may be fed and cleaned, but will not reach adulthood left alone. Pain can be fatal.

Perceptual extended consciousness is the capacity to acquire knowledge from our surroundings. While social consciousness is all about what is going on inside, per-

ceptual consciousness is all about what is going on outside. Through our senses, the external world can be observed. In order to understand how it is possible to collect and navigate the external world, we entered the debate between empiricism and rationalism. Far from settling a debate that has occupied great minds, we concluded for a compromise. Neither empiricism nor rationalism seem to provide satisfactory answers in describing knowledge acquisition as a whole. While empiricism is better fit for describing how perception can provide data to building up literal knowledge, rationalism is better fit for describing knowledge acquisition of abstract concepts. This suggests that empirical and theoretical methods may work together in cooperation for knowledge acquisition.

Ethical extended consciousness is an unfolding of extended social consciousness. The social world require us to coexist in society. Great responsibilities arise from navigating big groups of people. We briefly compared two theories: moral absolutism and moral relativism. From this comparison we reached an impasse. Humans are naturally predisposed to act morally *and* naturally predisposed to conform to society. This may generate a paradox. Being naturally predisposed to act morally means that humans are predisposed to avoid harming other people, but being raised in a society where harming other people was the norm would also predispose humans to harm other people. To be predisposed to avoid harming other people *and* to be predisposed harm other people is a contradiction. Acknowledging this paradox, we reached the conclusion that the debate between moral absolutism and moral relativism will probably resist any attempt of solution.

Social animals need to communicate in order to better organize their group. Linguistic extended consciousness plays a crucial role as it enhances our capacities in expressing information. In the early 20th century, the linguistic turn was a major development in western philosophy. As an extensive review of the literature about language was beyond our competence. We selected a narrow cut over the language debate: The Pirahã language debate. The Pirahã language dazzled linguists, Pirahã grammar's simplicity challenged a major claim hold by Universal Grammar theory proposed by Noam Chomsky. Everett's finding for the absence of recursive sentences and embedded structures in Pirahã language provides counter evidence for Chomsky's theory of language. The debate boils down to how culture influences perception. In the absence for Pirahã words for numbers, when Pirahã people is asked to tell with one of two small quantities is greater (for example, 6 fishing hooks in one hand and 8 fishing hooks in the other) they can only guess the answer. This evidence suggests the interdependence between perceptual consciousness and linguistic consciousness.

Temporal extended consciousness enables the capacity for remembering the past, acknowledging the present and predicting the future. Memory extends human capacity beyond the constraints of immediate perception. By recollecting past events, humanity invented history. The technology of memory allows for storing knowledge for future

generations. This major breakthrough was followed by another invention: written language. Evolution had no time to adapt our brains for manipulating symbols for sounds and numbers. Human cognition is greatly improved through reading and writing. By storing information, human kind preserves its culture and traditions.

We analyzed consciousness in its components, briefly discussing how the parts of consciousness fit together, according to the information theory account. This provided a plural mosaic of consciousness. By no means we have exhausted the problem of consciousness. Possibly we may have neglected some aspect of human extended consciousness, but our ignorance blind us from recognizing it. We thank you for joining us on this short journey, inviting you to surpass the ideas presented.

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