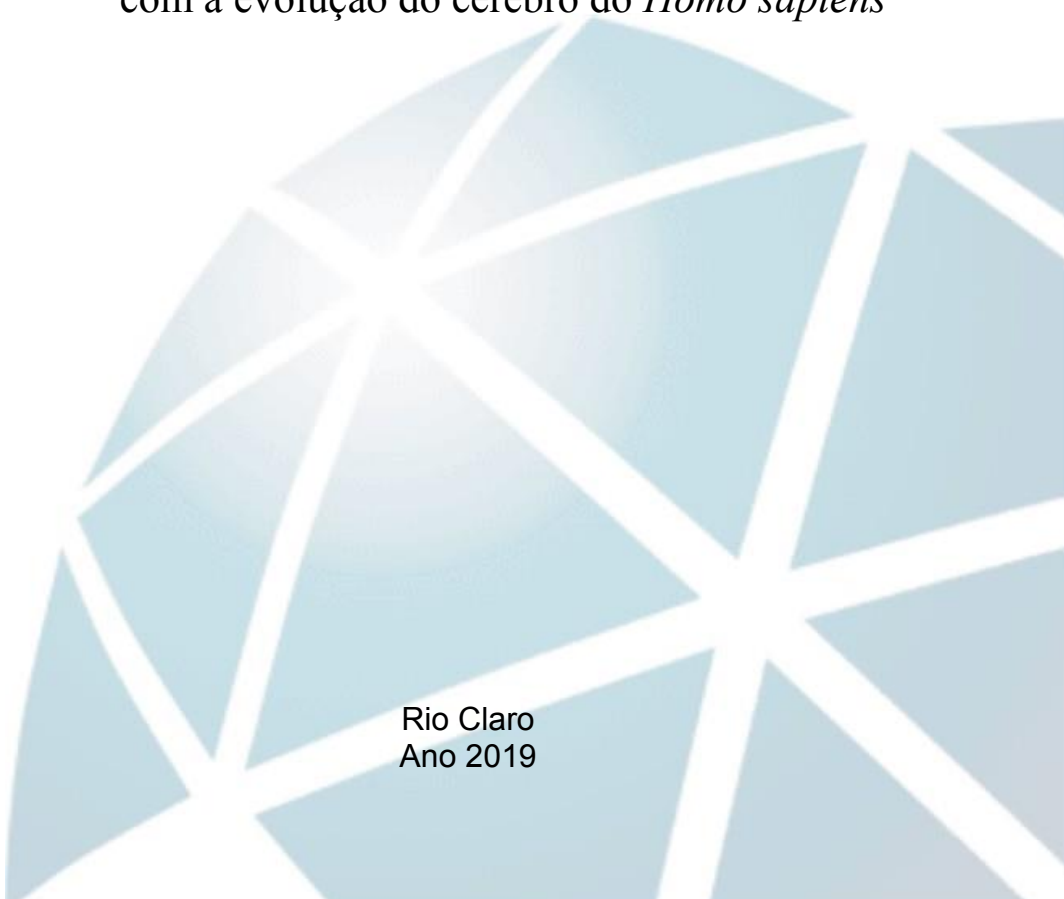

CIENCIA BIOLOGICAS

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The development of narrative capacity & its connection to the
evolution of the *Homo sapiens* brain

O desenvolvimento da capacidade de narrative e sua ligação
com a evolução do cérebro do *Homo sapiens*



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**"(...) Everything should be subordinate to the thing
that pays attention and learns (...)"**

J. B. Peterson

Resumo

A linguagem teve um papel determinante no sucesso dos *Homo sapiens*. A comunicação estruturada na forma de narrativa talvez represente um evento crítico na evolução da espécie humana. A complexidade das estruturas sociais e o desenvolvimento e manutenção da cultura são exemplos de sistemas onde a narrativa ocupa uma posição constitutiva. Esta revisão teve como objetivo analisar a seguinte hipótese: de que o surgimento da comunicação em estrutura narrativa foi relevante na história evolutiva humana a ponto de o sistema nervoso ter desenvolvido estruturas funcionalmente especializadas para este tipo de processamento de informação. Para buscar esta pergunta teorias evolutivas/ecológicas foram alinhadas a modelos filosóficos, neurológicos e psicológicos. Imagens de atividade cerebral foram comparadas aos processos discutidos na literatura teórica como uma forma de especificar as estruturas funcionais na literatura neuroanatomica.

O resultado deste trabalho foi uma introdução a estruturas psico-neuro-funcionais, envolvidas no processamento dinâmico de configuração da realidade em como ela é percebida pelos organismos. Essas estruturas manifestam padrões que, particularmente no caso das linhagens humanas, são reunidas em estruturas narrativas e povoadas por conteúdos derivados de experiências e da cultura, que podem ter origem essencialmente coletiva ou individual.

Este trabalho reúne fundamentos para uma compreensão mais completa e aprofundada das funções cognitivas e o desenvolvimento da mente. O indivíduo é exaltado como o ponto de referência da onde os processos cognitivos efetivamente operam, portanto incluindo eventos psíquicos como igualmente influentes e dinamicamente interativos com as *affordances* ambientais. Assim, desempenhando um papel constitutivo na capacidade adaptativa de nossa espécie.

Palavras-chave: Narrativa. Fitness. Cérebro social. Teoria da mente. Relevance Realization. Percepção. Orientação. Arquétipos. Teoria dos Jogos.

Abstract

Language played a definitive role in the success of the *Homo sapiens*. Communication through narrative structures represents a critical event in the evolution of human species, because it sets the stage for the development of complex social structures and the creation of what we generally call Culture. The present review examined the following hypothesis: that the human ability for communication in the form of narrative structures was relevant enough in the evolutionary history to develop functionally specialized structures in the brain. In order to pursue this question evolutionary/ecological theories were aligned to models in philosophical, neurological and psychological theories. Imaging research on brain activity was compared to the processes discussed in the theoretical literature in an attempt to pinpoint the functional structures on the neuroanatomic literature.

The result of this effort was the introduction to a psycho-neuro-functional structure which is involved in the dynamic configuration of reality as perceived by organisms. And these structures manifest patterns which, particularly in the case of human lineages, are picked up in narrative structures and populated by experiential (senses) and cultural content, which may be collective or individual in essence.

This paper lays way for a more profound and complete understanding of cognitive functions and the development of the mind. The individual organism is exalted as the reference point from which cognition operates, therefore including psychic events as equally influential and dynamically interacting with environmental affordances. Therefore, playing a constitutive part on our species' capacity for adaptation.

Keywords: Narrative. Fitness. Social brain. Theory of Mind. Relevance Realization. Perception. Orientation. Archetypes. Game theory.

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1 Introduction

Narratives are a core concept that will be underlying the text herein. The relevance of narrative as discussed in this paper is product of its essential structure. They reflect the elements needed to capture causality. These elements continually appear in a triad form: a subject, an object and a verb; an actor, an acted and an action; a character, a present state and a goal; $A + B = C$... Not surprisingly the structure of language itself follows this processing steps, as it can be argued through Chomsky's Universal Grammar. And just as the exposition to a linguistic environment populates a developing child's mind with sounds and patterns of a specific language, so does exposition to a constantly unfolding reality populate pre-disposed structures in the brain that play out in narrative form. Herein I consider *narrative* as the structural factors that will be populated by experience as personality develops alongside neurological ripening and maturation.

The structures themselves have been referred to by C. G. Jung (1959) in *Archetypes of the Unconscious* as the archetypes. Their configuration reflects the evolutionary history of human beings, in accordance with the pressures they were imposed and what adaptation evolution could tinker out of their bodies. The concept is better discussed on the Narrative discussion of this paper. Understanding the evolution of the brain before diving into its functional anatomy will aid me in enlightening these core concepts.

The archetypes and the narratives are evolutionarily significant because they manifest into conscious life as a product of unconscious processing of information (PETERSON, 1999; JUNG, 1959). They manifest subjectively in what can be called *instinct*. An intrinsic feeling, either hindering or propelling action. The "feeling" is product of limbic activity and hypothalamic regulation of bodily sensations through homeostatic, neuronal and hormonal release (GAZZANIGA, IVRY, MANGUN, 2002). These have been selected for their capacity to influence action that can be potentially adaptable.

Evolution is the process concerned with adaptability through the change organisms overtake across time. Such change is strongly influenced by the environment. The environmental demands for survival create barriers for living organisms, constraining through selection and changing in morphology, capacities and functions. The idea that all existing organisms survived a selection process is known as "natural selection" (DARWIN, 1859).

The evolution of any living being is a product of the interaction between the organisms and their environment. Then, the environment works as a filter for adaptation of a diverse

range of living organisms. Odling-smee, Laland e Feldman (1996) conceptualize niche as the sum of all natural selection pressures, Pinker (2010) defines niche as the complex of specializations that defines a mode of adaptation of each species while Ricklefs and Relyea (2016) define it as the range of biotic a abiotic conditions that an organism can tolerate.

Evolution is blind in the sense that when a new biological form is being created, a function isn't determined for it. In fact, an old form can be repurposed and shift in function as time progresses. For example, the tongue in human beings did not develop for speech, but for swallowing. Had it been so, all animals that have tongues would be capable of such (VERVAEKE, 2019). This is what is termed *exaptation* as proposed by Gould (1982). This is a concept which permeates the argument herein, because exaptation is synchronic to the evolution of the brain. Having the concept of exaptation in mind, the development of higher mental faculties can at least partially be attributed to the repurposing of evolutionarily derived forms that had different original functions (VERVAEKE, 2019; GAZZANIGA, IVRY, MANGUN, 2002), particularly when considering our capacity for narrative communication.

The brains within the genus *Homo* evolved in a short time span when compared to the rest of the phylogenetic tree. Within roughly 2 million years, the skull volume of hominids grew from 700cm³ to 1400cm³ for the modern human (RIBAS, 2006; GAZZANIGA, IVRY, MANGUN, 2002). This sort of growth is not a process that would happen spontaneously, mostly because the nervous tissue is energetically expensive, both to develop and to maintain. Therefore, the selective forces pushing for the evolution of large brains must have been powerfully adaptive.

Where did the pre-humans manage to draw this energy to be invested in the brain? Wrangham (1999) argued that early humans could have increased their energetic uptake with the advent of cooking. The cooking hypothesis rests on the reduction of gut size in humans as compared to other primates. Wrangham proposes that the behavior of cooking food before consumption promotes chemical changes which facilitate nutritional absorption, freeing the metabolic expenditure of digestion to be invested in the brain.

The capacity for cooking inherently includes the ability to voluntarily delay gratification. The delayed gratification, in this context, expresses what can be referred to as an eco-evolutionary feedback process. It requires that populations alter their environment (referred to as niche construction by Odling-Smee et al. 1996) and that those changes in the environment promote the subsequent evolution of the population (BURMAN, 2013; POST;

POLKOVACS, 2009). In this case, the behavioral choices of these primates altered their niche and, as a consequence, the selective pressures acting over their evolution.

The brain region commonly associated to impulse control is the Pre Frontal Cortex (PFC) (GAZZANIGA, IVRY, MANGUN, 2002). This is the most evolutionarily recent part of the brain that is particularly well developed in humans. Impulse control is a significant ability in social situations and is what takes the longest to develop in human beings. In our species the PFC will not completely mature until the mid-twenties.

Individuals prone to controlling their impulses, in the specific case of hunger, had a greater advantage because they could derive more energy from the same source of food when cooking it. This creates the opportunity to add behavioral nuances to the process. This is evident when considering the variation and improvement of cooking techniques. Greater sophistication in the behavior could account for a more effective cooking process and therefore less need for a large gut. Freeing up energy to be invested in the brain.

The cooking hypothesis cannot explain the evolution of large brains by itself though. There were other adaptations which were involved in the process. The transition to bipedal locomotion in *Homo erectus* (1.9 - 1.8 million years) e. g. created physiological demands on the body related to the changes of gravitational pull on the circulatory system (FALK, 1990). The adaptation that followed was a change in circulatory arrangement which involved a shift in blood flow to the brain. This meant that the brain could dissipate heat more effectively, through the Carotid Rete system (BAKER, 1979), and temperature no longer restrained brain development (an earlier constraint to brain growth) (WITTMAN; WALL, 2007, FALK, 1990). Also, the innervation of the thoracic muscles associated with better air flow control were essential for our capacity of speech (MACLARNON; HEWITT, 1999). All these serve to illustrate how important it is to remember that evolution tinkers with shapes rather than materialize new forms on demand. This will also remain true for the evolution of mental and cognitive processes.

The capacity to learn directly relates to the ability of developing novel behavioral patterns. Learning allows for the modulation of behavior. The underlying mechanism of this is cognitive, defined as "the mental action or process of acquiring knowledge and understanding through, experience, and the senses" by the Oxford Dictionary (2018). In this frame, information becomes a source of potential adaptability that does not rely solely on genetic variability and natural selection. Therefore, the systems involved in the acquisition and

processing of information are positively selected, and the term "cognitive niche" was coined to refer to the exploitation of the environment under such conditions (PINKER, 2010; TOOBY; DEVORE, 1987).

For some animals like the *Homo sapiens* the term cognitive niche is expanded into the social life. If the concept of niche is in reference to specific adaptations of a species to its environment and how they explore and exploit it, then the idea that humans live in social groups must be taken into account. So, the group's dynamics suffer adaptive selection and individual traits that are socially dependent are affected. Whiten and Erdal (2012) refer to it as "socio-cognitive niche".

Learning is product of the individual's exposition to the physical, social and cognitive environment they inhabit. The result of learning is the acquisition of novel information. The source of the information can come from a varied number of sources. One of the powerfully adaptive sources is social learning.

Coelho et al. (2015), observed the social learning processes in a population of tufted capuchin monkeys (*Sapajus spp.*) in Brazil. It is interesting to note how the learned behavior (nut-cracking), first performed by the younger members of the group as a novel technique they'd developed, was shifted as a more common behavior in the adults as time progressed. Then this behavior, which had been originally learned spontaneously, began to be taught by the adult members to the younger ones. The technique became akin to a tradition and it is an example of a change in behavior promoted by the socio-cognitive niche. A process that, in essence, is not too far removed from human conceptualization of culture.

Social interactions create cognitive demands on brain processing, p. el. the understanding of hierarchical structures and the representation of other individuals' mental states known as Theory of Mind (ToM) (GOLDMAN, 2012; CARLSON; KOENIG; HARMS, 2013). Considering the cognitive demands of participating in social groups, Dunbar (1998) proposed the social brain hypothesis. This hypothesis asserts that the size of the social groups in primates impacts brain PFC size. He presents evidence for this claim comparing group size to brain volume of different primates. In the case of *H. sapiens* the social complexity and cultural richness that can be observed possibly relates to primates PFC evolutionary enlargement.

The hypothesis explored in this review is in alignment with these selective pressures and the particular evolution of the genus *Homo*. As mentioned before, there is a myriad of

evolutionary reasons which contributed for the cephalization and eventual rise of our species and our cognitive capacity. The explanations are so broad that it is rather difficult to pinpoint a main cause, and there probably isn't. But there is reason to believe that the human capacity for narrative played a fundamental role in the human history. The social brain hypothesis (DUNBAR, 1998; DUNBAR; SHULTZ, 2007) and the concepts described in theory of mind (GOLDMAN, 2012; CARLSON; KOENIG; HARMS, 2013) will illustrate how this particular capacity gave the *Homo sapiens* adaptive advantages that are unique and exquisitely effective.

The emergence of narrative as a means of cognitive exchange probably represented a strong advantage for the early humans, otherwise the evolution of this trait would have been unlikely. Narrative acts as an information transferring too, which allows information to flow and it possibly intensified the demands on processing capacity within the human lineages. This literature review is organized in five major topics. The first topic (I) discusses theories associated with perception and orientation that are involved with the emergence of communication through narrative structures; the second topic (II) discusses functional and organizational differences observable in the central nervous system, as an attempt to effectively link the functional areas of brain activity to the theoretical underpinnings discussed; the third topic (III) taps into the processes of learning, acquisition of knowledge and development of new behavior, mostly because the PFC represents an evolutionary modulator of behavior, impacting narratives and their adaptive content; the fourth (IV) topic is a discussion on social life and how it impacts brain function also relating to narrative's effect on behavior; the fifth topic (V) is an overview on the topic of narrative, how it is structured, how it relates to brain function and why it is a powerfully adaptive tool. Finally, the conclusion concerns the strongest and weakest points of the arguments presented and offer possible directions for future research.

2 Research Methodology

The academic literature was revised in Journals, Articles, data bases and search engines (such as Google Scholar) within the theme of brain function, evolution, and social behavior in human beings, linking all these to the hypothesis on the impact of narrative communication in the course of our evolution. The ideas contained in the compiled articles are considered in accordance with their consistency across the areas of knowledge. That means to say that a phenomenon or model is considered representative of reality if it can be

observed in different areas simultaneously, such as psychology and brain functioning concomitantly p. el.

The problem with an interdisciplinary paper is a technical one. Specific and technical lexicon between different fields are often different. Therefore, vocabulary is broad because different fields may have different words for the same phenomena or similar words to different ones. For this reason, the author cared for explaining vocabulary in the moments deemed necessary. If by any case evidence was conflicting or methodology of referenced papers was considered weak, the matter was addressed in the body of the text.

As the main subject analyzed in this document are human beings themselves, case studies serve as a valuable source of information. As long as they are complemented by empirical data, case material can help attain insights that are not obvious otherwise. As Jung (1959) makes clear in his writings (p. 55):

"(...) I myself did experimental work for several years, but, through my intensive studies of the neuroses and psychoses, I had to admit that, however desirable quantitative definitions may be, it is impossible to do without qualitatively descriptive methods. Medical psychology has recognized that the salient facts are extraordinarily complex and can be grasped only through descriptions based on case material (...)"

This review will be divided in five main topics apart from the introduction and the conclusion: theories of perception; observable divisions of the nervous system; learning, development and play; social brain; and narrative.

3 Perception, Orientation & Relevance Realization

3.1 Definitions

Attention wanders. This is a consequence of the orientation reflex that was systematically studied by the neurophysiologist Sokolov (1963). This reflex is what instinctively guides our attention to unknown or anomalous stimuli. Which means to say that perception is not fully in our control. If when we attempt to meditate for example, we have decided to sit down with the will to make our mind's inner chatter grow calm, but what happens instead is that our attention wanders through a thousand different problems and thoughts invade our awareness without our permission. So, what does it mean to say that we

do not control our attention? If we don't have control over it, then who does, if anyone? This is the problem that concerns a dual process of orientation and perception concomitantly.

In order to understand how a human being orients him or herself in Reality, we must understand how we can perceive it. The problem seems simple enough. Reality from the perspective of science is composed of objects. All we do is look at them and see, by their edges, shapes, limits and properties, what they are. But if that were the case, how would we orient ourselves? The objective world is what science attempts to get the closest to. All things have the same value and all is reducible to its constituent parts. In order to get to this perspective, science has to remove the subjective experience, which means to say, science tries its best to look at Reality as if an observer weren't in it.

Our perception does not adhere to the same principles as the scientific methodology demands. Our perception is imbued in a body, an individual, a living organism with wills and desires, and emotions and feelings that mediate between them. A perceiver is a reference point and also an actor. So, it is only natural to assume that perception is organized around the living perceiver rather than objective reality. This observation lays way to Jung's arguments on symbolic perception, discussed ahead.

The content of perception is processed through affective processes in the case of mammalian brains (PANKSEPP, 2011). These are emotional, homeostatic and sensitive signals that communicate the nervous system about the environment (inside and outside the body). There are different systems that mediate through these processes, and they vary in their specialization in accordance with the medium that they are sensitive to. For example: the cones and rods of the eyes to light, the taste buds of the tongue to chemical molecules or the chemical receptors for dissolved carbon dioxide in the bloodstream. All feed information into what can be called limbic system, the system responsible for emotional processing in the mammalian brain (PANKSEPP, 2011; GAZZANIGA, IVRY, MANGUN, 2002; BEAR, CONNORS, PARADISO, 2008).

Motivation is a manifestation of the orientation impulse which results from a physiological "pull" towards a desired goal or state. This pull can manifest as the emotional configuration of the organism indulging him towards certain actions that will alleviate his physiological tension. So, motivation is both: product and factor of the process which results in orientation, participating on the subjective experience of the individual (MOOK, 1987; PANKSEPP, 2011; GAZZANIGA, IVRY, MANGUN, 2002).

Perception is relative to the individual's current goal (VERVAEKE, LILLICRAP, RICHARDS, 2009). Defining a goal manages to rank order perceptual input in accordance with that objective, filtering irrelevant input and freeing up the brain to focus on the information relevant in the present. So, orientation and perception are seemingly different parts of a single process which is involved in acting effectively in reality.

An aim, in order to be attained, places attention and perception under specific constraints, either raising or diminishing the salience of input (VERVAEKE; LILLICRAP; RICHARDS, 2009). When an organism is in a determined physiological present state and another state of being is the goal, experience manifests in negative, positive or neutral form, in accordance with its relationship to said goal (PANKSEPP, 2011). The input of negative evoking experience can be defined as a problem that needs to be solved or evaded. Problems can broadly be conceived of in two main categories; they are either ill structured problems or well-structured problems (SIMON; NEWELL, 1958).

A well-structured problem is defined as such when it can be described numerically and quantitatively. The goals to be attained can be specified in terms of well-defined objective functions and computational routines (algorithms and behavioral patterns p. el.) allowing for the solution to be reached. An ill structured problem is whatever problem does not fit into the requirements of a well-structured problem. Most of the constraints in an environment fall into the latter category (SIMON; NEWELL, 1958; VERVAEKE; LILLICRAP; RICHARDS, 2009).

Organisms were selected to become general problem solvers, having survival and reproduction as the primary constraints. That means that the decisions and subsequent behavior must follow at least two different processes, because we are dealing with ill-structured problems as well as well-structured ones. These same categories of problems can be thought of as problems to which we have a known routinized behavior (well-structured) and problems to which we have no answer (ill-structured). In other words, organisms are gambling with their energetic resources between perceived input to which they know the relevance of and perceived input to which relevance isn't yet known.

Vervake, Lillicrap and Richards (2009) pinpoint three constraints to a cognitive agent attempting to deal with the problem of relevance whilst acting effectively in the world. All of which connect with the energetic needs of a living being. First the applicability problem, which is concerned with the commitment to either general purpose or specific purpose

strategies in order to solve a specific problem in the environment, and this opponent processing (general versus specific) is termed *cognitive scope* (CS). The second constraint is related to the projectability problem. This relates to the possibility between exploitation versus exploration types of actions that can be taken by an individual. The internal processing concerned with this opposition is referred to by the authors as *cognitive tempering* (CT). The third constraint is concerned with how a cognitive agent should gamble flexibly when confronted with ambiguous information, whether the ambiguity is caused by noise (e. g. background noise) or the overlap of environmental entities generating similar perceptual signals (e. g. a whistle vs a bird song that have similar pitch and tone and nuance). They term the prioritization of structure and cost functions of individuals dealing with this problem *cognitive prioritization* (CP).

The three lower order constraints: CS, CT and CP, are interacting with one another in an economic arena because organisms are limited by their energetic reserves. So, during relevance realization the three constraints are poised against two higher order constraints: efficiency and resiliency. Both related to the strategy in energetic expenditure. These two are what effectively place the brain within an evolutionary frame. Efficiency creates the selective demands while resiliency is the driving force behind the need for an increase in variability which allows for new and better ways of interacting with the world. Thus, cognition is placed in a situation in which it must continually change between what it knows and what it does not yet adapted to (VERVAEKE; LILLICRAP; RICHARDS, 2009).

The three lower order constraints CS, CT and CP are consistent with the differences in function observed in hemispheric activity (MCGILCHRIST, 2010). The difference between the two main broad categories of attention that are reviewed by McGilchrist (2010) seem to be involved in a process very similar to the Relevance Realization (RR) model.

3.2 Proposed Evidence for Relevance Realization

Perception is an ambiguous endeavour. For example, a single image can be interpreted in different ways, such as in Figure 1. A figure that is either of a goblet or of two facing profiles. Only one of the interpretations can be seen at a time, and the perception changes back and forth between the possibilities. This is what is defined as *multistable perception* (GAZZANIGA, IVRY & MANGUN, 2002).

The event of multistable perception shows that the same input can be perceived in different ways. Which is to say that this image can be ascribed with two different sets of values. The same line can be either a forehead or the first portion of the neck on a goblet. What defines it as one or the other is the relevance it has to the observer, the perceiver. The contrasting black and white colours alter between being in the background or the forefront of the image.

How do we see things for what they are? The form or essence of something does not seem to be based on the shape of an object, but rather on that which is constant across the changes that the object might suffer. Gibson (1978) makes the case that, a perceiver who is looking at an object does not see the object-in-itself, but rather experiences the product of the processing of *affordances* (GIBSON, 1978). That means to say that the animal perceives reality in a relative and tool-like manner, because affordances can be defined as what the environment provides to the individual and the uses that can be derived from the available

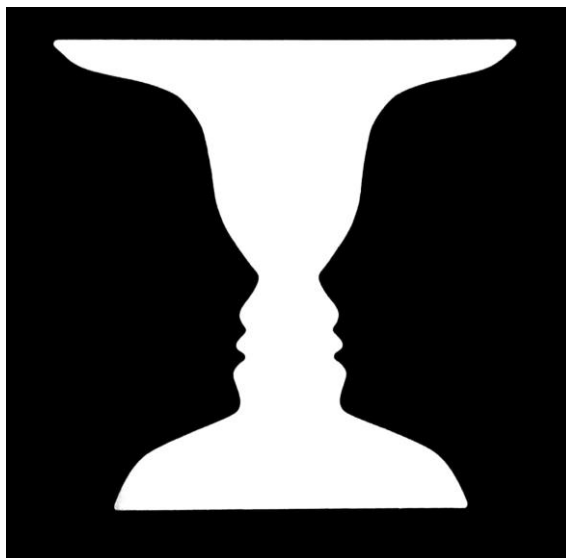


Figure 1: Profile & Goblet (GAZZANIGA, IVRY & MANGUN, 2002, p.201)

affordances. The perception is product of the complementarity of the organism and his surrounding environment.

3.3 Goal Oriented Perception

Simons & Chabris (1999) have observed in their experiment how a goal can skew perception. The experiment consisted of asking subjects to watch a video of two groups of

people playing with a basketball. One team was dressed in white and the other dressed in black, and the subjects were tasked with counting how many times the black team passed the basketball among their numbers. The subjects were given a clear objective.

There is a particular moment in the video, while people are passing the basketball to one another and the subjects are counting, when a person dressed in a full gorilla suit comes into view, stops at the center of the image, bangs on his chest a couple of times, and leaves. Interestingly, most people do not notice the anomaly unless they are cued in by someone else. Subjects' perception seems to pass on to conscious processing only the information of input that is relevant for the task at hand.

This example shows how CP, when loaded with a specific CS, and set on an exploitation oriented CT (which means to say that they engaged with a well-structured problem to which they had a known behavioral pattern associated), organizes perception accordingly. Simons & Chabris managed a simple experiment which illustrates how our perception is not based only on what we see, but also on what we are doing.

3.3.1 Patient GS & Agnosia

Gazzaniga, Ivry and Mangun (2002) discuss a case study of a perceptually impaired patient. Patient G.S., after recovering from a stroke, developed a syndrome referred to as visual agnosia, in which his capacity to process the verbal meaning of visual information was affected even though his visual systems were intact. This case may help to cast some light on how the significance (or relevance) of a perceptual input is created/interpreted by human beings. GS had the capacity to see but did not know, at least consciously, what he saw.

During the experiment, GS had an odd response. It was as if his body knew what his conscious and verbal mind did not. The experiment consisted of GS being presented with pictures of objects and naming them accordingly. When he was given a picture of a padlock he said it was a dial-phone, though his body, his hands, performed a strange mime as if they were opening a padlock. When enquired about his hands, the patient dismissed it as being just a nervous habit. The experimenter insisted, asking GS what the image was. Convinced by the experimenter's response that it wasn't a phone, GS hesitated for a second. Then, after a look at his fingers, he proudly announced, "It's a lock, a combination lock." Similar situations happened with different objects.

The area of the brain affected by GS's stroke was broad. Therefore, pinpointing the defected process to the right neural area is practically impossible considering only this account. Still, the case can serve as an example for some processes of RR. After all, being able to see but not to know, means that these two processes are relatively independent. This independence does not seem complete because of GS's strange unconscious "nervous habit". It suggests that in a behavioural level he actually knew what he was seeing. He could attach a pattern of action that fitted perfectly with the image presented.

Such behaviour as observed in GS's case is odd, but it creates the setting for possible hypothesis. Knowing something is not the same as being conscious of it, or maybe verbal and motor knowledge are independent. Or maybe GS's response might mean that motor knowledge is unconscious while verbal knowledge is conscious. Independent of what the real answer might be, the fact remains: GS knew and did not know what the object was, both at the same time.

A possible source of GS's symptoms could be the systems concerning his capacity for RR. If we use their (VERVAEKE, LILLICRAP, RICHARDS; 2009) three level constraint model we can see that GS's systems concerning his CTempering seemed fine, he could decide, even if unconsciously, on a pattern of exploitation of the given input. It isn't obvious how his CScope would have played a role, but his CPrioritization systems have definitely been affected: ambiguous and conflicting information was difficult to unpack successfully.

3.3.2 Patient HM & Independent Memories

The procedural memory and the semantic memory are both independent. That much we learned from HM (GAZZANIGA, IVRY & MANGUN, 2002). HM suffered from epilepsy and he underwent a medical procedure. His medial temporal lobe was bilaterally removed in what is called a temporal lobectomy.

Procedural memory is concerned with the pattern of action associated with a certain activity. For example, riding a bike, playing the violin, playing the piano or cutting onions. In this sense it is a particularly embodied form of memory. Semantic memory on the other hand is concerned with verbal and factual claims. These are the 'whats', 'wheres', 'whens' and 'hows' of things. "London is a city in the UK that exists since the time of the Romans" and as such we know what London is, where it is and how long it has existed. In essence, semantic memory is about how we categorize and conceptualize things.

After his surgery, HM's seizures indeed diminished, but he also lost the capacity to form new semantic memories. Other patients who underwent the same procedure of bilateral temporal lobectomy also lost this capacity (GAZZANIGA, IVRY & MANGUN, 2002). HM could still improve in procedural patterns when repeatedly trained, though he was unconscious of the repetitions. We can assume then, that the semantic memory, or in the least an essential part of the process for their formation, is performed by the medial temporal lobe and that procedural memory is not. More than that, it does not take conscious effort for new procedural memory to be formed.

4 Relevant Divisions of the Nervous System

4.1 From Movement to Thought

The brain is primarily selected for coordinating movement (GAZZANIGA, IVRY, MANGUN, 2002). This is clear from the observations in evolutionary history: Cnidaria is the first multicellular group of animals who moves and also the first group to have nervous cells (RIBAS, 2006). As evolution progresses and the patterns of movement become more complex, so does the brain (RIBAS, 2006). Even though this is a correlational claim, the matter of movement and neural activity is rather well established (GAZZANIGA, IVRY, MANGUN, 2002; MOOK, 1934).

4.2 From Action to Words

The motor theory of speech perception (LIBERMAN, MATTINGLY, 1985) posits that the understanding of speech is context dependent. Speech understanding has its own version of multistable perception (Fig. 1), because a specific acoustic utterance is relative to what came before and what comes after it. They propose that this problem is solved through the overlap between speech production and perceptual systems (SCHWARTZ et. al., 2012; LIBERMAN, MATTINGLY, 1985).

Stephens, Silbert and Hasson (2010) cohesively lay out functional Magnetic Resonance Imaging (fMRI) evidence for speaker, listener neural coupling during successful communication. Listeners' brain activity mirrors the speakers' with a delay, suggesting that the listener is modeling the speaker's brain activity in his own. Understanding and speaking manifest very similar patterns of neuronal firing.

Martin et al., (1996) investigated that premotor areas of the brain were more active while subjects named pictures of man-made objects. This lays way to the claim that when naming something we have to know what to do with it. For example, the case of patient GS mentioned earlier. The process of learning a new word is associated with a context where the new word is presented (PETERSON, 1999). The neurological parameter (and the emotion attached by the limbic system) that arises in the moment the word is learned is associated to it, aiding in the organization of future action when recall is performed in an experience similarity identification (MOOK, 1934).

A word that refers to an object gains depth as it resurges with new meanings across the life span of the individual. Because it gains a broader source of emotional input which is derived from memory. The longer an individual has lived, the greater the chance of encountering a greater variety of contexts in which words can be applicable. This is consistent with Zwaan's model of the Immersed Experiencer Framework (ZWAAN, 2004 *apud* MAR, 2004). This theory posits that words automatically activate experiences of their referents. Three steps are proposed to underlie narrative comprehension based on his premise:

"(...) (1) words activate broad functional webs that are also activated when the referent is experienced; (2) current webs are articulated by previous webs and vice versa, constraining initially broad activations to currently relevant information; and (3) integration into the current memory representation occurs via the construction of transitions between these articulated webs in ways similar to the modulation of attention...."

The point of the matter is that words emerge on the basis of action. Then the fact that the brain is primarily adapted for action seems obvious. That means that the evolution is concerned with how to move effectively. And in order to "decide" on a particular action pattern the organism's perception must be aligned with Reality as such.

4.3 The Chaos & Order Perspective (Hemispheric Division)

The hypothesis is that the right and left brain hemispheres are functionally distinct (McGilchrist, 2010). Not absolutely separate, but each hemisphere can perform tasks that the other cannot (GAZZANIGA, IVRY & MANGUN, 2002). From both: symbolic and neurological perspectives, Reality as is experienced by a living organism falls into two great categories: routine and novelty (JUNG, 1959; PETERSON, 1999). These categories can also

be referred to as what is known and what is unknown. Symbolically represented in myth and story as chaos and order (JUNG, 1959).

4.3.1 Evidence for Hemispheric Functional Separation

Iain McGilchrist (2010) brings forth a rather cohesive revision on the lateralization of brain hemispheres. The brain asymmetry is characterized in many different levels of analysis. The hemispheres differ from one another considering morphology, size, weight and conformation (KERTESZ; BLACK, 1992). Neurons also differ in size between the hemispheres (HAYES; LEWIS, 1993) and the extension of their dendritic branching areas (SCHEIBEL; FRIED, 1985). One of the differences that is particularly noticeable is on how the ratio of grey to white matter is higher on the right hemisphere than on the left, suggesting greater integration and diffusion of connections in the right cortex (GUR et al., 1980).

The experimental evidence presented suggests that there are functional differences between the hemispheres which relate to the morphological differences observable. The hemispheres are distinct when considering dopaminergic to noradrenergic pathway ratio (GLICK; ROSS; HOUGH, 1982; TUCKER; WILLIAMSON, 1984). These observations might be connected to two different kinds of attention that the brain can process. Dopamine seems to facilitate information processing redundancy, particularly within the left hemisphere while the noradrenergic pathways, that are more present in the right hemisphere, prioritize novelty (MCGILCHRIST, 2010; TUCKER; WILLIAMSON, 1984). Evidence also suggests that the corpus callosum is involved in the reciprocal inhibition of the brain hemispheres (MCGILCHRIST, 2010; MEYER et al., 1995) indicating a functional prioritization of one pathway over the other. There isn't an overall dominance of one hemisphere over the other, but rather that each kind of information is skewed towards one form of processing according with context. It appears that each hemisphere is specialized in one of two different ways of experiencing the world for effectively realizing relevance.

This dichotomy in world views during hemispheric activity illustrates further the concepts discussed by Vervaeke, Lillicrap and Richards (2009) that framing and RR are a fundamental issue for entities perceiving and experiencing reality. The dual nature of perception is conceptually present in the three pairs of constraints: CS, CT and CP (VERVAEKE, LILLCRAP, RICHARDS, 2009) and the physiological basis for McGilchrist's hypothesis is consistent with this proposition.

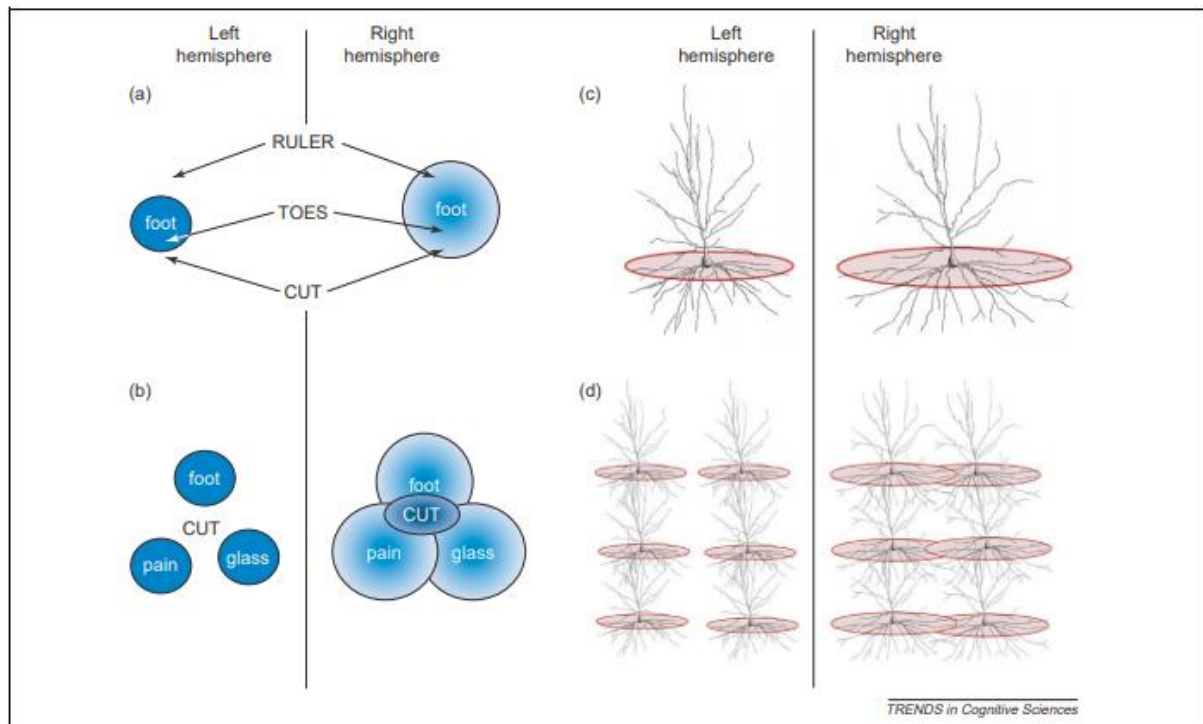


Figure 2: Adapted from Jung-Beeman (2005), a representation of structural, morphological differences of neuronal activation and connective distances between the two hemispheres. Which result in the conceptually varying perspectives of brain hemisphere functional activity in information processing.

McGilchrist's references suggest a rough hemispheric preference between pairs of dichotomist perceptual possibilities: the whole versus the part (YOSHIDA et al., 2007; LUX et al., 2004; GAZZANIGA, IVRY, MANGUN, 2002; van KLEECK, 1989), context versus abstraction (FEDERMEIER & KUTAS, 1999), individuals versus categories (YOSHIDA et al., 2007) and the living versus the nonliving (MARTIN et al., 1996). Natural language such as stories, texts and conversations are syntactically complex and context dependent. Understanding this form of communication means that humans have to sort through this complexity which may arise in the form of ambiguity or metaphors and effectively lock on the correct semantic category. Jung-Beeman (2005) refers to two different semantic activations: one relates to the more diffuse and widely spread connections of the Right Hemisphere (RH), which he calls *coarse semantic activation*, and the other is the *focused semantic activation* of the Left Hemisphere (LH), as represented in Figure 2.

The argument here is that experience is processed in this dual perspective manner because it's the most adaptable way to translate a reality that is relative and ambiguous (VERVAEKE, 2019). The better an organism is in interpreting reality and changing behavior accordingly, the greater his odds of survival. Therefore, an argument can be made: that what is being selected for is the process of interpretation itself which is reflected in the structural-functional organization of the hemispheres, which happen to maximizing the capacity of learning as a way to increase adaptation potential.

5 Learning to Act

The process of learning is essentially a process concerned with the adaptation of the organism to the environment. During learning, the organism responds to changes in the environment through a process which is composed of the constructive pairing of two processes: "assimilation" and "accommodation". The definition of the terms is rather well described in Burman's "*Updating the Baldwin Effect*" (2013).

"(...) If the environment never changes, then the organism is born equilibrated; the inherited evolutionary history of the species has shaped its individual fitness, into which it must simply mature. But if the environment does change, then the organism must respond if it is to stay equilibrated: first it must assimilate the effects of the change, then it must accommodate its way of life to that change in order to retain its fitness. To the extent that these accommodations then feed-back to affect the environment, the organism must also continue to respond to the changing demands placed upon it. The organism, in other words, is part of what ultimately came to be called "a dynamic system". (...)" (BURMAN, 2013 p. 364)

This can be misunderstood as a homeostatic process, but the argument is that the set-point of development is fluid (BURMAN, 2013). It can be said that every newly learned skill is changing the morpho-functional organization which characterized the organism's behavior. Herein, the organization of skill and the acquisition of novel behavior is hierarchically organized allowing for the range of stimuli to which an organism responds to widen as development progresses.

Hierarchies of skills, as Fischer (1980) models it, describe the capacity of learning new skills (e. g. a motor pattern) through a change over an already routinized (known) output. The development of new motor capacity builds on top of the *a priori* present structure. This conceptualization models the progressive learning of individuals under general conditions while allowing for peak performance, an evolutionarily desirable model.

The modeling of hierarchically organized categorization of information is so efficient in maintaining optimal performance while maximizing attainment of novel information that similar conceptual processes are being employed in computer sciences in attempts to produce optimally effective and self-teaching programs (see ASADI & HUBER, 2007). These models seem to be representative of an adaptively selected capacity because it allows behavior to adjust by adding nuance to an already known behavior (PAPALIA & FELDMAN, 2013).

5.1 Memories & RR

So far, the evidence for how motivation is vital for RR and how the brain hemispheres exist as functionally distinct entities which process perception through two opposing and parallel perspectives has been laid out (VERVAEKE, LILLICRAP, RICHARDS, 2009; MCGILCHRIST, 2010; GAZZANIGA, IVRY, MANGUN, 2002). Based on that, an argument can be made that the brain has adapted to process information either as something learned or as something not yet known.

As an organism develops, he accumulates experience in the form of memory. This memory feeds into the process of transformation of the brain (manifested on the property of, for example, neuroplasticity) which changes behavior and characterizes learning (PAPALIA & FELDMAN, 2013). HM's case shows that it isn't obvious how many pathways there are to learning, but it serves as evidence for the argument that different pathways, that may or may

not be independent, do exist. In the mentioned case, at least two were observed: procedural and factual memories.

Molecular mechanisms that create and manipulate memories are not absolutely known. There is evidence for RNA transfer to be occurring between neurons during memory formation. Gene Arc encodes for a repurposed or *exapted* Retrotransposon Gag protein, which is capable of intercellular transfer (PASTUZYŃ et al., 2018). The Arc proteins self-assemble into virus-like capsids, and evolutionary analysis does relate the Arc gene to Ty3/gypsy, a vertebrate gene evolutionarily associated to retroviruses (PASTUZYŃ et al., 2018).

Korb and Finkbeiner (2011), discuss the importance of the Arc gene in the regulation of neural plasticity and behavior. Arc stands for Activity-Regulated Cytoskeletal gene, and it encodes a protein that is vital for memory consolidation as it strengthens synaptic connections between neurons (KORB & FINKBEINER, 2011).

Neurons evolved to "(...) process and store information from the outside world through synaptic connections between interconnected networks of neurons (...)" (PASTUZYŃ et al., 2018, p. 275). One hypothesis is that through the intercellular transfer of genetic material, neurons change their sensitivity and manage to coordinate their activity in a neuro-network level. The coordinated activation results in change of the response to the environment, or, in other words, learning.

This learning can be measured by neuronal growth, but also by level of influence that different functional areas have over one another. This influence can be quantified in the form of neuronal distance to the main neuroendocrine mediator (the hypothalamus). As for example the case of the amygdala, which can communicate with the hypothalamus either through the *stria terminalis* (one neuron away), or through the hippocampus, which is at a longer neuronal distance (SAPOLSKY, 2010).

Memory formation from an anatomical perspective, is broadly associated to hippocampi activity. This brain region is part of a whole system though, the limbic system. Which is an ancient part of the brain. It contains the Hypothalamus, Amygdala, Hippocampus, Mammary Bodies, Septum, Fornix, Nucleus Accumbens, the Ventral Tegmental Area, among other areas, and it connects to the cortex through the Anterior Cingulate gyrus and the Pre Frontal Cortex directly (SAPOLSKY, 2010; GAZZANIGA, IVRY, MANGUN, 2002).

The homeostatic center of the brain is the hypothalamus. The hypothalamus exerts direct control over bodily homeostatic and neural regulation. It is the direct link with the body.

So, the other parts of the limbic system influence the body strongly, or weakly, in accordance with their neuronal distance from and influence in, the hypothalamus.

Emotions, and particularly fear and pain, are involved in memory formation. The amygdala is the brain region associated with fear, anxiety and aggressiveness (SAPOLSKY, 2010; GAZZANIGA, IVRY, MANGUN, 2002). And fear, can easily be argued as a powerfully adaptive emotion. The amygdala has synaptic projections to the hippocampus and it connects to the hypothalamus. The importance of this connection to actual behavior is involved in the characteristic emotional imprint of human cognitive processing during learning and experience itself.

Through the hippocampal connection, the amygdala is involved directly with memory formation of individual's experience (CANLI et al., 2000). This suggests that amygdala activity reflects portion of the emotional experience of an individual at any given moment, mainly fear, anxiety and aggression (GAZZANIGA, IVRY & MANGUN). And the greater intensity of the experience, the stronger is the memory retention (CANLI et al., 2000). Learning, therefore, is an emotional endeavor.

As a determining factor in the learning process, memory becomes important as a source of information and probably interacts with the ability of realizing relevance. RR is manifesting salience in the perceptual landscape and salience can be acknowledged by emotional intensity. As an organism learns, salience deepens and refines as the memory source increases. Then, RR interacts with the attentional systems and modifies behavior. This change in behavior is expressed in the form of a learned pattern of action. In this sense, development is essentially the optimization of the capacity to generate behavior that is more adaptive by refining RR. Learning is learning how to perceive and how to orient action.

5.2 Play & the Emergence of Morality

The process of learning is motivated (PAPALIA & FELDMAN, 2013; GAZZANIGA, IVRY, MANGUN, 2002). In the case of mammals, one of the ways this motivation manifests is through play (PANKSEPP, 1981; PANKSEPP, 2011, PETERSON, 1999). Panksepp observed this behavior in rats. The argument for the motivated character of play is based on the fact that the rats would *work* (make effort/spend energy) to enter a "pinning arena" (PANKSEPP, 2011; PANKSEPP, 1981), and this means to say that playing is a desirable

activity, a motivated activity. The question that arises is what is the evolutionary advantage and repercussions of such activity for it to have developed a motivational character?

The main advantage of play is to learn proper action, learn how to maneuver a body in space-time. In Panksepp's observations, rats (*Rattus norvegicus*) played by "pinning" each other to the ground in a sort of rough-and-tumble play. The first winner of a match established which rat was the dominant one, and after this establishment, the other rat had to initiate the play by inviting the first one to it. Rats who were bigger could have enough weight and muscle to pin down his opposing competitor most times. When such case happened and the rats were paired multiple times, if not allowed to win at least a rough one third of the times, the smaller rat wouldn't invite the bigger one to play anymore. This illustrates an emergent "rule", something akin to fair play (PETERSON, 1999).

First the rats are learning to coordinate their bodies and maneuver them effectively. They have to learn the limits of the strength and boundaries they can go to while wrestling. For example, how hard they can squeeze and bite without hurting each other. This is like a process of "calibration" of muscles and nerves. They are learning how to move their own bodies as well as learning to coordinate themselves to another's body. Not unlike what human children do when playing hide-and-seek, or catch, or dancing.

Social structure is also learned simultaneously. Patterns that are established when the games are repeated across time emerge in the form of "rules". And the word "rule" is used here rather carefully, in the case of the rats, only in the sense that the rats establish conditions before the game can repeat itself, and not necessarily conscious of their intent. Now, in the case of humans, how much of the rules reach conscious awareness is debatable (PAPPALIA & FELDMAN, 2013).

Here is how the repetitive nature of the process is relevant. Once rats are paired multiple times, a general rule is established and the basis for what can roughly be called moral behavior emerges. Therefore, the emotional circuits are directly involved in what can be considered fair social behavior (PANKSEPP, 1981; PANKSEPP, 2011).

The fundamental mathematical concepts present in Game Theory reflect the "rules" that establish the ecological effect of cognitive, gambling-like strategies in populations. The same strategies that arise in play are also present in ecological and social interactions, having direct adaptive power. The natural development of the individual organism, in the case of

social animals such as rats, apes and humans, is product of his exploitation of the socio-cognitive niche.

For a more proximal account of the evolutionary and behavioral aspects of social structures see DeWaal (2006). His work on chimpanzees (*Pan troglodytes*) lays further argument for a natural development of moral behavior. De Waal observed that chimpanzees live in a male dominated hierarchical structure. In which he noted that there are at least two different strategies that the males can employ when attempting to surge up the hierarchy. The males are either aggressively dominant and climb the social layers through force and threat of physical aggression, or they are mutually reciprocal in the sense that they participate in sharing and the building/maintenance of social connections. DeWaal (2006) recognized that the troops that were led by the less aggressive males were much more stable than those led by an aggressive individual. One of the reasons for that is because an aggressive and physically powerful chimpanzee can be decimated by a group of weaker individuals working together. So, if a chimpanzee is willing to maintain his position atop the hierarchy, then he must follow this emergent “rules” that can be thought of as a primordial morality. This places morality under the custody of evolution and therefore as an adaptive behavior being selected by nature.

How does this "morality" relate to narrative and its potential adaptability though? Panksepp (2011), does show evidence for animal models to be representative of human affective systems. The "rules" that manifest in animal behavior are product of affective subcortical processes that he describes. Narrative, as seen in humans, can be a portrayal of such rules, which in the case of our species can reach a rather complex level. It could take the form of language and travel through the population in the form of a poem or a hymn, it can be acted out in a play, or it can be achieved by a piece of painting or sculpture. Art in general, defined here as any symbolic and emotionally charged manifestation and expression of the human psyche, is a source of what these “rules” are. And therefore represent a platform for moral behavior to be transmitted, recorded and evolved. Collectively in the case of culture and mythology and religion and history, and individually in particularities of each individual mind and reality.

6 The Social Brain & Theory of Mind

The *social brain hypothesis* as proposed by Dunbar (1998) rests on evidence concerning brain size correlates to social group size in primates. As described by him "[...] the hypothesis implies that constraints on group size arise from the information-processing capacity of the primate brain, and that the neocortex plays a major role in this [...]" (DUNBAR, 1998, p. 184). It could be argued that the differences observed are derived from memory demands increasing with larger social groups, however Dunbar takes his time to make the statement that memory cannot be the sole constraint determining the differences in brain size observed. "[...] The hypothesis is about the ability to manipulate information, not simply to remember it [...]" (DUNBAR, 1998, p. 185), and this thought is derived from the impact on behavior when effectively employing Theory of Mind (ToM) during social interactions (DUNBAR, SCHULTZ, 2007; DUNBAR, 1998; FLETCHER et al., 1995).

Theory of Mind is the capacity to understand the state of mind of others (De Waal, 2006). In a sense, theory of mind could be thought of as the capacity to represent the subjective feeling of another being. Understanding what another organism feels like, which means also understanding what their desires are or what they know and do not know. For example, a mother who by the cry of their infant knows that the newborn desires milk, is performing ToM through an empathetic link with the child and her own knowledge of basic desires.

It isn't only empathy that is possible because of ToM. The existence of behaviors such as deceit and trustworthiness demand that the organism effectively simulates another's mental state if they are to employ social tactics effectively (DE WAAL, 2006), and as will be shown in topic 6, the social and individual value attached to objects is also at least partly dependent on the functional structures that allow for ToM like processing.

If indeed this is the case, that social groups that evolve in complexity as a function of adaptability, then similar cognitive abilities and functional nervous system configurations could have evolutionarily converged (HOLEKAMP et al., 2015; BYRNE; WHITEN, 1992). Holekamp et al. (2015) observed a probable case of such an event in spotted hyenas (*Crocuta crocuta*). The size and complexity of spotted hyena's' social groups is similar to that of cercopithecine primates, they also experience an extended early period of learning about their social environment and their need for social dexterity matches that of primates (HOLEKAMP et al. 2015).

The evidence in the case of spotted hyenas for the social brain hypothesis indicate that, although the complexity of social structures does seem to create cognitive demands that have selective capacity, it does not account exclusively for larger brains. For example, knowledge about the relationship among conspecifics has been documented on animals that lead solitary lives (see GROSENICK, CLEMENT, FERNALD, 2007). And the notion that social complexity affects the size of brains might apply at the level of family on carnivores as is the case of the spotted hyena, but it fails at the level of order (HOLEKAMP et al., 2015). If so, then size is not the determining factor.

According to Charvet and Finlay (2012) the performance of finer statistical analyses concerning the social brain hypothesis (in this case a regressive factor analysis) yields weaker association between social complexity and brain size. It is important to emphasize that the existence of the connection between social complexity and brain volume is not contested but rather that the data compared to other measures of behavioral complexity is not unidimensional. In other words, other factors should be considered when considering the evolution of brain structures and overall cognitive capacity, apart from only size.

There is an array of attempts at explaining the evolution of large cortex in primates that can be considered complementary to the social brain hypothesis. Other rationales include: the expensive tissue hypothesis (AIELLO & WHEELER, 1995), the radiator hypothesis (FALK, 1990) and the cooking hypothesis (WRANGHAM, 1999). All of which relate to fundamental constraints such as energy availability (which emphasizes the RR model) and physiological limitations such as temperature.

This is apparently one of the greatest constraints: the capacity to understand our conspecifics. Or, in other words, having the knowledge of others motivations, because if one understands the motivational state of another organism, action can be adjusted to match that force. The adaptive potential of this empathic capacity is what serves as precursor to altruism, it manifests in the caring of mothers for their children for example (DE WAAL, 2006), and it also gives another scope to selfish behavior, such as allowing for the appearance of deceiving intent, for example. An empathic predisposition is only possible because of what is called Theory of Mind (ToM).

6.1 ToM & Understanding Narrative Structures

Fletcher et al., (1995) observed in functional imaging studies the areas of the brain involved in theory of mind and story comprehension in humans. He makes a compelling case for "mentalizing" (the capacity for employing theory of mind) as a process performed by a "[...] innately determined cognitive mechanism [...]"(FLETCHER et al., 1995, p. 110) as opposed to a learned capacity. The idea of this being a biologically based system comes from considerations on autism. One of the main symptoms observable in autistic people is a difficulty in social interactions. These difficulties can be explained by an overall failure to represent the thoughts and feelings of others. And the impairment seems to be relatively isolated and independent of intelligence. During story telling comprehension tasks "[...] autistic individuals, even of normal IQ, confused, p. el., a lie with a joke, or persuasion with misunderstanding [...]" (FLETCHER et al., 1995, p. 111). This illustrates the importance of theory of mind during social interactions as it allows for effective understanding of another individual's mental states and it is essential for an appropriate social response.

ToM is essentially a set of morpho-functional commonalities capable of "simulating or mirroring another's internal subjective state of being. It is because of the common architecture that different individuals can understand one another and simulate one another. The use of a common interpretative structure facilitates communication because it allows information to be both; encoded and decoded. A concept that seems to couple all too well with Jung's (1959) notion of the collective unconscious.

The hypothesis is that the archetypes are "empty" forms of instinctively driven *behavioral patterns*. An "innately determined cognitive mechanism" that serves as an *a priori* structure on top of which the individual can effectively develop, which in accordance to Jung's perspective, would mean integrate and individuate. Jung makes an observation about this concept that he deems relevant: the archetype are not defined by their content (for the content is derived from the individual's own experience). The archetype is the form (a morpho-functional structure) which corresponds to the instincts themselves, and that are later populated by symbols with an emotional attachment as memory is encoded during experience.

6.2 An Evolutionarily Adaptive Perspective - Game Theory

Game Theory is a mathematical model which reflects the strategies that may be taken in any given interaction (HAMMERSTEIN, SELTEN, 1994). This model can be employed

when studying the dynamics of populations in accordance with the evolutionary perspective. Individuals of a population manifest personalities, that is to say, preferred strategies, when interacting. The strategies are, essentially, behavioral patterns that manipulate the fitness of the organism either increasing or decreasing their reproductive chances.

The model serves as an argument for the importance of individual level specializations (BOLNICK, 2003; HAMMERSTEIN, SELTEN, 1994). Because it shows the impact of individual nuance of behavior strategies in adaptation in the level of population. This characterizes differences in personality, which are a product of natural variation between individuals within populations, and alter population fitness by their own individual increase in reproductive success (BOLNICK, 2003).

A question that arises then, is which strategy is the most adaptive? Game theory can give this answer (see CASE, 2017). The problem is that the mathematical modeling of these complex interactions is possible now, but during evolutionary history human beings did not have this capacity. The hypothesis is that narrative can encapsulate the modeling in symbolic representation of the interactions that we take part on as a manner to communicate the information of which strategies result in what outcomes, in a cultural setting (JUNG, 1959; PETERSON, 1999).

The patterns that contain greater fitness value will be selected for and spread across cultures, while the patterns that do not increase adaptability through fitness increase will be selected out of the population. One example of such archetypal pattern that is rather wide spread is the Hero myth, as portrayed by Campbell in *The Hero with a Thousand Faces* (1989). Here we retake the idea of archetypes, as they manifest in symbolic form in the most basic of narrative structures such as mythology, religion and dreams for example (JUNG, 1959). Knowing that memory and learning are organized in a hierarchical assimilation-accommodation system, there is evidence to suspect that the narratives will also follow the logic of this process. This means that, as culture progresses and narratives have more opportunities to interact with the environment, the stories themselves will fall into the dynamic system of learning/memory and participate in it and interact with it. Therefore, as time progresses stories change in complexity and this complexity reflects adaptive behavior itself, but they maintain an underlying structure which is common. This commonality is what allows human beings to understand one another through this stories, and these commonality is also what characterizes the archetypes.

7 Narrative

7.1 Narrative & Archetypes

Archetypes manifest through narratives as a product of preconscious processing of information. The representation is derived from a specific pattern of neural activity which is product of the morpho-functional organization of the structure of the brain, mainly the hypothalamic circuitry alongside the limbic system. These are neurological structures that functionally manifest instinct, learning, emotions, bodily states and sensations, homeostasis, and overall unconscious activities that directly influence behavior. This structure is the basis for what Jung (1959) calls the archetypes. Jung's analysis of the matter has a holistic approach which stands from a psychological viewpoint and is worth visiting both for its content and sophistication:

"(...)Primitive tribal lore is concerned with archetypes that have been modified in a special way. They are no longer contents of the unconscious, but have already been changed into conscious formulae taught according to tradition, generally in the form of esoteric teaching. This last is a typical means of expression for the transmission of collective contents originally derived from the unconscious. (...)The term "archetype" thus applies only indirectly to the "representations collectives," (the unconscious) since it designates only those psychic contents which have not yet been submitted to conscious elaboration and are therefore an immediate datum of psychic experience. In this sense there is a considerable difference between the archetype and the historical formula that has evolved. (...)The archetype is essentially an unconscious content that is altered by becoming conscious and by being perceived, and it takes its colour from the individual consciousness in which it happens to appear (...)" (JUNG, 1959, p. 5)

"(...) Primitive man impresses us so strongly with his subjectivity that we should really have guessed long ago that myths refer to something psychic. His knowledge of nature is essentially the language and outer dress of an unconscious psychic process. But the very fact that this process is unconscious gives us the reason why man has thought of everything except the psyche in his attempts to explain myths. He simply did not know that the psyche contains all the images that have ever given rise to myths, and that our unconscious is an acting and suffering subject with an inner drama which primitive man rediscovers, by means of analogy, in the processes of nature both great and small (...) A symbol is the best possible expression for an unconscious content whose nature can only be guessed, because it is still unknown (...)" (JUNG, 1959, p. 6-7)

Jung's mastery of classical references places his argument in a spot of difficult dismissal. The terms archetype, instinctual behavioral pattern, unconscious and symbol are seemingly referring to the same underlying structure. Mainly the morpho-function organization of the nervous system while performing RR, and that is to say, perceiving reality.

7.2 Narrative & RR

Narrative is a process through which value can be attached to perceptual input. Narrative contain both; the societal expectations, agreements and values, as well as the individual ones. It manifest collectively in culture itself, and/or it participates in cultural creation. Individually, narrative unfolds portraying every quality of human interaction. From a psychological and philosophical perspective it is a tool that produces or unveils *qualia*, or in other words, the properties of subjective experience (it is concerned with the relation between phenomenological properties and their physical counterpart) (CHALMERS, 1995).

If we analyze the world of narrative that we've construed, which means to say any form of story-telling, such as myth, religion, philosophy and history p. el, we can see two possible variants of the structure of how a narrative may unfold. The first structure is equitable to "in order for A to become B do C", as mentioned before, a well-structured problem. That is the simplest processing structure that can produce effective action. It presupposes that the individual knows what is A and B and C, and that isn't always obvious. It's "algorithmic".

Then, what would the processing structure concerned with ill structured problems be like? After all, if the problem is ill structured it means that the organism does not know how to behave in order to solve it. An action is still demanded of organism. The answer to that is a cyclical process that is better understood as the search for relevant information.

Relevance Realization plays a central role in information acquisition, guiding perception and impacting behavior. So, as narrative is concerned with the flux of information, the content of narrative will be placed under the same constraints as relevance realization performed by cognitive systems. The narratives which optimize an individual's efficiency and resiliency are more relevant for the organism's survival and, therefore, have a greater chance of perpetuating within populations. This connection between relevance realization, information and narrative, furthers the argument for narrative as a tool (DENNETT, 2017) that is capable of altering the *fitness* of an organism. Thus, narrative is placed within the evolutionary framework of selection and propagation according to the relevance of its content and effectiveness of its adaptability potential.

Narrative is in essence relating to the portrayal of behavioral patterns. How does it effectively impact behavior though? Jordan Peterson (1999) gives a powerful example of how

during development a child may be taught both: the objective view and the narrative view (behavioral pattern) of an experience:

"[...] Imagine that a baby girl, toddling around in the course of her initial tentative investigations, reaches up onto a counter-top to touch a fragile and expensive glass sculpture. She observes its color, sees its shine, feels that it is smooth and cold and heavy to the touch. Suddenly her mother interferes, grasps her hand, tells her not to ever touch that object. The child has just learned a number of specifically consequential things about the sculpture – has identified its sensory properties, certainly. More importantly, however, she has determined that approached in the wrong manner, the sculpture is dangerous (at least in the presence of mother); has discovered as well that the sculpture is regarded more highly, in its present unaltered configuration, than the exploratory tendency – at least (once again) by mother. The baby girl has simultaneously encountered an object, from the empirical perspective, and its socioculturally-determined status. The empirical object might be regarded as those sensory properties “intrinsic” to the object. The status of the object, by contrast, consists of its meaning – consists of its implication for behavior. Everything a child encounters has this dual nature, experienced by the child as part of a unified totality. Everything is something, and means something – and the distinction between essence and significance is not necessarily drawn. [...]"

- Peterson (1999), p. 15

In order to understand the relationship of the glass sculpture to her own mother, the toddler must use ToM. The baby girl needs to accommodate the mother's protective behavior towards the sculpture, and by doing so she naturally establishes a value structure towards that object. At first her new established structure translates into the *qualia* of her experience. It mirrors the mother's and consequently societies value of said object. And even if the child does not yet understand why the object is valued, she did learn something about how to behave towards it.

The girl went through the process that is laid out on Figure 3 as she developed an imprint of the sequence of emotional changes she experienced in her little exploratory adventure. At first, she felt curious as to what the sculpture was. She reached out to explore it and was surprised by the mother's behavior. Unexpected information entered her field of awareness, she descended into the unknown where complexity is overwhelming, and returned with a tiny bit of ordered information, in this case: that mother values this object. This structure can be observed in many different stories. In essence, all stories that are interesting and engaging revolve around this same flow (security or original state > novelty or anomaly > new state or desired state). Above, we can see Figure 3 which relates to this structure in a more abstract representation from a psychological perspective as adapted from Peterson

(1999). It is worth noting that the same structure presented in Figure 3 is translatable in other areas of knowledge such as logic or computational and algorithmic mathematical processes. The lexicon to refer to it changes but the structure of the process remains constant.

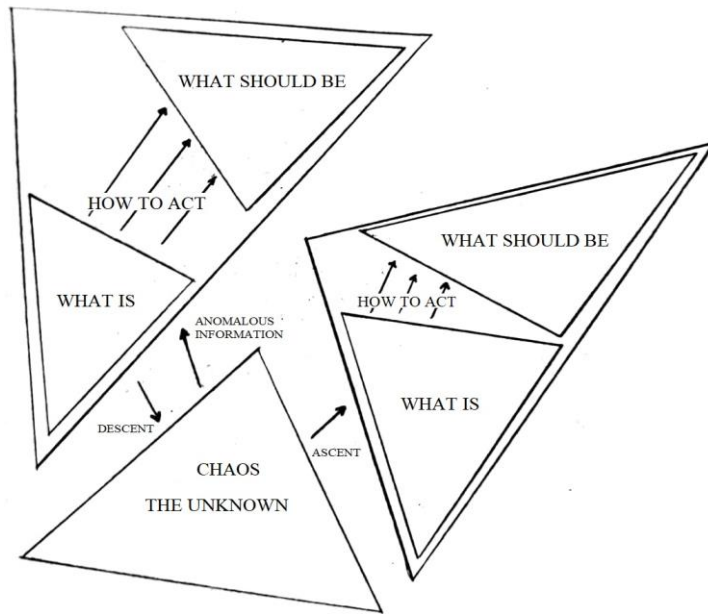


Figure 3: The structure of the acquisition of new information and behavioural change. Adapted from Peterson (1999).

7.3 Narrative & Functional Structures

Mazoyer et al. (1993) while conducting Positron Emission Tomography (PET) scans on subjects while they attempted to understand language, found material substrate correlates for varied levels of linguistic analysis. They experimented on acoustical, phonological, lexical, prosodic, syntactic and conceptual levels. The conceptual analysis is the one that is particularly relevant for this discussion and it was performed by auditory stimulation through story telling. It was the only protocol in which Brodmann's area 8 was activated which is in accordance with Fletcher et. al., (1995) observations. This lays ground for the claim that area 8 is particularly involved in processing ToM. Not exclusively though.

During Fletcher's et. al., (1995) PET scans three brain areas were active during story comprehension in both mentalizing and non-mentalizing tasks: the temporal poles bilaterally, the left superior temporal gyrus and the posterior cingulate cortex. Activated exclusively

during theory of mind tasks was the medial frontal gyrus (*Brodmann's area 8*) along with a portion of the posterior cingulate gyrus.

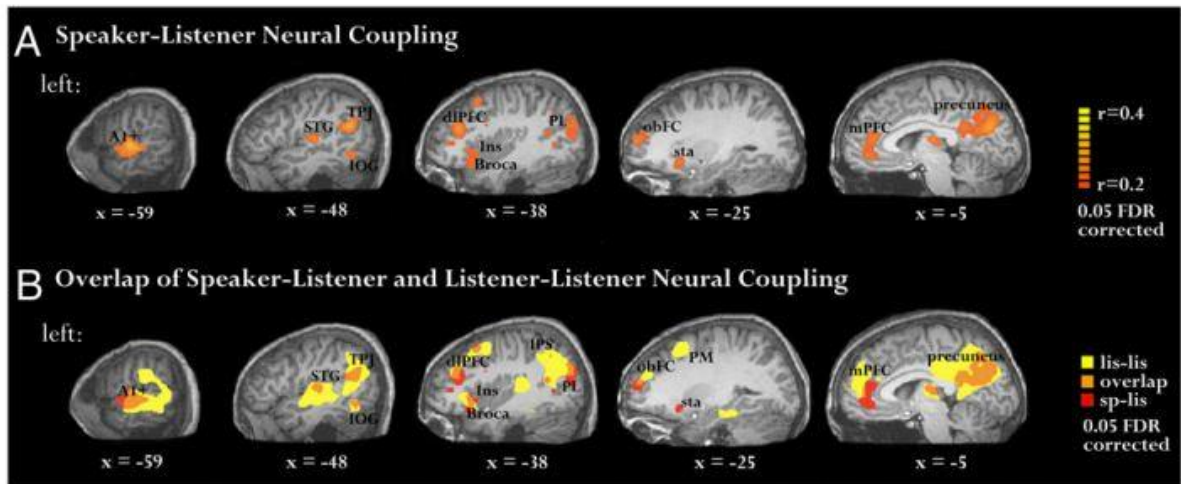


Figure 4: (A) refers to the areas in which the activity during speech productions coupled to the activity during speech comprehension. Sagittal slices of the left hemisphere (with similar results for right hemisphere). (B) The overlap (orange) between areas that exhibit reliable activity across all listeners (listener–listener coupling, yellow) and speaker–listener coupling (red). Note the widespread overlap between the network of brain areas used to process incoming verbal information among the listeners (comprehension-based activity) and the areas that exhibit similar time-locked activity in the speaker’s brain (production/comprehension coupling). For methodological references see Stephens et al., (2010) p. 14427

Symony et al. (2016) speak of the Default Mode Network (DMN), a functional structure product of brain default activity. The areas of the brain to which this kind of activity is associated are: the temporal parietal junction, angular gyrus, precuneus, posterior cingulate cortex (PCC), Medial Prefrontal Cortex (MPFC) and temporal pole. These areas are capable of accumulating and integrating information over minute-long timescales, and mainly PCC and MPFC are implicated in DMN activity (SYMONY et al., 2016, GREICIUS, 2002).

DMN activity readily locks onto narrative processing (Fig. 5) (SYMONY et al., 2016) and Stephens et al. (2010) observed the neural activity of speaker-listener situation during story comprehension (Fig. 4). During communication the brain activity of those involved coupled as they functionally reflected one another, suggesting that the encoding and decoding of narrative-like processing uses the same underlying morpho-functional structure.

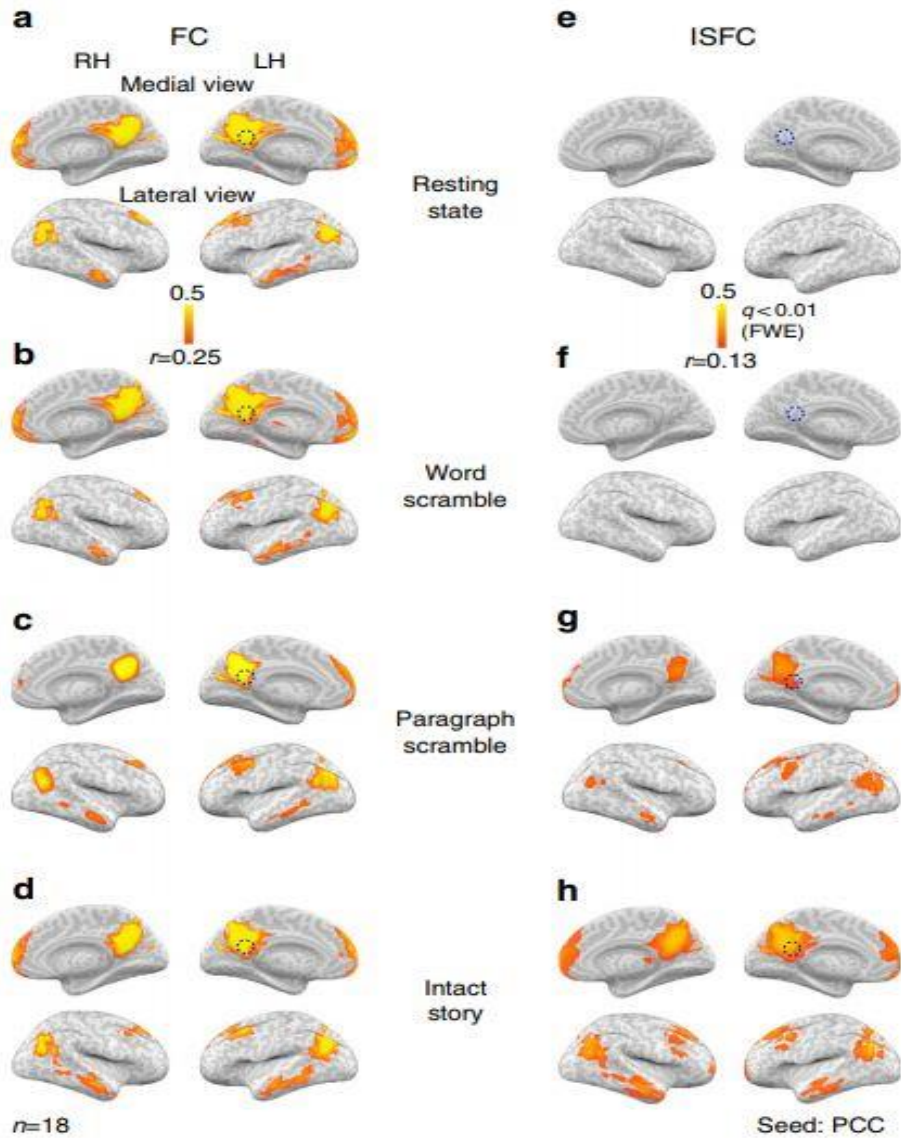


Figure 5: (a–d) Average functional connectivity (FC) maps across 18 subjects between the posterior cingulate cortex (PCC) seed (dashed circle) and the entire brain reveals the same DMN during (a) resting state, (b) word scramble, (c) paragraph scramble and (d) intact story conditions ($r=0.25$, nonparametric family-wise error, FWE, correction $q=0.01$). (e–h) Inter subject functional correlation (ISFC) between the PCC seed (dashed circle) and the entire brain across 18 subjects reveals no significant stimulus induced correlations in the DMN during resting state (e) or word scramble (f). In contrast, seed-based ISFC reveals significant stimulus-induced correlations in the DMN during paragraph scramble (g) and maximum correlations during intact story (h). Adapted from Simony et. al., (2016), p. 4

8 Conclusion & Future Research

The Darwinian perspective of reality is in essence pragmatic. If an organism isn't interacting with the environment in an adaptable manner, then the organism ceases to exist.

That means that the organisms who survive, perceive reality through a landscape of value that reflects the environmental affordances accurately. These affordances can be thought of as either tools or obstacles, which are either aiding or hindering action. This process of realizing the relevance of the environment is vital if an organism's goal is to be adaptable.

The brain of the *Homo sapiens* has been selected in this exact sense. The brain has enough of a basic structure to allow the organism to sustain his basic needs, added to enough plasticity which gives it the capacity of changing in accordance with what the environment demands, both assimilating novel information and then accommodating it through the development of new forms of behavior, or, in other words, new forms of action.

Narrative is one of the processes which mediate between the existent structure and the ever changing demands of the environment. The causal structure of narrative formats allows for the value of experience to be braided with action. In the case of human beings, the emergence of culture, language and society, is product of this same process but in a representational form. If this social and cognitive source of narratives fits reality in a pragmatic manner, then the species fitness is expanded.

The underlying structure that processes narrative is partly determined biologically which makes it product of the morpho-functional organization of the brain during natural activity. The processes concerned with RR, ToM and the DMN are constituents of this organization. As the individual develops, the environmental and social experiences populate this a priori biological structure. The archetypes refer to these structures activity in its unconscious form, but when the archetypes are fleshed out by experience and conscious awareness, they manifest in a narrative form.

The argument that has been laid out here is that narrative is central to human development and evolutionary success. Understanding the evolutionary process that led us to develop our capacity for language, action, imagination, creativity and problem solving sheds some light on how the processes observed in brain activity may connect with one another. This is pertinent for different areas such as artificial intelligence (A.I.) and robotics, or psychology, psychiatry and their influence on psychopathologies, for example.

The matter of how we perceive reality must be attended to if we are to tackle practical problems of present day society. If attention is guided by perception and goal specificity is relevant in this process, then the goals of our societies and the individuals in them must be clear and morally arranged so that our perceptions follow suit. Therefore, understanding how

keystone processes, such as the development of ToM and RR take place, and how they vary to their pathological extremes as is the case of autism, neurosis or personality disorders p. el., is essential. What are the physiological and psychological mechanisms that constrain an individual's behaviour? How do these constraints impact society, and what sorts of problems do they manifest? Are these problems somehow avoidable?

The case of GS is an example where it is not obvious if conscious processing is not the mediator between the conflicting inputs he experiences. In this case, the motor information wasn't reaching conscious awareness until GS looked at his hands, after which the conflict was resolved, or so it seemed. Is consciousness then, at least in part, the cognitive element that resolves Cognitive Prioritization problems? This was not the question pursued in this paper but it lays ground for its exploration.

These questions are not simple to answer, and they manifest in many different levels of analysis that range through an array of areas. From the biological, through the social, the political, the economical and the psychological. All have narratives as a factor, translating information between these levels. Being conscious of how all these mechanisms and processes play themselves out is paramount if our goal is to develop the individual, and consequently society, into our most efficient, resilient and adaptive potential.

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